APPENDIX R: REPORT SUPPORTING AN APPLICATION FOR A TEXAS WATER RIGHT FOR LOWER BOIS D'ARC CREEK RESERVOIR

Report Supporting an Application for a Texas Water Right for Lower Bois d'Arc Creek Reservoir

DECEMBER 2006

Prepared for:

NORTH TEXAS MUNICIPAL WATER DISTRICT

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NTD06128

ENGINEER'S CERTIFICATION

I certify that the preliminary design for the structure of the dam for Lower Bois d'Arc Creek Reservoir complies with the Texas Administrative Code, Title 30, Part 1, Chapter 299 rules and supporting documentation. According to the criteria given in Chapter 299, the dam would be classified as a large, high hazard structure.

_____

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REPORT SUPPORTING AN APPLICATION FOR A TEXAS WATER RIGHT FOR LOWER BOIS D'ARC CREEK RESERVOIR

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REPORT SUPPORTING AN APPLICATION FOR A TEXAS WATER RIGHT FOR LOWER BOIS D'ARC CREEK RESERVOIR

December 2006

1. BACKGROUND AND NEED FOR THE PROJECT

Lower Bois d'Arc Creek Reservoir is a proposed reservoir on Lower Bois d'Arc Creek, a tributary of the Red River. Figure 1.1 shows the location of the project, which is in Fannin County in North-Central Texas. A reservoir at this site (then called the Bonham Reservoir) was included in the Red River Compact (Red River Compact Commission, 1979). The project has been studied previously for the Red River Authority and the North Texas Municipal Water District (Freese and Nichols, 1984 and 1996) and was recommended as a water supply for the North Texas Municipal Water District in the 2001 and 2006 *Region C Water Plan*s (Freese and Nichols *et al.*, 2001 and 2006) and the 2002 Texas state water plan (Texas Water Development Board, 2002) and 2007 Texas state water plan (Texas Water Development Board, 2006).

The project will develop a reliable water supply from inappropriate flows of Lower Bois d'Arc Creek. The water will be used in Fannin County and in the North Texas Municipal Water District service area in Collin, Dallas, Denton, Kaufman, Rockwall, Hunt and Rains Counties.

1.1 North Texas Municipal Water District Water Supply System

The North Texas Municipal Water District (NTMWD or the District) provides wholesale treated water supply, wastewater treatment, and regional solid waste services to member cities and customers in a service area covering parts of Collin, Dallas, Denton, Fannin, Hunt, Kaufman, Rains, and Rockwall Counties in North Central Texas. Figure 1.2 shows the approximate extent of the wholesale treated water service area for NTMWD as of 2006. Figure 1.3 shows the District's member cities and water supply customers as of September 2006. Over 95 percent of the water supplied by NTMWD is used for municipal purposes.

Table 1.1 shows the sources of water supply currently available to the District and the supply expected to be available from those sources in 2010 and 2060. NTMWD provides potable water to about 1.6 million people, and the population in its service area is growing rapidly. This growing population is driving increased demands for water, projected to reach 799,000 acre-feet per year by 2060 (Freese and Nichols *et al.*, 2006). To meet the projected

needs and provide a reasonable reserve for future growth and unforeseen conditions, the *2006 Region C Water Plan* recommends water management strategies to develop over 750,000 acre-feet per year of additional water supplies for NTMWD from conservation and reuse, the connection of existing sources, and the development of new water supplies (Freese and Nichols *et al.*, 2006). Lower Bois d'Arc Creek Reservoir is one of the strategies recommended for NTMWD in the 2006 *Region C Water Plan*.

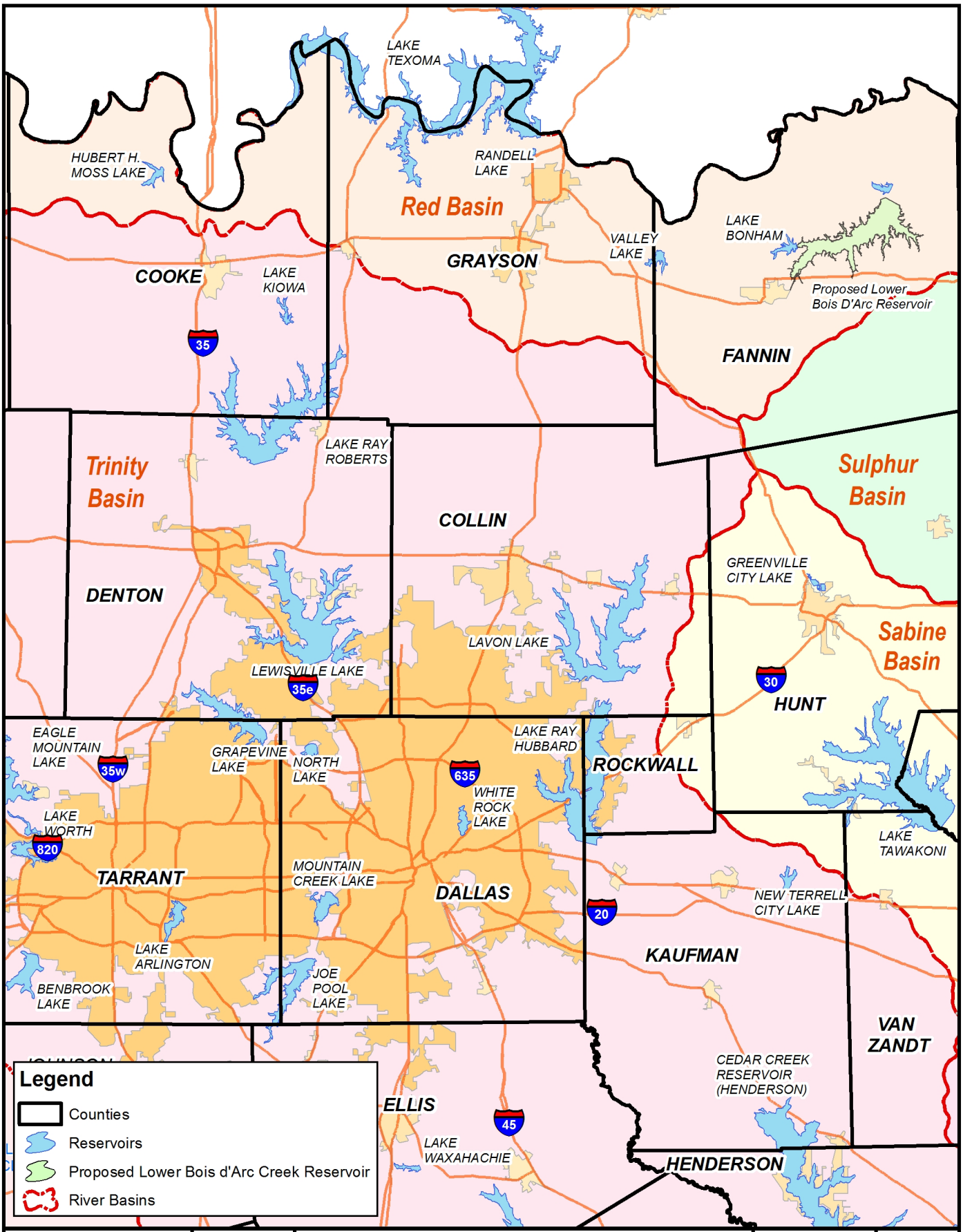
Table 1.1
Supply Available to NTMWD from Existing Sources

Source	Supply Available (Acre-Feet per Year)	
	2010	2060
Lake Lavon	104,000[a.]	104,000[a.]
Lake Texoma	77,000[a.]	77,000[a.]
Lake Chapman	50,000[a.]	46,000[a.]
Wilson Creek Reuse	63,000[b.]	72,000[b.]
Lake Bonham	4,000[a.]	4,000[a.]
Lake Texoma (Interim Purchase from GTUA)	18,000[c.]	0[a.]
Total	316,000	303,000

Notes:
a. Supply is from Table 4E.7 in the *2006 Region C Water Plan* (Freese and Nichols *et al.*, 2006) rounded to the nearest thousand acre-feet.
b. Supply is from Table 4E.7 in the *2006 Region C Water Plan* (Freese and Nichols *et al.*, 2006) rounded to the nearest thousand acre-feet, including Wilson Creek Reuse (permitted) and Wilson Creek Reuse (new).
c. Supply as of 2010 from Interim Purchases from GTUA is based on 16 mgd, which was available in 2006, rounded to the nearest thousand acre-feet.

1.2 Projected Population and Demand for Water

As part of Texas' statewide regional water supply planning effort, regional water planning groups and the Texas Water Development Board developed projections of population and water demands for Texas water suppliers through 2060. Table 1.2 and Figure 1.4 summarize projections of population for North Texas Municipal Water District member cities and customers



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North Texas Municipal Water District
Proposed Lower Bois d'Arc Creek Reservoir

Project Location

FN JOB NO	NTD06128
FILE	GeneralLocationMap.mxd
DATE	August 28, 2006
SCALE	1:830,000
DESIGNED	BME
DRAFTED	BME

1.1
FIGURE

Figure 1.2
Extent of NTMWD Wholesale Treated Water Service Area

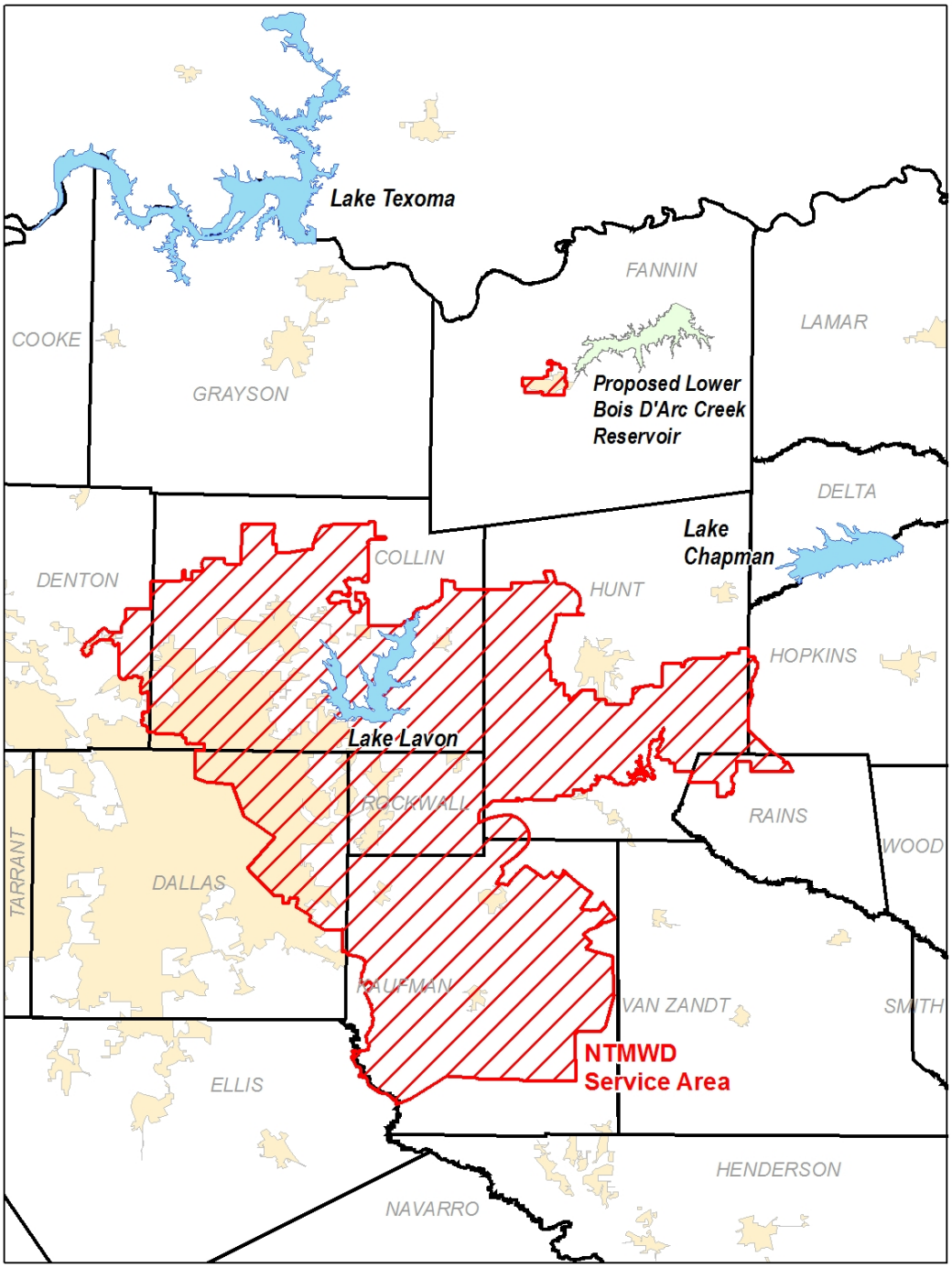
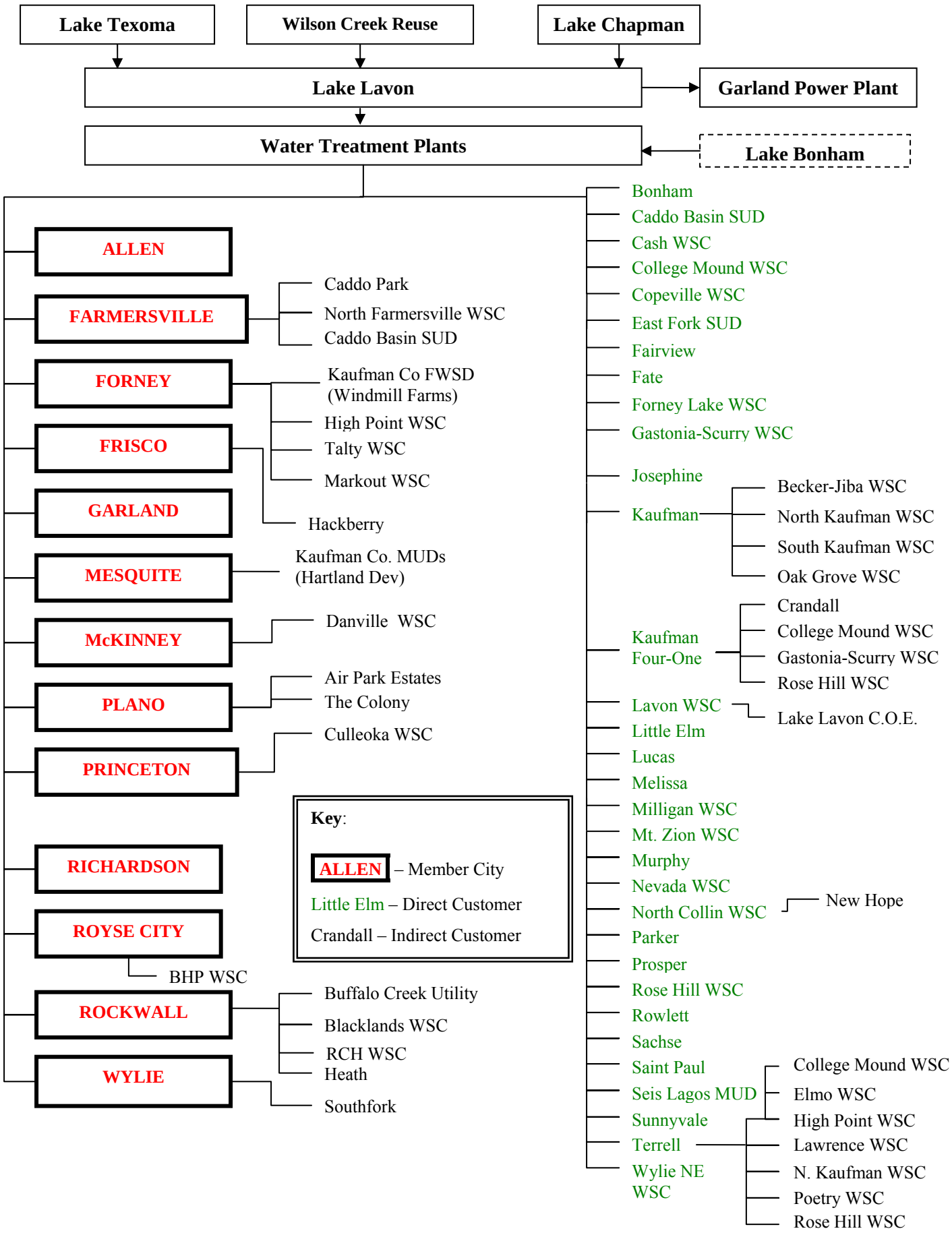


Figure 1.3: NTMWD System Schematic



based on the 2006 regional water plans. Table 1.3 and Figure 1.5 summarize demand projections. Some points to consider in these projections:

- The projections are for dry year water use. In the NTMWD service area, dry year water use is about 15 percent higher than water use in an average year.
- As required in Texas Water Development Board planning regulations, the projected demands include reductions due to conservation from the use of low flow plumbing fixtures.
- The projected demands do not include savings from other conservation measures, including reuse, which are treated as a source of supply. NTMWD's conservation and reuse efforts are discussed in Section 1.3.

Table 1.2
Projected Population Served by NTMWD through 2060

Entity	Projected Population Served by NTMWD by Decade					
	2010	2020	2030	2040	2050	2060
McKinney	93,492	147,235	215,118	292,231	348,508	400,000
Plano	253,608	264,932	275,000	285,000	295,000	305,000
Frisco	137,115	200,000	244,000	269,000	290,000	300,000
Garland	235,020	255,000	272,000	287,000	300,000	300,000
Mesquite	160,002	195,003	225,004	242,006	249,008	250,610
Allen	88,000	101,647	119,646	125,617	128,145	129,215
Richardson	102,880	116,000	116,000	116,000	116,000	116,000
Wylie	35,000	50,000	62,413	86,956	91,543	100,000
Other Member Cities and Current Customers	395,498	584,434	712,728	849,555	1,001,809	1,189,443
Total Member Cities and Current Customers	1,500,615	1,914,251	2,241,909	2,553,365	2,820,013	3,090,268
Potential Customers	15,602	47,342	79,947	125,202	174,620	236,907
Total Current and Potential Customers	1,516,217	1,961,593	2,321,856	2,678,567	2,994,633	3,327,175

Note: Listed in order of projected 2060 population served by NTMWD, with 2060 populations of 100,000 or more listed individually. Projections are from the *2006 Region C Water Plan* (Freese and Nichols *et al*., 2006).

Table 1.4 and Figure 1.6 compare the supplies currently available to the District with the projected demands. In order to meet the projected demands and provide a reasonable reserve for future growth, NTMWD will need to develop over 750,000 acre-feet per year of new supplies between now and 2060. Table 1.5 and Figure 1.7 show the water management strategies recommended in the *2006 Region C Water Plan* to meet the projected demands for NTMWD.

Figure 1.4
Projected Population Served by NTMWD through 2060

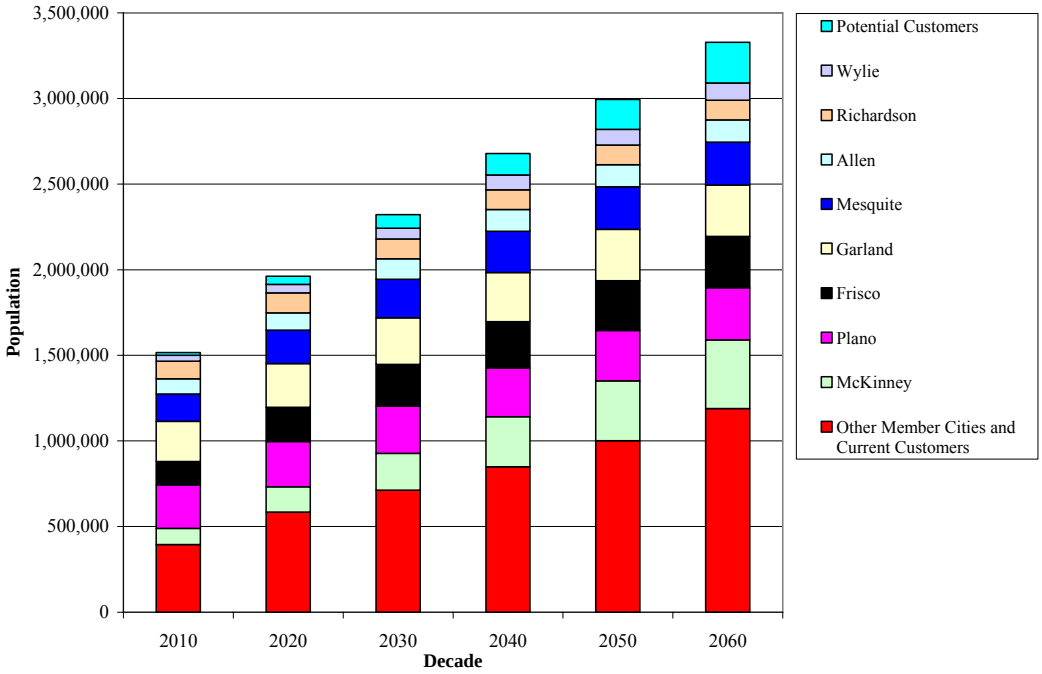


Table 1.3
Projected Water Demands through 2060

Entity	Projected Demands for Water from NTMWD through 2060 (Acre-feet per Year)					
	2010	2020	2030	2040	2050	2060
McKinney	24,715	40,242	58,554	79,216	94,472	108,430
Frisco	45,615	66,088	80,628	88,889	95,829	99,133
Plano	72,439	75,080	77,318	79,810	82,281	85,069
Garland	42,911	45,702	48,139	50,151	52,087	52,087
Mesquite	28,676	34,294	38,814	41,475	42,396	42,670
Allen	23,657	28,806	33,773	35,318	36,029	36,330
Richardson	32,383	36,123	35,993	35,602	35,343	35,343
Rockwall	8,423	14,971	19,167	21,507	22,075	22,075
Wylie	6,862	10,754	13,353	18,506	19,483	21,283
Rowlett	12,283	15,318	17,154	18,668	19,860	20,905
Other Member Cities and Current Customers	67,437	102,673	124,914	150,809	181,496	221,401
Total Member Cities and Current Customers	365,401	470,051	547,807	619,951	681,351	744,726
Potential Customers	5,842	12,887	20,074	30,016	40,749	54,450
Total Current and Potential Customers	371,243	482,938	567,881	649,967	722,100	799,176

Notes:
a. Listed in order of projected 2060 demands for water from NTMWD, with 2060 demands of 20,000 acre-feet per year or more listed individually.
b. Projected 2060 demands are 210 acre-feet per year less than those in the *2006 Region C Water Plan* (Freese and Nichols *et al*., 2006) due to slight differences in projected demands for water from NTMWD in Fannin County.

Figure 1.5
Projected Demands for NTMWD through 2060

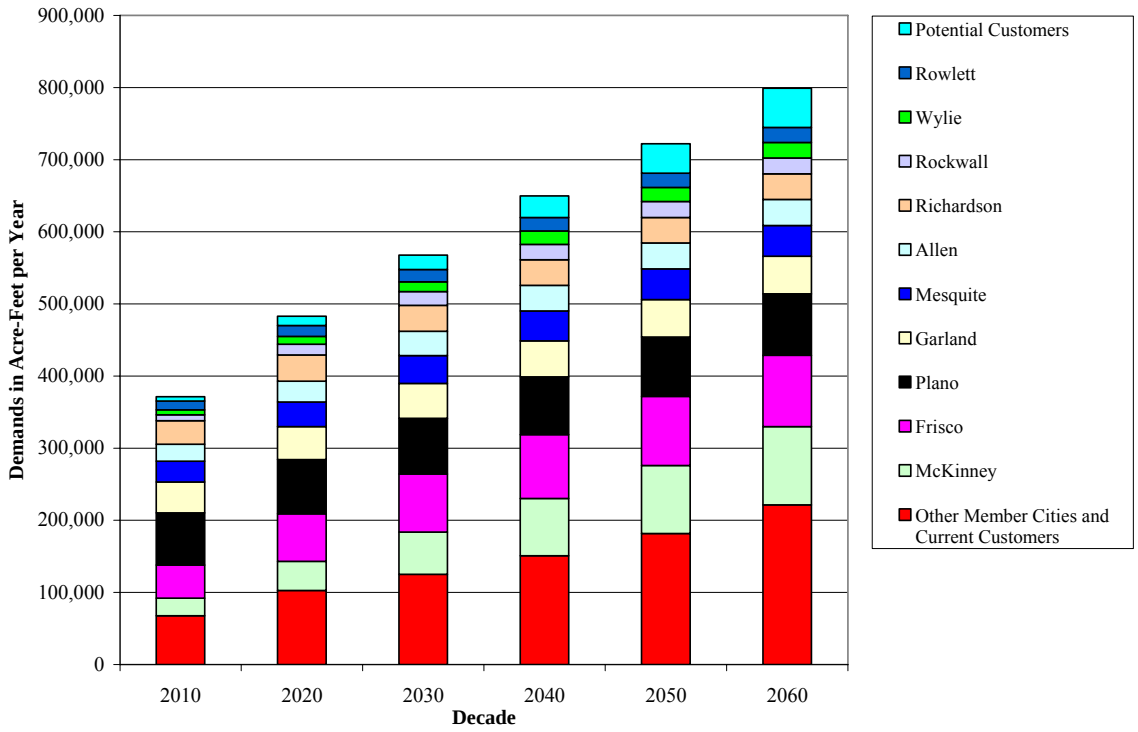


Figure 1.6
Comparison of Current Supply and Projected Demands for NTMWD

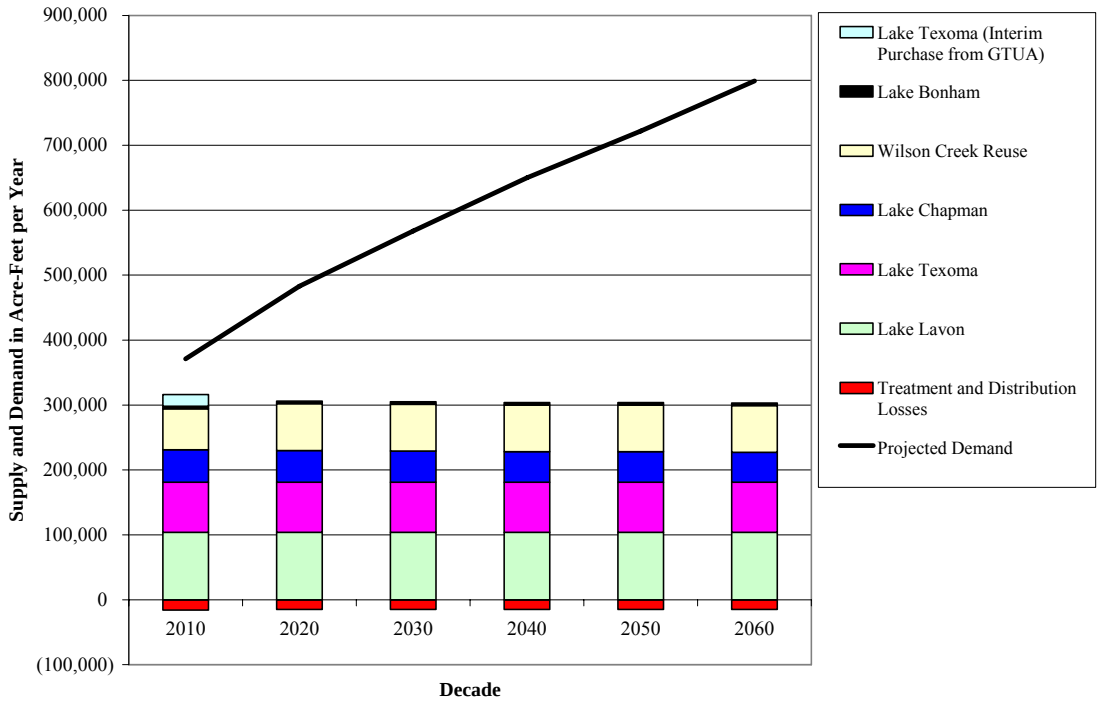


Table 1.4
Comparison of Current Supply and Projected Demands for NTMWD

Water Supplier	Available Supply and Demand (Acre-Feet per Year)					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Lake Lavon[a.]	104,000	104,000	104,000	104,000	104,000	104,000
Lake Texoma[a.]	77,000	77,000	77,000	77,000	77,000	77,000
Lake Chapman[a.]	50,000	49,000	48,000	47,000	47,000	46,000
Wilson Creek Reuse[b.]	63,000	72,000	72,000	72,000	72,000	72,000
Lake Bonham[a.]	4,000	4,000	4,000	4,000	4,000	4,000
Lake Texoma (Interim purchase from GTUA)[c.]	18,000	0	0	0	0	0
Treatment and Distribution losses[d.]	(16,000)	(15,000)	(15,000)	(15,000)	(15,000)	(15,000)
Available Treated Water Supply	**300,000**	**291,000**	**290,000**	**289,000**	**289,000**	**288,000**
Projected Demand[e.]	371,243	482,938	567,881	649,967	722,100	799,176
Shortage (to nearest thousand)	*71,000*	*192,000*	*278,000*	*361,000*	*433,000*	*511,000*

Notes:
a. Supply is from Table 4E.7 in the *2006 Region C Water Plan* (Freese and Nichols *et al*., 2006) rounded to the nearest thousand acre-feet.
b. Supply is from Table 4E.7 in the *2006 Region C Water Plan* (Freese and Nichols *et al*., 2006) rounded to the nearest thousand acre-feet, including Wilson Creek Reuse (permitted) and Wilson Creek Reuse (new).
c. Supply as of 2010 from Interim Purchases from GTUA is based on 16 mgd, which was available in 2006, rounded to the nearest thousand acre-feet.
d. Based on historical records, treatment and distribution losses in the NTMWD system are assumed to be 5 percent of raw water diversions.
e. Projected demands are from Table 1.3.

Table 1.6 lists the member cities, customers, and projected future customers of NTMWD. Most of the customers served by NTMWD are in Region C (Freese and Nichols *et al.*, 2006). The District also serves some customers in Region D (Bucher, Willis and Ratliff *et al.*, 2006). Appendix A includes more detailed breakdowns of projected population and demand by member city and customer.

Table 1.5
***2006 Region C Water Plan* Recommended Water Management Strategies for NTMWD**

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies as Reported in *2006 Region C Water Plan*						
Lake Lavon	*104,000*	*104,000*	*104,000*	*104,000*	*104,000*	*104,000*
Lake Texoma	*77,300*	*77,300*	*77,300*	*77,300*	*77,300*	*77,300*
Lake Chapman	*49,976*	*49,150*	*48,324*	*47,498*	*46,672*	*45,843*
Wilson Creek Reuse (permitted)	*35,941*	*35,941*	*35,941*	*35,941*	*35,941*	*35,941*
Lake Bonham	*3,800*	*3,800*	*3,800*	*3,800*	*3,800*	*3,650*
Treatment and Distribution losses	*(13,163)*	*(13,122)*	*(13,120)*	*(13,770)*	*(12,553)*	*(12,714)*
Total Currently Available Supplies	***257,854***	***257,069***	***256,245***	***254,769***	***255,160***	***254,020***
Water Management Strategies that Have Been Implemented						
Conservation	12,638	33,936	47,866	60,800	72,991	86,114
Interim GTUA Supply	20,000[1]	0	0	0	0	0
Wilson Creek Reuse (new)	26,956	35,941	35,941	35,941	35,941	35,941
Water Management Strategies to Be Implemented						
Interim DWU Supply	11,210	11,210	0	0	0	0
East Fork Reuse	81,400	96,400	102,000	102,000	102,000	102,000
Additional Lake Lavon Yield	11,000	10,000	9,000	8,000	7,000	6,000
Upper Sabine Basin	50,000	30,000	20,000	10,000	10,000	10,000
New Lake Texoma		38,250	57,105	54,105	100,460	112,460
Lower Bois d'Arc Creek Reservoir[2]		126,200	125,450	124,700	123,950	123,200
Marvin Nichols Reservoir			87,420	87,420	174,840	174,840
Toledo Bend Phase 1					100,000	100,000
Oklahoma Water						50,000
Treatment and Distribution losses	(10,028)	(17,400)	(21,846)	(21,108)	(32,710)	(35,722)
Total Supplies from Strategies	**213,204**	**381,937**	**484,782**	**482,966**	**727,182**	**800,555**
Total Supplies (Including Losses)	**461,030**	**621,606**	**719,181**	**716,627**	**949,632**	**1,018,853**

1. The *2006 Region C Water Plan* recommended that up to 20,000 acre-feet per year of water would be provided to NTMWD from GTUA. In 2006, the supply from GTUA is for 16 mgd, which is approximately 18,000 acre-feet per year.

2. The yield of the Lower Bois d'Arc Creek Reservoir was estimated at 123,000 acre-feet per year in the *2006 Region C Water Plan*. The revised yield for this water rights application is 126,200 acre-feet per year.

Figure 1.7
Recommended Water Management Strategies for NTMWD

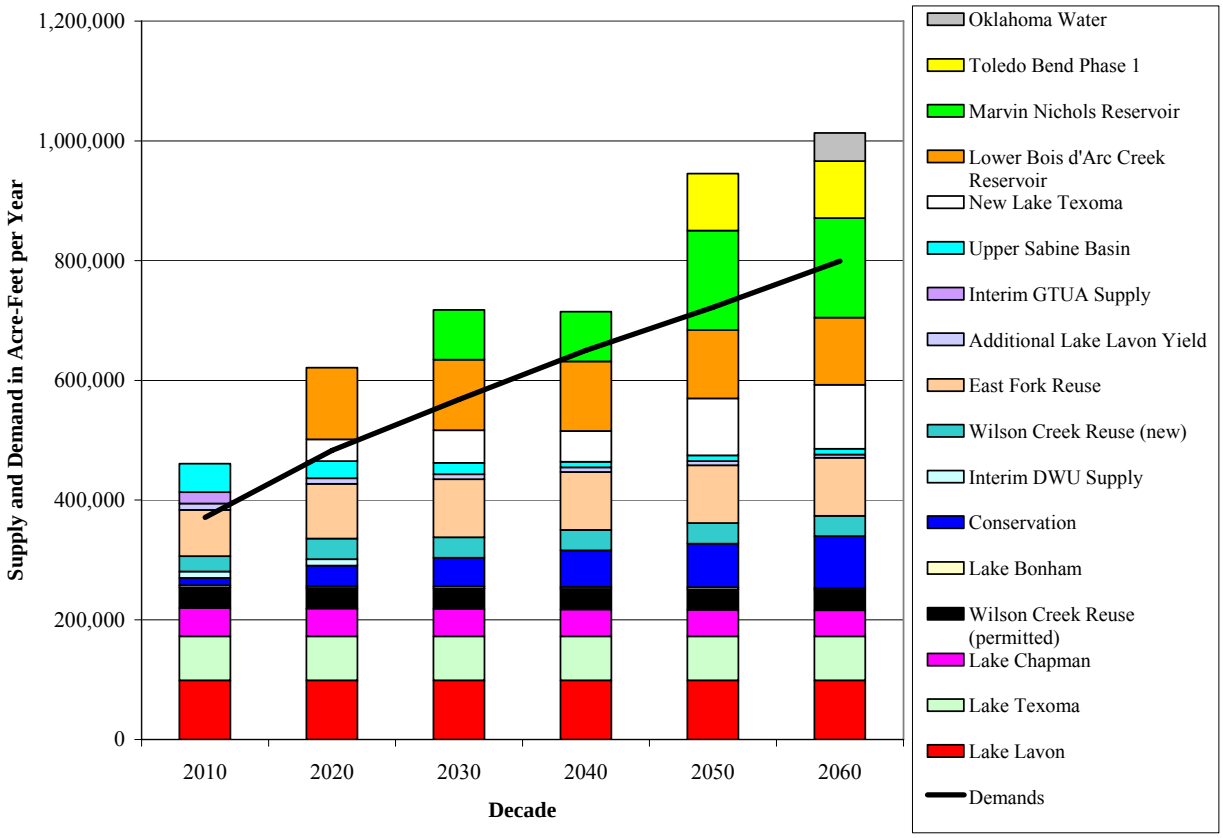


Table 1.6
Current Direct and Potential Customers

Member City	Customer	Potential Future Customers
Allen	Bonham	Anna
Farmersville	Caddo Basin SUD	Blue Ridge
Forney	Cash WSC	Caddo Mills
Frisco	College Mound WSC	Celina
Garland	Copeville WSC	Ector
Mesquite	East Fork SUD	Honey Grove
McKinney	Fairview	Howe
Plano	Fate	Leonard
Princeton	Forney Lake WSC	South Grayson County WSC
Richardson	Gastonia-Scurry WSC	Savoy
Royse City	Josephine	Southwest Fannin County SUD
Rockwall	Kaufman	Trenton
Wylie	Kaufman Four-One	Van Alstyne
	Lavon WSC	
	Little Elm	
	Lucas	
	Melissa	
	Milligan WSC	
	Mt. Zion WSC	
	Murphy	
	Nevada WSC	
	North Collin WSC	
	Parker	
	Prosper	
	Rose Hill WSC	
	Rowlett	
	Sachse	
	Saint Paul	
	Seis Lagos MUD	
	Sunnyvale	
	Terrell	
	Wylie NE WSC	

1.3 North Texas Municipal Water District Water Conservation and Reuse Efforts

The North Texas Municipal Water District supplies water to suburban cities north and east of Dallas. NTMWD's service area has been developing rapidly in recent years, and per capita demand has tended to increase over the years as the area has changed from small towns

and rural areas to suburbs. In recent years, NTMWD has made significant efforts to promote water conservation and efficiency. The District has committed substantial funds in developing water conservation strategies and implementing those strategies as a first response to securing additional water supplies. These efforts include:

- The development of the largest water reuse project currently operating in the state by the reuse of treated wastewater effluent from the Wilson Creek Wastewater Treatment Plant;
- Development of an exemplary water conservation and drought contingency program, including model water conservation and drought contingency plans intended for use by member cities and customers in developing their own plans;
- Implementation of a major drought response campaign in 2006, including the first deployment of the Water IQ program developed by the Texas Water Development Board Water Conservation Implementation Task Force;
- A $4 million investment by NTMWD in a public information campaign on water conservation measures and drought awareness in 2005 and 2006, with a $1.8 million financial commitment to continue the conservation campaign in fiscal year 2007; and
- Implementation of mandatory water-saving measures in response to the on-going drought.

NTMWD is implementing the water management strategies from the *2006 Region C Water Plan*, which recommends the development of significant water supplies for NTMWD from water conservation and reuse. As shown in Table 1.5, over 25 percent of the year 2060 water supply for the District will be from water conservation measures and reuse.

1.3.1 Water Conservation and Drought Contingency Planning

As a wholesale water supplier, NTMWD does not have direct contact with the end users of water. NTMWD focuses its water conservation efforts on the following:

- Conducting its internal operations to treat and deliver water efficiently and to minimize water losses.
- Maximizing water reuse to promote efficient water supplies and minimize environmental impacts.
- Providing public information and educational materials to raise public awareness of water conservation and encourage responsible public behavior.
- Providing technical assistance to member cities and customers, which have direct contact with water users.

- Monitoring drought conditions and implementing drought response measures as appropriate.

In 2004, NTMWD prepared an updated *Water Conservation and Drought Contingency Plan*, which was amended in 2006 (Freese and Nichols 2006a). The plan includes the following elements:

- Specification of Water Conservation Goals.
  - Keep NTMWD "unaccounted for" water below 5 percent.
  - Maintain universal metering of customers.
  - Maintain leak detection and repair program.
  - Continue to utilize wastewater reuse, and seek TCEQ authorization for additional reuse.
  - Continue to recycle wash water from water treatment plants.
  - Continue to implement in-house water conservation efforts.
    - Use native or adapted drought tolerant plants wherever possible.
    - Irrigate at night to avoid waste.
    - Limit irrigation to amount necessary for survival and health of landscape.
    - Irrigate with treated wastewater effluent wherever feasible and reasonable.
  - Raise public awareness of water conservation and encourage responsible public behavior by a public education program.
  - Maintain dry-year per capita municipal use (without credit for indirect reuse) at 197 gallons per capita per day in 2009 and 2014.
- Requirement for Water Conservation Plans by Wholesale Customers.
- Continued System Operation of NTMWD Reservoirs.
- Assistance in Water Conservation for Member Cities and Customers.
  - Hold water conservation workshops for member cities and customers.
  - Develop a model water conservation plan for member cities and customers (Freese and Nichols, 2004).
  - Develop a model drought contingency plan for member cities and customers (Freese and Nichols, 2006b).
  - Assist member cities and customers with industrial wastewater pretreatment programs.

The model water conservation and drought contingency plans for member cities and customers are a major part of NTMWD's water conservation efforts. These model plans are used as guides by member cities and customers in the development of their own plans. The model plans are intended to encourage a regional approach to efficient water use while allowing flexibility to respond to the specific needs and situations of the suppliers.

The model water conservation plan for member cities and customers (Freese and Nichols, 2004) includes the following elements:

- Specification of Water Conservation Goals.
  - Keep per capita municipal water use below specified levels.
  - Keep unaccounted water below 12 percent. (The 12 percent goal is recommended. The goal may be lower or higher, depending on local circumstances.)
  - Implement and maintain universal metering of customers and meter replacement and repair.
  - Decrease waste in lawn irrigation by implementation and enforcement of landscape water management regulations.
  - Raise public awareness of water conservation and encourage responsible public behavior by a public education program.
  - Develop a system-specific strategy to conserve water during peak demands.
- Metering, Water Use Records, Control of Unaccounted Water and Leak Detection and Repair.
  - NTMWD accurately meters water deliveries (±2 percent).
  - Meter all customers, including public and governmental users.
  - Develop and maintain a meter testing and replacement program.
  - Implement a record management system allowing separation of water sales into residential, commercial, public/institutional, and industrial categories.
  - Calculate unaccounted water and keep it below 12 percent.
  - Prepare annual water conservation report to NTMWD.
- Water Rate Structure.
  - Adopt an increasing block rate structure intended to encourage water conservation and discourage excessive use of water within 5 years.
  - Recommend at least 3 tiers for residential use.
    - Base charge per thousand gallons for residential use up to average residential use.

        - 2nd tier 1.25 to 2.0 times the base charge for use up to 2 times the average residential use.
        - 3rd tier 1.25 to 2.0 times the 2nd tier for use above 2 times the average residential use.
    - Recommend at least 2 tiers for commercial use.
- Other Water Conservation Measures.
    - NTMWD reservoir system operation plan.
    - NTMWD reuse and recycling program.
    - (For entities operating own plants) Seek alternatives for reuse of recycled wastewater.
    - State and federal low-flow plumbing laws.
    - Consider landscape water management ordinances.
    - Require water conservation plans for wholesale customers.
    - Coordinate with Regional Water Planning Group and NTMWD.
- Implementation and Enforcement of Water Conservation Plan.

The model drought contingency plan for member cities and customers (Freese and Nichols, 2006b) includes the following elements:

- Provisions to Inform the Public and Opportunities for Public Input.
- Provisions for Continuing Public Education and Information.
- Rules for Initiation and Termination of Drought Response Stages.
- Designation of Stages:
    - Stage 1 – Mild.
        - Goal – raise public awareness.
        - No designated reduction in use.
        - Voluntary measures.
    - Stage 2 – Moderate.
        - Goal – 2 percent reduction in use.
        - Halt non-essential city use.
        - Voluntary measures.
    - Stage 3 – Severe.
        - Goal – 5 percent reduction in use.

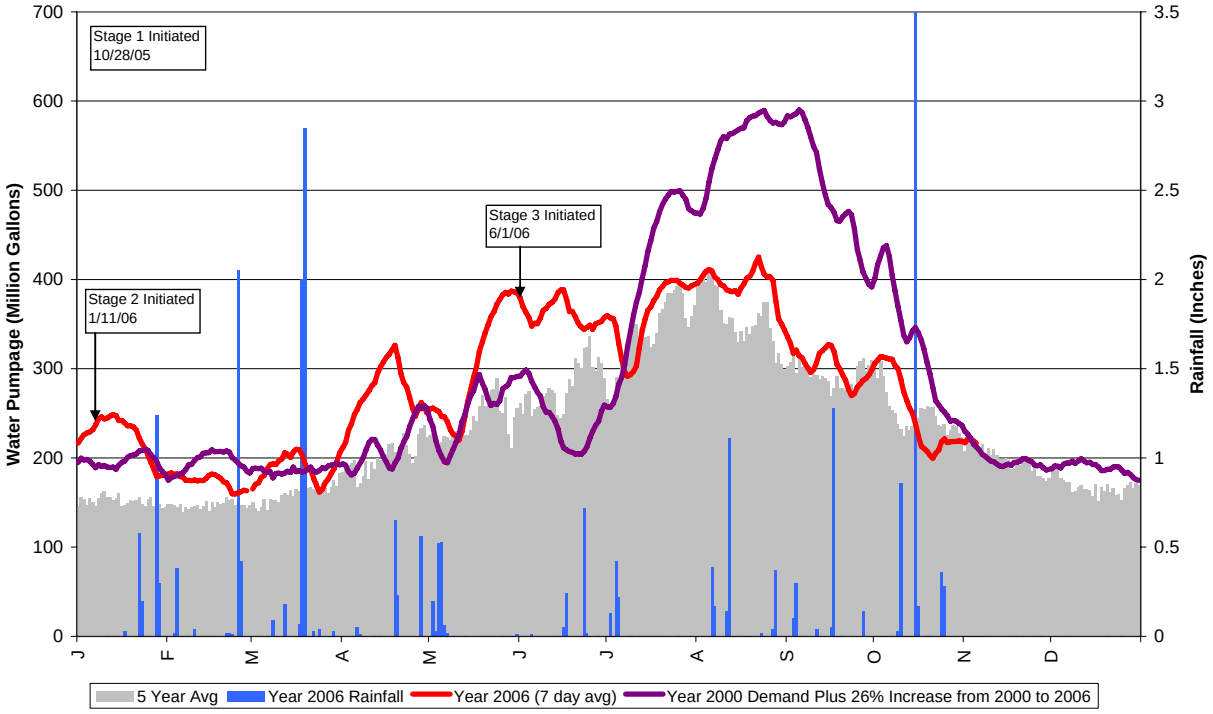
        - Can set goal for greater reduction.
        - Allows for mandatory water use restrictions, including:
            - No sprinkling between 10:00 a.m. and 6:00 p.m.
            - Landscape watering limited to 1 day per week.
            - Rate surcharges.
            - Impose use reductions as mandated by NTMWD.
            - Golf course water prohibition (except tee boxes and greens).
    - Stage 4 – Emergency.
        - Goal – 10 percent reduction in use.
        - Can set goal for greater reduction.
        - Allows for mandatory water use restrictions, including:
            - All Stage 3 measures.
            - Prohibit new landscaping.
            - Prohibit landscape watering (expect foundations and trees).
- Procedures for Variances.
- Enforcement Procedures.
- Coordination with Regional Water Planning Group and NTMWD.
- Review and Update of the Plan Every 5 Years.

<u>Response to Drought Conditions in 2005 and 2006</u>

In the fall and winter of 2005, the NTMWD service area entered a drought, which has so far continued through October 2006. The extremely dry conditions in the fall and winter of 2005-2006 led to record water use for those months. In response to this drought and to lower water levels in Lake Lavon and Lake Chapman, the NTMWD and its member cities and customers have implemented drought response measures. As of June 1, 2006, NTMWD declared a Stage 3 drought condition. Figure 1.8 shows tracking of NTMWD's water use in 2005-2006, compared to average use over the last 5 years and to the actual use in 1999 and 2000 that was adjusted for population increases.

Figure 1.8 shows that the drought response measures have been very effective in maintaining the five-year average water use despite extreme drought conditions and significant increases in population served.

Figure 1.8
NTMWD Water Use in 2000 vs. 2006
Daily Water Consumption



1.3.2 Long-Term Water Conservation and Efficiency Efforts

In November of 2004, the Texas Water Conservation Implementation Task Force completed a study of water conservation in Texas and produced two documents, a *Report to the 79th Legislature* and a *Water Conservation Best Management Practices Guide* (Water Conservation Implementation Task Force, 2004a and 2004b). The report to the legislature set out a series of recommendations to the Texas Legislature, and the best management practices guide listed a series of best management practices (BMP) for water conservation that should be considered by water suppliers. NTMWD's water conservation efforts meet the standards set forth in these two reports.

The *Report to the 79th Legislature* includes recommendations for the setting of water conservation standards and goals, including the following:

- Develop specific goals for per capita water use and for water loss programs using appropriate water conservation best management practices or other water conservation techniques.
- Include five-year and ten-year per capita water use goals in municipal water conservation plans.
- Reestablish targets and goals every five years (at a minimum).
- Consider including a minimum reduction of 1 percent in total gpcd, based on a five-year rolling average, until a total gpcd of 140 or less is reached (after credits for reuse).
- Consider inclusion of the water conservation component included in the regional water plan in which the entity is located.
- Seek to achieve a statewide water demand to an average of 140 gpcd through average annual reductions of 1 percent per year (after credits for reuse).
- Work to achieve an overall statewide indoor water use of 50 gpcd through education, research, and funding programs.

The NTMWD established the year 2009 and 2014 water conservation targets for per capita water use to be 197 gpcd or less (before credit for reuse). The model plan developed for the member and customer cities calls for each city to provide five-year and ten-year goals appropriate to the city's unique circumstances.

The *Water Conservation Best Management Practices Guide* includes information regarding best management practices (BMPs) for municipal water conservation. The list is shown in the first column of Table 1.7. The guide indicates that water suppliers should consider each BMP and adopt those that are cost-effective and useful.

Table 1.7
Summary of Best Management Practices for Water Conservation

BMP	Included in NTMWD and/or Model Plans?	Reason for BMP Being Excluded
System water audit and water loss	Both (includes metering, leak detection, and repair)	
Water conservation pricing	Both	
Prohibition on wasting water	Both	
Showerhead, aerator, and toilet flap retrofit	No	Already required by state and will occur over time.
Residential toilet replacement program	No	Already required by state and will occur over time.
Residential clothes washer incentive program	No	Already required by state and will occur over time.
School education	Both	
Water survey for single-family and multi-family customers	No	Not cost-effective
Landscape irrigation conservation and incentives	No	Not cost effective
Water wise landscape design and conservation programs	Both	
Athletic field conservation	No	Left to individual cities
Golf course conservation	No	Left to individual cities
Metering all new connections and retrofit of existing connections	Both	
Wholesale agency assistance programs	NTMWD	
Conservation coordinator	NTMWD and some cities have	
Water reuse	Both	
Public information	Both	
Rainwater harvesting and condensate reuse	No	Limited public participation and high cost
New construction graywater	No	Limited public participation and high cost
Park conservation	No	Left to individual cities
Conservation programs for industrial, commercial, and institutional accounts	No	95 percent of use is for municipal purposes. Left to individual cities.

The NTMWD also included water conservation strategies that are not mentioned above but are part of the water saving program. These strategies include:

- **Water conservation workshops.** In 2003, the NTMWD began holding water conservation workshops with its member cities on a regular basis. These workshops have provided a venue for open communication regarding water conservation and drought planning. The NTMWD continues to meet with the member cities on a regular basis.
- **Model plans for member and customer cities.** In order to assist its member cities and customers in the development of their own water conservation and drought contingency plans, the NTMWD developed a *Model Water Conservation Plan for NTMWD Member Cities and Customers* and a *Model Drought Contingency Plan for NTMWD Member Cities and Customers*. These plans were developed in cooperation with the member cities in 2004, and the drought plan was updated in 2006.
- **Industrial pre-treatment program.** As part of its wastewater system, NTMWD has developed industrial pretreatment programs for the cities of Allen, Forney, Frisco, McKinney, Mesquite, Murphy, Plano, Richardson, Rockwall, Terrell, and Wylie. The pretreatment programs reduce the allowable volumes of specific pollutants and encourage pretreatment of industrial wastes, which has improved the water quality in the region's streams and lakes.
- **Annual reports.** The NTMWD member cities and customers are required, as part of the model plan, to submit an annual water conservation report to the District. This information is used to review the effectiveness of the water conservation program.
- **In-house water conservation efforts.** The NTMWD has an in-house water conservation program, including drought-tolerant landscaping, specified off-peak irrigation times, limited irrigation, and irrigation with treated wastewater effluent where feasible.

All of the Task Force's recommended BMPs were considered for NTMWD. The reasons that some were not included in the NTMWD or model water conservation plans are explained in more detail below.

- **Showerhead, aerator, and toilet flap retrofit.** As a result of the 1991 Water Saving Performance Standards for Plumbing Act, low-flow plumbing fixtures are now required in new construction and remodeling projects. A showerhead and faucet aerator retrofit program would target single-family and multi-family homes that have not been retrofitted with water-efficient plumbing fixtures and would accelerate the natural replacement of inefficient plumbing fixtures. Much of the housing within the NTMWD service-area has been constructed since this code was established. All inefficient fixtures will eventually be replaced without a retrofit program. This rebate program would accelerate the natural replacement of inefficient plumbing fixtures, but does not provide additional long-term water savings.

- **Residential toilet replacement program.** As a result of the 1991 water saving Performance Standards for Plumbing Act, water efficient toilets are now required in all new construction and toilet replacements. A water-efficient toilet rebate program would offer rebates or incentives for replacement of toilets in single- and multi-family homes that have not been retrofitted with water-efficient toilets and would accelerate the natural replacement of inefficient toilets. Much of the housing within the NTMWD service-area has been constructed since the 1991 code was established. All inefficient toilets will eventually be replaced without a rebate program. This rebate program would accelerate the natural replacement of inefficient toilets, but does not provide additional long-term water savings.
- **Residential clothes washer incentive program.** Federal residential clothes washer energy standards that take effect in 2007 will require all new clothes washers to be energy efficient, and potentially provide significant water savings. Over time, existing washers will be replaced with more efficient ones. For washers, the replacement life is estimated at 13 years, indicating that most washers would be replaced naturally by 2020. A single-family water-efficient clothes washer rebate program would offer rebates or incentives for replacement of clothes washers in single-family homes that have not been retrofitted with water-efficient clothes washers. This rebate program would accelerate the natural replacement of inefficient clothes washers, but does not provide additional long-term water savings.
- **Water survey for single-family and multi-family customers.** The water survey involves the water utility to conduct surveys of single-family and multi-family customers to provide information regarding methods to reduce indoor and outdoor water use. The model water conservation plan includes a sample irrigation ordinance for cities to incorporate as appropriate, but the provision of water surveys is left to individual cities.
- **Landscape irrigation conservation and incentives.** A landscape irrigation system rebate program is targeted toward residential and Institutional/Commercial/Industrial customers that use automatic irrigation systems. Irrigation system equipment that could qualify for a rebate might include: irrigation controllers that allow programmed amounts for use with evapotranspiration-based water budgets, low-precipitation-rate sprinkler heads, drip irrigation equipment, pressure regulators, soil moisture sensors, rain sensors, and freeze sensors. The unit costs for irrigation rebate are estimated at $8.71 to $11.78 per 1,000 gallons of water saved. These rebates are costly for the amount of water saved and customers likely to install such a system would do so without the rebate incentive.
- **Athletic field conservation.** Athletic field conservation allows the athletic field manager to implement a watering regimen that uses only the amount of water necessary to maintain the viability of the turn and maintain the turf adequately to maintain the health of users by watering only the areas that are essential to the use of the field. This BMP is so specific that it must be analyzed on a case-by-case basis within each city.

- **Golf course conservation.** Golf course conservation is intended to have each golf course develop a water conservation plan. This BMP is so specific that it must be analyzed on a case-by-case basis within each city.
- **Rainwater harvesting and condensate reuse (RWH/CR).** This BMP provides customers with support, education, incentives, and assistance in proper installation and use of RWH/CR systems. These systems collect rainwater from rooftops and store it in cisterns or surface impoundments for irrigation use at a later time. These systems are costly and are not expected to be widely implemented within the NTMWD customer service area.
- **New construction graywater.** Graywater includes wastewater from clothes washers, showers, bathtubs, handwashing lavatories, and sinks (not used for disposal of hazardous or toxic solutions). New construction graywater is the installation of dual piping in new home construction that allows water from such sources to be collected and distributed throughout the development for irrigation purposes. These systems are costly and are not expected to be widely implemented within the NTMWD customer service area.
- **Park conservation.** This BMP includes a water conservation plan for each park facility within a city. Maintenance and operation of facilities are addressed, including city pools. At this time, there is insufficient data available to determine the amount of water that can be saved by this measure in the NTMWD service area. Implementation is left to individual cities.
- **Conservation programs for industrial, commercial, and institutional accounts.** This BMP includes identification of Institutional/Commercial/Industrial customers and focuses on those with high water use. The industry-specific process is analyzed to determine potential water saving measures. 95 percent of the water provided by NTMWD is used for municipal purposes. Implementation of this BMP is left to individual cities.

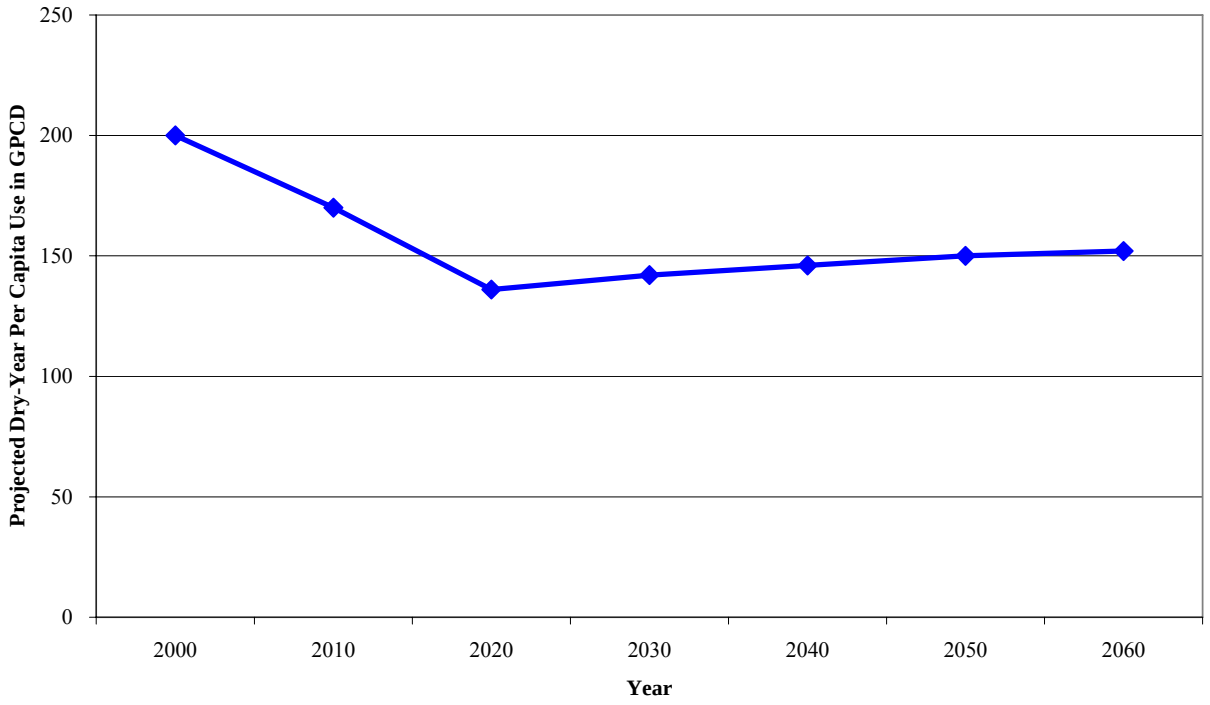
Table 1.8 and Figure 1.9 show the projected per capita water use for NTMWD after credit for conservation and reuse. By 2020, the projected per capita use meets the Conservation Implementation Task Force goal of 140 gpcd after credit for reuse. In a normal rainfall year, with the water demands about 15 percent less than those in a dry year, the per capita use after credit for reuse is projected to remain below the 140 gpcd through 2060.

Table 1.8
Projected Dry-Year Per Capita Water Use for NTMWD

	Year						
	2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Projected Total Demand (Acre-Feet)[b.]	251,495	371,243	482,938	567,881	649,967	722,100	799,176
Projected Potable Demand (Acre-Feet)[b.]	251,495	367,809	478,665	562,501	643,057	714,031	789,913
Projected Potable Treatment and Distribution Losses (Acre-Feet)[c]	12,575	18,390	23,933	28,125	32,153	35,702	39,496
Projected Total Potable Demand (Acre-Feet)	264,070	386,199	502,598	590,626	675,210	749,733	829,409
Supply from Conservation (Acre-Feet)[d.]	N/A	12,638	33,936	47,866	60,800	72,991	86,114
Supply from Reuse (Acre-Feet)[d.]	32,737	144,297	168,282	173,882	173,882	173,882	173,882
Assumed Use from Reuse (Acre-Feet)	32,737	84,297	168,282	173,882	173,882	173,882	173,882
Other Potable Supply Needed (Acre-Feet)	231,333	289,264	300,380	368,878	440,528	502,860	569,413
Projected Population Served[e.]	1,028,985	1,516,217	1,961,593	2,321,856	2,678,567	2,994,633	3,327,175
Projected Per Capita Use After Credit for Conservation and Reuse (gpcd)	200	170	136	142	146	150	152

Notes:
a. Demand and potable demand for 2000 are from the Region C Water Plan.
b. Demand and potable demand for other years are from Table A-1 in Appendix A.
c. Treatment and distribution losses are estimated at 5 percent of the potable demand.
d. Supply from conservation and reuse are from Table 1.5. Full use of these inexpensive supplies is assumed after 2010.
e. Projected population served is from Table A-2 in Appendix A.

Figure 1.9
Projected Dry Year Per Capita Demands with Conservation and Reuse



References for Chapter 1

Bucher, Willis and Ratliff *et al.* 2006. *North East Texas Regional Water Plan.* Prepared for North East Texas Water Planning Group.

Freese and Nichols, Inc. 1984. *Report on New Bonham Reservoir*. Prepared for the North Texas Municipal Water District and Red River Authority of Texas.

Freese and Nichols, Inc. 1996. *Preliminary Studies of Additional Water Supply*. Prepared for the North Texas Municipal Water District.

Freese and Nichols, Inc. 2004. *Model Water Conservation Plan For North Texas Municipal Water District Member Cities And Customers.* Prepared for the North Texas Municipal Water District.

Freese and Nichols, Inc., Alan Plummer Associates, Inc., Chiang, Patel, and Yerby, Inc., and Cooksey Communications, Inc. 2001. *Region C Water Plan*. Prepared for Region C Water Planning Group.

Freese and Nichols, Inc., Alan Plummer Associates, Inc., Chiang, Patel, and Yerby, Inc., and Cooksey Communications, Inc. 2006. *2006 Region C Water Plan*. Prepared for Region C Water Planning Group.

Freese and Nichols, Inc. 2006(a). *Water Conservation and Drought Contingency Plan,* prepared for the North Texas Municipal Water District.

Freese and Nichols, Inc. 2006(b). *Model Drought Contingency Plan For North Texas Municipal Water District Member Cities And Customers.* Prepared for the North Texas Municipal Water District.

Red River Compact Commission (Arkansas, Louisiana, Oklahoma, and Texas). 1979. *Red River Compact with Supplemental Interpretive Comments of Legal Advisory Committee*.

Texas Water Development Board. 2002. *Water for Texas - 2002*.

Texas Water Development Board. 2006. *Water for Texas – 2007*.

Water Conservation Implementation Task Force. 2004(a). *Report to the 79th Legislature.* Texas Water Development Board, Special Report.

Water Conservation Implementation Task Force. 2004(b). *Water Conservation Best Management Practices Guide.* Texas Water Development Board Report 362.

2. DESCRIPTION OF THE PROJECT

2.1 Overall Project Description

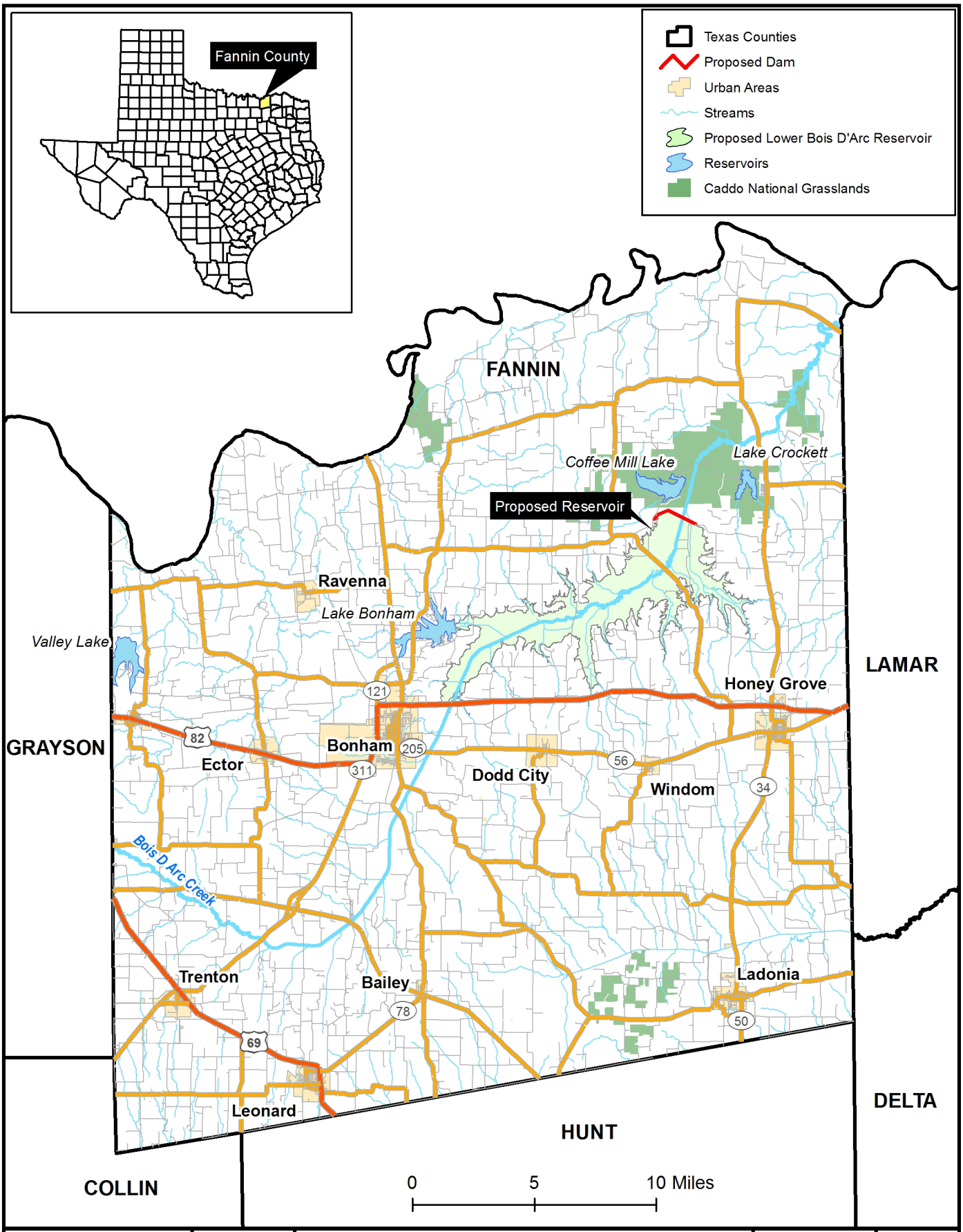
The proposed Lower Bois d'Arc Creek Reservoir Dam would be located in Fannin County in the Red River Basin, approximately 15 miles northeast of the City of Bonham. Figure 2.1 is a location map of the proposed reservoir. The reservoir is located upstream of the Bois d'Arc Unit of the Caddo National Grasslands.

The drainage area of the proposed reservoir is approximately 327 square miles, of which 29.6 square miles are above Lake Bonham. At its full conservation elevation of 534 feet, the reservoir is expected to cover 16,526 acres, store 367,609 acre-feet of water and be approximately 70 feet deep at its deepest point.

There are several previous studies of proposed reservoirs in the Bois d'Arc Creek watershed, including studies by the Corps of Engineers (U.S. Army Corps of Engineers, 1968 and 2000), studies by the Red River Compact Commission (Engineering Advisory Committee, 1970), and by Freese and Nichols, Inc. for the North Texas Municipal Water District (Freese and Nichols, Inc., 1984 and 1996). Some of these studies refer to the proposed project as the New Bonham Reservoir.

The project is a recommended strategy for the North Texas Municipal Water District (NTMWD) in both the 2001 and 2006 Region C water plans (Freese and Nichols, Inc., 2001 and 2006), the 2002 state water plan (Texas Water Development Board, 2002), and the 2007 state water plan (Texas Water Development Board, 2006). The project will be used as municipal water supply for customers of NTMWD in North Central Texas and Fannin County. Most of the water used by NTMWD is expected to be transported via pipeline to a treatment plant located near the City of Princeton in Collin County, or delivered by the bed and banks of Pilot Grove Creek and Lake Lavon to existing NTMWD diversion points.

The reservoir is expected to add a significant recreational resource in the area, providing opportunities for boating, fishing and other water sports. Because of its location near the Dallas-Fort Worth Metroplex, the reservoir, in conjunction with the adjacent Caddo Grasslands and the associated Wildlife Management Area, should make Fannin County a more attractive area for outdoor recreation, enhancing the local economy.



Freese and Nichols
4055 International Plaza, Suite 200
Fort Worth, TX 76109 - 4895
Phone - (817) 735 - 7300

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North Texas Municipal Water District
Proposed Lower Bois d'Arc Creek Reservoir

Location Map for Lower Bois D'Arc Creek Reservoir Site

FN JOB NO	NTD06128
FILE	Figure 21(General Location).mxd
DATE	September 7, 2006
SCALE	1:345,000
DESIGNED	BME
DRAFTED	BME

2.1
FIGURE

2.2 Dam and Reservoir

Lower Bois d'Arc Creek Reservoir Dam will be constructed as a zoned earthen embankment, as shown on sheets 3, 4, and 5 of the application drawings in Appendix B. The dam will be about 10,400 feet in length and will have a maximum height of about 90 feet. The design top elevation of the embankment will be 553.0 msl, with varying amounts of overbuilding to allow for settlement after construction. A flex base roadway will be provided on top of the embankment. The embankment will provide 19 feet of freeboard above the conservation pool of Lower Bois d'Arc Creek Reservoir, at elevation 534.0 msl, and 3.2 feet of freeboard above the Probable Maximum Flood (PMF) elevation of 549.8 msl. The upstream and downstream side slopes will be 3.5 horizontal to one vertical. All fill for the embankment is expected to come from required excavations of the spillways and from the reservoir area. Twenty-four inches of soil cement will be placed on the upstream slope and a grass cover will be placed on the downstream slope. Appendix C contains a copy of *Preliminary Geotechnical Feasibility Study, Lower Bois d'Arc Creek Reservoir Surface Water Supply Project, Fannin County, Texas.*

In accordance with the criteria set forth in Section 299 of the Texas Water Code, Section 299.12 (Size Classification) and Section 299.13 (Hazard Classification Criteria), the proposed Lower Bois d'Arc Creek Reservoir Dam would be classified as a large, high-hazard dam. Section 299.14 of the Water Code indicates that the appropriate design storm for the dam is the Probable Maximum Flood (PMF). Appendix D describes the design storm analysis for the project, and the design storm analysis is summarized on sheet 7 of Appendix B. The peak reservoir elevation during the PMF is 549.8 msl, 3.2 feet below the top of the dam. The recently completed *Hydrologic and Hydraulic Guidelines for Dams in Texas* from TCEQ was used to estimate the design flood. Appendix D also includes an analysis of wave action at various flood levels, which indicates that the proposed top-of-dam elevation of 553.0 msl provides adequate freeboard.

2.3 Service Spillway and Outlet Works

The service spillway will be located near the right (east) abutment of the dam. The spillway will consist of an approach channel; a 150-foot uncontrolled concrete weir, chute, hydraulic jump stilling basin and outlet channel. The weir will consist of a concrete gravity, ogee-type section with a crest length of 150 feet. The crest of the weir will be at elevation 534.0

msl and the weir will have a discharge capacity of about 37,300 cfs at the maximum design water surface, elevation 549.8 msl. The spillway structure will extend 958 feet downstream from the centerline of the dam to the downstream edge of the end sill. A hydraulic jump stilling basin, with baffle blocks and an end sill, will be provided. The stilling basin will be at elevation 456.0 msl and it will be 128 feet long. Spillway discharges will be conveyed to Bois d'Arc Creek by a discharge channel approximately 2,300 feet long with a 150-foot bottom width.

Required low-flow releases will be made through a 36-inch diameter low-flow outlet located on the right (east) side of the floodplain near the toe of the right abutment. This outlet will have a discharge capacity of about 190 cfs when the reservoir is at elevation 534.0 msl. The conduit will extend through the dam and will have an impact basin as an energy dissipation structure. Its exit channel will extend to the service spillway exit channel and then back to Lower Bois d'Arc Creek. The outlet will include a multiple-level intake tower in the reservoir to allow for required downstream releases.

An emergency spillway will be located in the right abutment of the dam. The spillway is designed as a 1400-foot wide uncontrolled broad crested structure with the crest elevation at 541 feet msl. This elevation was selected to contain the 100-year storm such that no flow passes through the emergency spillway during this event.

2.4 Raw Water Transmission Facilities

Raw water from the reservoir will be transported to the main NTMWD service area by a pipeline to a proposed water treatment plant near the City of Princeton in Collin County. To allow the District the ability to treat water from Lower Bois d'Arc Creek Reservoir at its existing facilities in Wylie, Texas, the pipeline will include a discharge outlet to Pilot Grove Creek to deliver raw water to Lake Lavon. The outlet structure will be located approximately 3 to 7 miles upstream of Lake Lavon in the reach of Pilot Grove Creek between F.M. 545 and F.M. 2756. The raw water would be transported via the bed and banks of Pilot Grove Creek and Lake Lavon to the District's existing intake structures on Lake Lavon.

The primary pipeline consists of approximately 47 miles of 96-inch pipe, a pump station and intake structure at the reservoir, and a 460 million gallon terminal storage reservoir located near the water treatment plant. The pipeline will have a capacity of 236 mgd. The discharge

outlet will include a small segment of 72-inch pipeline, an outlet structure at the creek and appropriate controls. The maximum daily discharge to Pilot Grove Creek will be 236 mgd.

In addition to the primary NTMWD transmission system, some portion of the water will likely be used locally in Fannin County. The *2006 Region C Water Plan* estimates that by 2060 as much as 8,600 acre-feet of water could be provided from the proposed reservoir to Fannin County. The proposed Fannin County Water Supply Project would require construction of additional transmission, treatment and distribution facilities in Fannin County. Supplies from the proposed Lower Bois d'Arc Creek Reservoir are dependent on local entities entering contracts with NTMWD.

2.5 Proposed Project Operation

NTMWD currently has multiple sources of water, including Lake Lavon, Lake Texoma, Lake Chapman and reuse. In the future, NTMWD plans to add other sources of water in addition to the Lower Bois d'Arc Creek Reservoir, some of which may be located farther away from the NTMWD service area. During relatively wet times, NTMWD would rely primarily on water supply sources close to its service area, while during drier periods NTMWD would take water from more expensive sources farther away from its service area. As such, NTMWD proposes to optimize its water supplies by operating the Lower Bois d'Arc Creek Reservoir as part of its overall system, taking water in excess of the estimated firm yield of the reservoir at times and cutting back to less than the firm yield of the reservoir during other times. Initially, the reservoir will be more expensive to use relative to other NTMWD sources. Therefore, the reservoir could be underdrafted during relatively wet periods, saving additional supplies for relatively dry periods. However, because of its proximity to the NTMWD service area relative to other future sources of water supplies, Lower Bois d'Arc Creek Reservoir will eventually be one of NTMWD's closer and thus more economical sources of water. Therefore, NTMWD would optimize its system by overdrafting Lower Bois d'Arc Creek Reservoir during relatively wet times, relying on other projects that are farther away during drier periods.

The proposed transmission system will permit NTMWD to supply raw water directly to a new water treatment facility via the primary transmission line. The discharge structure at Pilot Grove Creek will allow water from Lower Bois d'Arc Creek Reservoir to be transported through Lake Lavon and used at the existing NMTWD water treatment plant in Wylie or other facilities.

2.6 Estimated Project Costs

Table 2.1 shows the estimated capital costs for the Lower Bois d'Arc Creek Reservoir Project, including construction costs, engineering, permitting and mitigation. The total estimated cost of the project is $533 million (December 2006 prices). Assuming a yield of 126,200 acre-feet per year, raw water from the project will cost approximately $409 per acre-foot ($1.26 per 1,000 gallons) before amortization. After amortization, the cost of raw water from the project drops to $65 per acre-foot ($0.20 per 1,000 gallons). Detailed cost estimates may be found in Appendix E.

Table 2.1
Estimate of Probable Costs for the Lower Bois d'Arc Creek Reservoir Project
- Costs Based on December 2006 Prices -

Item	Estimated Cost
Land Cost	$86,893,700
Dam & Reservoir	$70,113,800
Conflicts	$23,924,600
Pipelines & Outlet Structure	$202,009,000
Pump Stations	$34,467,000
Terminal Storage Reservoir	$19,416,600
Permitting and Mitigation	$95,807,700
Total Cost	***$532,632,400***

Construction costs include cost of clearing and grubbing of the reservoir site, construction of the dam and outlet structures, intakes, pipelines and pump stations, right-of-way for transmission facilities, a terminal storage reservoir, and an outlet structure on Pilot Grove Creek for transmission through Lake Lavon. Engineering and contingencies are estimated at 30 percent of construction cost for the reservoir and pipeline and 35 percent for pump stations and conflict resolution. Land cost is estimated at an overall average $3,000 per acre for purchase and $2,000 per acre for easements. Permitting and mitigation costs are estimated at nearly $96 million. These costs are higher than previous estimates due in part to the increases in land and materials costs, slightly longer transmission to a new water treatment plant near Princeton, and additional information obtained as part of this study.

Annual costs for the project assume repayment of the debt service at 6 percent interest over 30 years, and electric costs at $0.08 per kWh. Operation and maintenance costs are assumed to be 1.5 percent of construction costs for the dam, 2.5 percent of construction costs for pump stations, and 1 percent of construction costs for pipelines.

References for Chapter 2

U.S. Army Corps of Engineers. 1968. *Comprehensive Basin Study. Red River Below Denison Dam.*

U.S. Army Corps of Engineers. 2000. *Bois d'Arc Creek Local Protection Study.*

Freese and Nichols, Inc. 1984. *Report on New Bonham Reservoir,* prepared for the North Texas Municipal Water District and the Red River Authority of Texas.

Freese and Nichols, Inc. 1996. *Preliminary Study of Additional Sources of Water Supply*, prepared for the North Texas Municipal Water District.

Freese and Nichols, Inc. et al. 2001. *Region C Water Plan*, prepared for the Region C Water Planning Group.

Freese and Nichols, Inc. et al. 2006. *2006 Region C Water Plan*, prepared for the Region C Water Planning Group.

Engineering Advisory Committee. 1970. *Report of the Engineering Advisory Committee to the Red River Compact Commission*, Reach II.

Texas Commission on Environmental Water Quality. 2006. *Hydrologic and Hydraulic Guidelines for Dams in Texas*, August 28, 2006.

Texas Water Development Board. 2002. *Water for Texas – 2002*.

Texas Water Development Board. 2006. *Water for Texas – 2007*.

3. ALTERNATIVES TO THE PROPOSED PROJECT

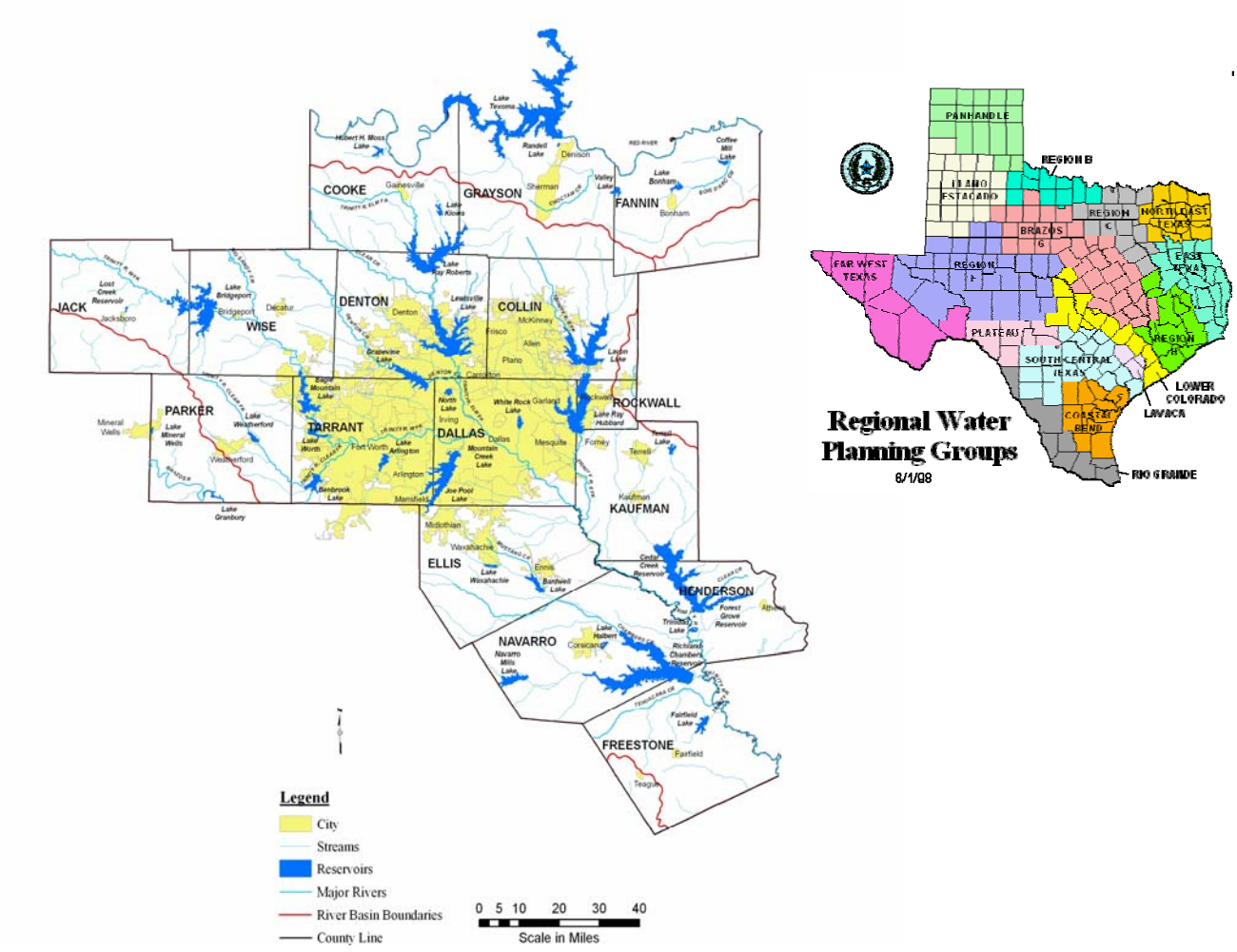
3.1 Description of the Region C Planning Process

The regional water planning process was initiated in 1997 with the passage of Senate Bill One by the 75th Texas Legislature. This legislation put in place a grass-roots approach to planning for the future water needs of all Texans. To implement this process, the Texas Water Development Board created 16 regional water planning groups across the state and established regulations governing regional planning efforts. Region C covers all or part of 16 North Central Texas counties, as shown in Figure 3.1. North Texas Municipal Water District provides water to customers in Region C and some customers in Region D (located immediately east of Region C).

The *2006 Region C Water Plan* was developed under the direction of the 19-member Region C Water Planning Group (Freese and Nichols *et al.*, 2006). This plan was adopted by the Region C Water Planning Group on December 5, 2005, and approved by the Texas Water Development Board in April 2006.

The primary purpose of the regional water planning process is to identify future water needs and outline a plan to meet those needs. Each region must plan for specific water users and wholesale water providers, which requires projections of future water demands, assessments of existing water supplies, identification of projected water surplus or shortage, and evaluations of water management strategies to meet the identified shortages. The development of water management strategies includes assessments of the quantity, reliability and cost of the supply, and must consider the potential impacts of the water management strategy to natural resources, the environment, agricultural and rural areas, key water quality parameters, and other water management strategies. The regional water planning process includes detailed technical analyses, as well as a public process with numerous public meetings and hearings to solicit input and comments. The result is a comprehensive water plan that addresses the issues and water needs of the region.

Figure 3.1
Region C Location Map



The North Texas Municipal Water District is a designated wholesale water provider in the Region C water plan. As such, a water supply planning process was conducted for the District in the Region C water plan, and a plan was outlined to meet the projected shortages for the District through 2060. The recommended strategies identified for the District in the Region C water plan are discussed in Section 3.2. Sections 3.3 and 3.4 discuss the strategies that were considered, but not recommended. A comparison of the strategies considered and recommended is presented in Section 3.5.

3.2 Recommended Water Management Strategies in the Region C Plan for the North Texas Municipal Water District

The Region C Water Planning Group considered 23 different water management strategies to meet the projected water supply shortages for NTMWD. Of these considered strategies, twelve strategies are recommended and nine are identified as alternative strategies. In the recommended plan, the NTMWD will implement conservation measures and develop reuse projects to fully utilize existing water resources, develop new water supplies, and utilize interim water sources while long-term strategies are developed. The recommended water management strategies in the *2006 Region C Water Plan* for NTMWD include:

- Water Conservation
- Additional Reuse from Wilson Creek Wastewater Plant
- Interim Purchase of Lake Texoma Water from the Greater Texoma Utility Authority
- Interim Treated Water Purchase from Dallas Water Utilities
- Additional Lake Lavon Yield
- East Fork Reuse Project
- Upper Sabine Basin Supply
- New Supply from Lake Texoma
- Lower Bois d'Arc Creek Reservoir
- Marvin Nichols Reservoir
- Toledo Bend Reservoir
- Oklahoma Water

The development of the Marvin Nichols Reservoir, connection to Toledo Bend Reservoir, and connection to Oklahoma water sources are multi-provider strategies. These strategies will be developed jointly with other wholesale water providers. The other listed strategies will be developed independently by the NTMWD.

During the development of the *2006 Region C Water Plan* and subsequently, the District has been active in implementing water conservation, wastewater reuse, and interim supply measures. Substantial progress has been made in reaching the District's conservation goals outlined in the Region C plan. This progress is discussed in more detail in Section 1.3. On September 8, 2005, the District was granted an amendment to its water right for Lake Lavon to

increase the amount of wastewater reuse from the Wilson Creek Wastewater Treatment Plant to 64 mgd. This amendment was a recommended strategy in the *2006 Region C Water Plan*. Also, the District has contracted with the Greater Texoma Utility Authority (GTUA) for interim water supply, and GTUA was granted an interbasin transfer permit (Permit No. 4301A) on February 6, 2006. This supply is only for available water in excess of the needs of GTUA and the City of Sherman. In 2006, the amount of supply to be provided to the District is 16 mgd (18,000 acre-feet per year). Brief discussions of all of the Region C recommended strategies, including those that have been implemented, are presented below.

3.2.1 Recommended Strategies That Have Been Implemented

Water Conservation**.** Water savings for NTMWD from conservation strategies in the Region C plan are measured as the projected conservation savings for the NTMWD's existing and potential customers, based on the Region C recommended water conservation program. Savings from low-flow plumbing fixtures (which amount to about 5 percent of demand) are built into the demand projections and are not included in the total projected water savings. Total conservation savings by NTMWD customers, excluding reuse, are projected to reach 86,114 acre-feet per year by 2060. This strategy is currently being implemented and the water savings attributed to these conservation measures are expected to increase with growth.

Additional Reuse from Wilson Creek Wastewater Plant. This strategy recommends that NTMWD amend its water right in Lake Lavon to reuse up to 64 mgd (71,882 acre-feet per year) of treated effluent from the Wilson Creek Wastewater Treatment Plant. As discussed above this amendment has been granted and the District is currently reusing about 37 mgd (41,500 acre-feet per year) of effluent discharged to Lake Lavon. This amount is expected to increase to 56 mgd by 2010 and to the full permitted amount by 2020.

Interim Purchase of Lake Texoma Water from the Greater Texoma Utility Authority. NTMWD has reached an agreement with the City of Sherman and the Greater Texoma Utility Authority (GTUA) to purchase additional Lake Texoma water. The water would be delivered through NTMWD's existing pump station and pipeline from Lake Texoma. This supply is expected to be available for up to 20 years, and only water surplus to the in-basin needs of GTUA and Sherman would be purchased. The interbasin transfer permit to allow the proposed sale and transfer was granted in 2006.

3.2.2 Recommended Strategies to Be Implemented before Lower Bois d'Arc Creek Reservoir

Interim Treated Water Purchase from Dallas Water Utilities. The NTMWD is negotiating with Dallas Water Utilities (DWU) to purchase an annual average of up to 10 mgd (11,210 acre-feet per year) of treated water. The water would be delivered to NTMWD at multiple metered locations between DWU's water distribution system and the NTMWD treated water distribution system. It is assumed that this supply would be available for 20 years and would eventually be replaced with supplies from other sources. The current estimate of an on-line date is 2007

Additional Lake Lavon Yield. NTMWD currently has a water right allowing the diversion of up to 104,000 acre-feet per year from Lake Lavon (in addition to water delivered to the lake from return flows, Lake Texoma, and Lake Chapman). The Trinity River Water Availability Model (Texas Commission on Environmental Quality, 2004) shows that the yield of Lake Lavon is greater than 104,000 acre-feet per year. NTMWD has applied for a water right to divert up to an additional 14,840 acre-feet per year from Lake Lavon. Based on estimated area and capacity conditions in the lake, the additional supply from this measure will vary from 11,000 acre-feet per year in 2010 to 6,000 acre-feet per year in 2060.

East Fork Reuse Project. NTMWD has applied for a water right to divert treated wastewater from the East Fork of the Trinity River near Crandall. The water would be diverted to a constructed wetland for treatment, pumped through a pipeline to Lake Lavon, and rediverted from Lavon for treatment and use. The estimated supply available from this project will increase over time with increasing wastewater flows to 102,000 acre-feet per year. It is expected that the supplies will be available by 2008.

Upper Sabine Basin Supply. NTMWD has negotiated with the Sabine River Authority to divert water from Lake Tawakoni or Lake Fork Reservoir on an interim basis. NTMWD would divert only water surplus to the needs of other users and would eventually replace this water with supplies from other sources. SRA has sought an interbasin transfer and NTMWD is constructing a pump station and pipeline to deliver water from Lake Tawakoni (or water transported from Lake Fork Reservoir to Lake Tawakoni) to Lake Lavon. This supply is expected to be available by 2008.

New Supply from Lake Texoma. Lake Texoma is an existing Corps of Engineers reservoir on the Red River on the border between Texas and Oklahoma. NTMWD has a water right to divert 84,000 acre-feet per year of water from Lake Texoma, and use 77,300 of this amount from Lake Lavon (after an allowance of 6,700 acre-feet per year in channel losses).

The U.S. Congress has authorized the reallocation of 150,000 acre-feet of storage in Lake Texoma from hydroelectric power generation to municipal use in Texas, with 50,000 acre-feet reserved for the Greater Texoma Utility Authority (GTUA). NTMWD has requested a contract with the Tulsa District of the Corps of Engineers for the remaining 100,000 acre-feet of storage in Lake Texoma authorized for Texas and has applied for a Texas water right to impound this water and divert up to 113,000 acre-feet per year from the lake. The NTMWD would divert the water directly from Lake Texoma and/or from the Red River downstream of the lake. The water right for this project is expected in 2007, with the infrastructure completed before 2015.

3.2.3 Recommended Lower Bois d'Arc Creek Reservoir

Lower Bois d'Arc Creek Reservoir. The development of Lower Bois d'Arc Creek Reservoir is a recommended project in the *2006 Region C Water Plan*. According to the Region C plan, the Lower Bois d'Arc Creek Reservoir would provide up to 123,000 acre-feet per year for NTMWD and Fannin County and would be developed by 2020. The current firm yield estimate for the project is 126,200 acre-feet per year.

3.2.4 Recommended Strategies to Be Implemented after Lower Bois d'Arc Creek Reservoir

Marvin Nichols Reservoir. The Marvin Nichols Reservoir is a recommended strategy for the NTMWD, the Tarrant Regional Water District (TRWD), and the Upper Trinity Regional Water District (UTRWD). The project would provide a large source of additional supply for Region C at a relatively low cost. The total yield of Marvin Nichols Reservoir is 612,300 acre-feet per year, assuming that Lake Ralph Hall is senior to Marvin Nichols Reservoir and that Marvin Nichols Reservoir is operated as a system with Wright Patman Lake. Of this amount, the 2006 Region C plan assigns 174,840 acre-feet per year to NTMWD. This project is expected to be developed in phases. Phase 1 would be developed by 2030 and would include the reservoir and the initial pipelines and pump stations. Phase 2, planned for 2050, would include parallel pipelines and additional pump stations to deliver the remainder of the supply from the project.

Toledo Bend Reservoir. The use of water from Toledo Bend Reservoir (East Texas) to North Texas is a recommended strategy for the NTMWD, the Tarrant Regional Water District, and the Sabine River Authority. This joint project will deliver a total of 500,000 acre-feet per year, with 200,000 acre-feet per year for NTMWD. The facilities to deliver the water would be developed in phases, with Phase I planned for 2050 and Phase II planned after 2060.

Oklahoma. The Region C water plan recommends the purchase and use of water from Oklahoma as a long-term strategy. At the present time, the Oklahoma Legislature has established a moratorium on the export of water from the state. Assuming the moratorium is lifted in the future, the Region C plan recommends that the NTMWD, the TRWD, and the UTRWD jointly develop a project to use water from Oklahoma. The recommended project is planned for 2060 and includes 50,000 acre-feet per year each for TRWD and NTMWD and 15,000 acre-feet per year for UTRWD.

3.3 Alternative Strategies for North Texas Municipal Water District from the Region C Plan

Alternative strategies are not recommended in the *2006 Region C Water Plan*, but have sufficient merit for further consideration if one or more of the recommended strategies cannot be implemented as planned. The following alternative water management strategies are identified for NTMWD in the Region C Water Plan:

- Accelerated Phase II Toledo Bend
- Lake O' the Pines
- Lake Wright Patman
- Lake Texoma with Desalination
- Ogallala Aquifer Groundwater
- Carrizo-Wilcox Aquifer Groundwater
- George Parkhouse North Lake
- George Parkhouse South Lake
- Lake Livingston.

Accelerated Phase II Toledo Bend. Phase II of the Toledo Bend project includes additional infrastructure to increase water transmission capacity from the reservoir to the NTMWD and other Region C water suppliers. This strategy proposes that the additional

infrastructure be implemented prior to 2060. This strategy is an alternate strategy rather than recommended due to the infrastructure costs and high energy use to move water from Toledo Bend to North Texas.

Lake O' the Pines. Lake O' the Pines is an existing Corps of Engineers reservoir in the Cypress River Basin with Texas water rights held by the Northeast Texas Municipal Water District (NETMWD). The NTMWD has explored the possibility of purchasing supplies in excess of local needs from the Cypress Basin. There could be as much as 89,600 acre-feet per year available for export from the basin. Development of this source would require an interbasin transfer permit and contracts with the NETMWD and other Cypress River Basin suppliers with excess supplies. At this time, NETMWD and other suppliers have not committed to selling this amount of water. Lake O' the Pines is about 120 miles from the Metroplex, and the distance and limited supply make this a less desirable water management strategy.

Lake Wright Patman. Lake Wright Patman is an existing reservoir in the Sulphur River Basin, about 150 miles from NTMWD. It is owned and operated by the Corps of Engineers. The City of Texarkana has contracted with the Corps of Engineers for storage in the lake and holds a Texas water right to use up to 180,000 acre-feet per year from the lake. However, to obtain a reliable supply of 180,000 acre-feet per year from Lake Wright Patman, Texarkana would have to activate a contract with the Corps of Engineers to increase the conservation storage in the lake.

There are three different strategies by which water could be made available to the NTMWD from Wright Patman Lake:

- Water could be purchased from the City of Texarkana under its existing water right.
- Flood storage in Wright Patman Lake could be converted to conservation storage, and the NTMWD could use the increased yield.
- Wright Patman Lake could be operated as a system with Jim Chapman Lake (formerly Cooper Lake) upstream to further increase yield.

The cost for each of these options is greater than the estimated costs for the Lower Bois d'Arc Creek Reservoir project, and as such, the strategies for developing supplies from Wright Patman Lake are recommended alternatives for NTMWD in the 2006 Region C plan. There are

also other implementation issues that affect the viability of the strategies. Each strategy is discussed in more detail below.

- *Purchase from Texarkana.* Of the 180,000 acre-feet per year for which Texarkana currently has a water right, Texarkana could sell 100,000 acre-feet per year and still have sufficient supplies to meet its projected needs. It is assumed that development of this supply would require activating the contract between Texarkana and the Corps of Engineers for additional conservation storage (which would require some environmental studies and mitigation) and improvements to Texarkana's pump station on the lake. This strategy would require Texarkana to be willing to sell water to NTMWD. To date, Texarkana has not committed to selling water.

- *Raise Flood Pool.* According to a recent study conducted for the Corps of Engineers, increasing the top of conservation storage in Wright Patman Lake to elevation 228.64 feet msl and allowing diversions as low as elevation 215.25 feet msl would increase the yield of the project to about 364,000 acre-feet per year (Freese and Nichols, 2003). It was assumed that 180,000 acre-feet per year of the additional supply developed could be made available to the NTMWD. The studies found that increasing the elevation above 228.64 feet msl would inundate portions of the White Oak Creek mitigation area, located upstream from Wright Patman Lake. (Approximately 500 acres of the mitigation area are below elevation 230 feet msl, and about 3,800 acres are below elevation 240 feet msl.) This strategy would require changes to the Corps of Engineers operation of Wright Patman. Also, this strategy is recommended for Dallas in the City's long-range water supply plan and the 2006 Region C plan. It is not feasible for both NTMWD and Dallas to pursue this strategy.

- *Purchase from Texarkana, Raise Flood Pool, and System Operation.* The recent study conducted for the Corps of Engineers indicated that system operation of Wright Patman Lake and Jim Chapman Lake could increase the yield from the two projects by about 108,000 acre-feet per year. It was assumed that the combination of purchasing water from Texarkana, converting flood storage to conservation storage, and system operation with Jim Chapman Lake could make 390,000 acre-feet per year available from Wright Patman Lake. The Region C plan assumed that this strategy would be developed jointly with multiple water providers in North Texas. The amount of supply for the NTMWD would be 130,000 acre-feet per year. Other suppliers have not committed to participating with this strategy.

<u>Lake Texoma with Desalination.</u> As discussed in Section 3.2, Lake Texoma is a recommended source of additional water supply for the NTMWD (113,000 acre-feet per year). However, the strategy to implement desalination is an alternative strategy. The lake has elevated levels of dissolved solids, and the water must be blended with higher quality water or desalinated for municipal use. The elevated dissolved solids in Lake Texoma would have some

environmental impacts whether the water is used by blending or desalination. Blending water from Lake Texoma with water from other sources provides an inexpensive supply for the NTMWD, if sufficient quantities of higher quality water are available. Desalination provides treated water but is a more expensive strategy, and there are considerable uncertainties in the operation and long-term costs of a large-scale desalination facility.

The estimated costs for desalination of water from Lake Texoma are based on current cost information for large desalination facilities. However, they are more uncertain than other cost estimates in the Region C water plan for the following reasons:

- There is not an established track record of success in the development of large brackish water desalination facilities.
- Most of the large desalination facilities built to date are located on or near the coast. If a 100-million-gallon-per-day or larger plant were to be developed for Lake Texoma water, it would be the largest inland desalination facility in the world.
- The method, cost and regulatory requirements of brine disposal for such a facility are uncertain. Brine disposal has the potential to significantly increase the estimated cost for desalination. Detailed studies to solidify the cost estimates will be required if this strategy is pursued.

Ogallala Aquifer Groundwater. Mesa Water, Incorporated, is interested in selling groundwater from the Ogallala aquifer in Roberts County to water suppliers in Region C. (Roberts County is in Region A, the Panhandle Region.) Mesa Water controls rights to 150,000 acre-feet per year of groundwater in Roberts County with options for additional supply and has permits from the local groundwater conservation district to export groundwater. Mesa Water has indicated that they can develop a reliable supply of 200,000 acre-feet per year for water suppliers in Region C through 2060 and beyond. The groundwater in Roberts County is about 250 miles from the Metroplex. Because of the distance, this is a relatively expensive source of supply for the NTMWD.

Carrizo-Wilcox Aquifer Groundwater. The Carrizo-Wilcox aquifer covers a large area of east, central, and south Texas. Organizations and individuals have been studying the development of water supplies in Brazos County and surrounding counties for export. The NTMWD has been approached as a possible customer for the water. The aquifer is located in Region G, called the Brazos G Region, and this supply has also been studied for use by

communities in that region. Brazos County is about 150 miles from the Metroplex. This is a relatively expensive source of supply for the NTMWD.

George Parkhouse North Lake. George Parkhouse Lake (North) is a potential reservoir located on the North Sulphur River in Lamar and Delta Counties. It would yield 148,700 acre-feet per year (with 118,960 acre-feet per year available for Region C), but its yield would be reduced substantially by the development of Lake Ralph Hall or Marvin Nichols Reservoir. George Parkhouse Lake (North) could potentially provide an inexpensive source of supply for the NTMWD. The project would inundate 12,250 acres. Ninety percent of the land impacted is cropland or pasture. The proposed reservoir is an alternate strategy due to the uncertainty of the reliable supply with the development of other reservoirs in the river basin.

George Parkhouse South Lake. George Parkhouse Lake (South) is a potential reservoir located on the South Sulphur River in Hopkins and Delta Counties. It is located downstream from Jim Chapman Lake and would yield 135,600 acre-feet per year (with 108,480 acre-feet per year available for Region C). Its yield would be reduced substantially by the development of Marvin Nichols Reservoir. George Parkhouse Lake (South) would inundate 29,740 acres. Ninety percent of the land impacted is cropland or pasture. As with the George Parkhouse North Lake site, there is concern about the reliable supply with the development of other reservoirs in the river basin.

Lake Livingston. Lake Livingston is an existing reservoir on the Trinity River. The larger portion of the lake is located in Polk and San Jacinto Counties. The Trinity River Authority (TRA) and the City of Houston hold the water rights for Lake Livingston. The TRA has indicated that as much as 200,000 acre-feet per year might be available to water suppliers in Region C from the lake. Lake Livingston is about 180 miles from the Metroplex. Due to the distance to NTMWD, this is a relatively expensive strategy.

3.4 Other Alternatives Studied for North Texas Municipal Water District

3.4.1 Other Strategies Considered in the Region C Water Plan

Additional Water Conservation Strategies – The Region C water plan conducted an initial screening of 23 municipal conservation strategies, including each of the strategies identified in the Water Conservation Best Management Practices Guide, which was prepared under the

direction of the Water Conservation Implementation Task Force (Water Conservation Implementation Task Force, 2004). Of these strategies, seven were determined as not feasible for Region C water users. The other 16 strategies were evaluated for quantities and costs. Eleven strategies were recommended in the Region C conservation packages, and five strategies were determined to be less cost effective and were not included in the recommended packages.

The consideration of water conservation strategies for NTMWD is discussed in Section 1.3. NTMWD has included each of the Region C recommended conservation strategies in their water conservation plan and/or the model conservation plans for their member cities and customers. In addition, the District has included three strategies that were not recommended in the *2006 Region C Water Plan*. These include:

- Metering of all new connections and retrofitting existing connections,
- Wholesale water assistance programs, and
- Conservation coordinator.

Sam Rayburn Reservoir/Lake B.A. Steinhagen**.** Sam Rayburn Reservoir is an existing Corps of Engineers reservoir on the Angelina River in the Neches River Basin. Lake B.A. Steinhagen is located on the Neches River downstream from Sam Rayburn Reservoir. The Lower Neches Valley Authority holds Texas water rights in the reservoirs, and they have indicated that as much as 200,000 acre-feet per year might be available to water suppliers in Region C. In order to preserve hydropower generation from Sam Rayburn Reservoir, the Lower Neches Valley Authority wants the water to be diverted from Lake B.A. Steinhagen, which is about 200 miles from the Metroplex. Because of the distance, this is a relatively expensive source of supply for NTMWD. There also has been recent interest in supplies from Sam Rayburn Reservoir/ Lake B.A. Steinhagen from other users. If granted, the amount of supply available to NTMWD would be substantially smaller.

Gulf of Mexico with Desalination**.** The State of Texas has sponsored initial studies of potential seawater desalination projects, and this is seen as a potential future supply source for the state. Because of the distance to the Gulf of Mexico, seawater desalination is not a particularly promising source of supply for NTMWD. The supply from seawater desalination is essentially unlimited, but this is a high energy use strategy and the cost is much higher than the cost of other water management strategies for NTMWD.

3.4.2 Other Potential Water Supply Sources

Several other proposed and existing reservoirs were recommended or considered for water users in Region C. These reservoirs were not specifically considered for NTMWD in the Region C water plan because of commitments to other users. A brief discussion of each of the proposed reservoirs is presented below.

Lake Fastrill – Lake Fastrill is a recommended strategy for the City of Dallas. This proposed lake would be located in the Neches River Basin downstream of Lake Palestine, which is one of Dallas' water supply sources. Lake Fastrill would be operated as a system with Lake Palestine to meet Dallas' water needs. The estimated yield of the lake is 148,780 acre-feet per year, with 112,100 acre-feet per year designated for Dallas. The remainder of the supply is intended for in-basin uses. There is no supply available for NTMWD. Also, since the completion of the *2006 Region C Water Plan*, the U.S. Fish and Wildlife Service designated an area within the reservoir footprint for a wildlife refuge.

Lake Tehuacana – This proposed reservoir is located on Tehuacana Creek in Freestone County adjacent to Richland-Chambers Reservoir, which is a TRWD facility. Lake Tehuacana is an alternate strategy for TRWD, and if built would be operated jointly with TRWD's system. The estimated yield is 56,800 acre-feet per year, which would be used for TRWD customers.

Lake Ralph Hall – Lake Ralph Hall is a proposed lake on the North Sulphur River in Fannin County and is a recommended strategy for the Upper Trinity River Water District (UTRWD). The UTRWD has applied for a water right permit to develop the proposed lake. The project would yield 32,940 acre-feet per year, which would be fully committed to UTRWD. There is no available supply for NTMWD.

Lake Columbia – The Angelina and Neches River Authority has a Texas water right for the development of the proposed Lake Columbia on Mud Creek in the Neches River Basin. The Authority is pursuing development of the reservoir and has applied for a Federal 404 permit from the Corps of Engineers. The estimated yield of the project is 75,700 acre-feet per year. Of this amount, over 60,000 acre-feet per year is committed to water users in the East Texas Region. The amount of supply that may be available to NTMWD is small and the approximate 125 mile distance to NTMWD make this an expensive supply option.

Other Existing Lakes – Other existing lakes in the vicinity of NTMWD service area include Lake Ray Hubbard, Ray Roberts Lake, Lewisville Lake, Lake Grapevine, Lake Fork, Cedar Creek Reservoir, Richland-Chambers Reservoir and Lake Palestine. Each of these sources is fully committed to existing customers. Lakes Ray Hubbard, Ray Roberts, Lewisville Lake, Grapevine, Fork and Palestine are water supply sources for the City of Dallas, and these sources are needed to meet the demands of the City, its customers and other holders of water rights in the lakes. Cedar Creek and Richland-Chambers reservoirs are owned and operated by the Tarrant Regional Water District (TRWD). This water sources are fully committed to meet the water demands of the TRWD.

3.5 Comparison of Alternatives

The alternative strategies considered for NTMWD can be grouped into major categories: strategies that are recommended for implementation prior to the Lower Bois d'Arc Creek Reservoir, strategies recommended for implementation after Lower Bois d'Arc Creek Reservoir, strategies that are currently not recommended but may be alternate sources if needed, and strategies that are not recommended. The selection of the recommended strategies considered many factors, including cost of the water, quantity, reliability, the potential impacts of developing the project on the environment, natural resources and other water users, timing to develop the strategy and potential implementation issues. A comparison of the alternative strategies is shown on Figure 3.2 and Table 3.1.

The strategies that could be developed quickly at a reasonable cost are identified for implementation before Lower Bois d'Arc Creek Reservoir. These strategies include conservation, reuse, interim supply purchases from other water providers and blending additional water from Lake Texoma with existing water supplies. Collectively these strategies provide approximately 220,000 acre-feet per year of new water supply for the District. Additional water will be needed before 2020. If the District's customer populations and demands continue to grow at a faster rate than assumed in the *2006 Region C Water Plan*, the need for additional supplies will be sooner.

Lower Bois d'Arc Creek Reservoir is the recommended strategy to provide additional water supplies by 2020. This strategy is located relatively close to the area with need, can provide sufficient water, and has a relatively low unit cost of water.

Strategies that are recommended for implementation after Lower Bois d'Arc Creek Reservoir are large strategies that are developed in cooperation with other water providers. These include the proposed Marvin Nichols Reservoir, connection to Toledo Bend Reservoir, and connection to water from Oklahoma sources. Each of these projects requires considerable capital investment and consideration of the timing and needs of the other participants. The unit costs for the Marvin Nichols Reservoir and Oklahoma projects are comparable to the costs to develop the Lower Bois d'Arc Creek Reservoir. Costs for the Toledo Bend connection are higher, but there is some flexibility in the quantity and timing for water from this strategy. Each of these strategies is a long-term strategy, scheduled for implementation after 2030.

Strategies recommended as alternates for NTMWD typically have higher unit costs or greater uncertainty of reliable yield than Lower Bois d'Arc Creek Reservoir. Only the proposed George Parkhouse Reservoir has unit costs that are lower than Lower Bois d'Arc Creek Reservoir, but the yield of this reservoir would be impacted by the construction of Lake Ralph Hall or Marvin Nichols Reservoir, which are both recommended strategies in the *2006 Region C Water Plan*.

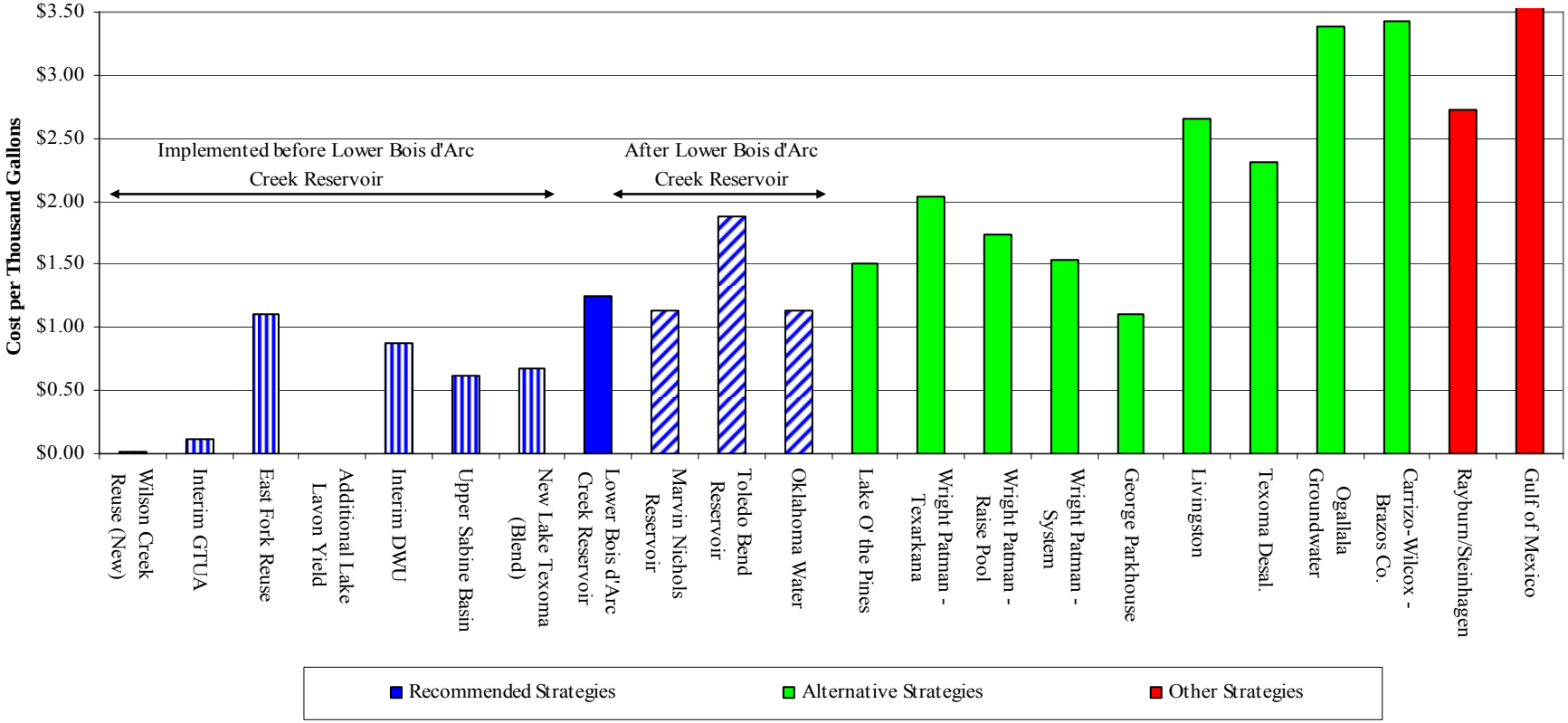
Strategies that are not recommended have much higher unit costs than Lower Bois d'Arc Creek Reservoir, require transporting water over substantial distances, and have other implementation issues.

Table 3.1
Costs for Alternative Strategies

Strategy	Region C Water Plan Costs			Updated 2006 Costs		
	NTMWD Share of Capital Cost	Unit Cost for NTMWD ($/kGal.)		NTMWD Share of Capital Cost	Unit Cost for NTMWD ($/kGal.)	
		Pre-Amort.	Post-Amort.		Pre-Amort.	Post-Amort.
Implemented before Lower Bois d'Arc Creek Reservoir						
Wilson Creek Reuse (New)	$1,150,000	$0.0072	$0.00	$1,349,000	$0.008	$0.00
Interim GTUA Supply	$104,000	$0.090	$0.086	$122,000	$0.110	$0.107
East Fork Reuse	$288,879,000	$0.92	$0.21	$338,765,000	$1.10	$0.27
Additional Lake Lavon Yield	$270,000	$0.0056	$0.00	$317,000	$0.006	$0.00
Interim DWU Supply	$1,350,000	$0.75	$0.72	$1,583,000	$0.88	$0.84
Upper Sabine Basin	$60,232,000	$0.52	$0.25	$70,633,000	$0.62	$0.30
New Lake Texoma (Blend)	$201,829,000	$0.58	$0.18	$236,683,000	$0.68	$0.21
Lower Bois d'Arc Creek Reservoir	**$399,190,000**	**$0.87**	**$0.14**	**$597,437,400[1]**	**$1.26**	**$0.20**
Implemented After Lower Bois d'Arc Creek Reservoir						
Marvin Nichols Reservoir	$534,125,000	$0.94	$0.26	$626,362,140	$1.13	$0.33
Toledo Bend Reservoir	$886,002,000	$1.56	$0.57	$1,039,004,000	$1.88	$0.73
Oklahoma Water	$128,898,000	$0.95	$0.37	$151,157,000	$1.14	$0.46
Not Recommended						
Lake O' the Pines	$257,192,000	$1.25	$0.60	$301,606,000	$1.50	$0.73
Wright Patman - Texarkana	$429,176,000	$1.70	$0.74	$503,290,000	$2.04	$0.92
Wright Patman - Raise Pool	$825,088,000	$1.42	$0.39	$967,571,000	$1.70	$0.51
Wright Patman - System	$418,251,000	$1.26	$0.45	$555,191,000	$1.52	$0.57
George Parkhouse North	$362,322,000	$0.91	$0.23	$424,891,000	$1.11	$0.31
Livingston	$1,299,183,000	$2.21	$0.77	$1,523,537,000	$2.65	$0.95
Lake Texoma Desalinate	$538,635,300	$1.96	$0.82	$631,651,000	$2.31	$0.97
Ogallala Groundwater	$1,994,699,000	$2.83	$0.61	$2,339,160,000	$3.38	$0.78
Carrizo-Wilcox - Brazos Co.	$577,413,000	$2.89	$1.28	$677,125,000	$3.43	$1.54
Sam Rayburn /Steinhagen	$1,252,392,000	$2.27	$0.69	$1,660,739,000	$2.72	$0.87
Gulf of Mexico	$2,836,207,000	$5.57	$2.41	$3,325,987,000	$6.63	$2.92

1. Capital cost includes interest during construction, which is required for SB1 cost estimates. Cost without interest during construction is $532,632,400.

Figure 3.2
Comparison of Alternative Strategies



References for Chapter 3

Freese and Nichols, Inc. et al., 2006. *2006 Region C Water Plan*, prepared for the Region C Water Planning Group.

Freese and Nichols, Inc., 2003. *System Operation Assessment of Lake Wright Patman and Lake Jim Chapman,* prepared for the U.S. Army Corps of Engineers.

Texas Commission on Environmental Quality, 2004. Trinity River Basin Water Availability Model.

Water Conservation Implementation Task Force. 2004. *Water Conservation Best Management Practices Guide.* Texas Water Development Board Report 362.

4. WATER SUPPLY AVAILABLE FROM LOWER BOIS D'ARC CREEK RESERVOIR

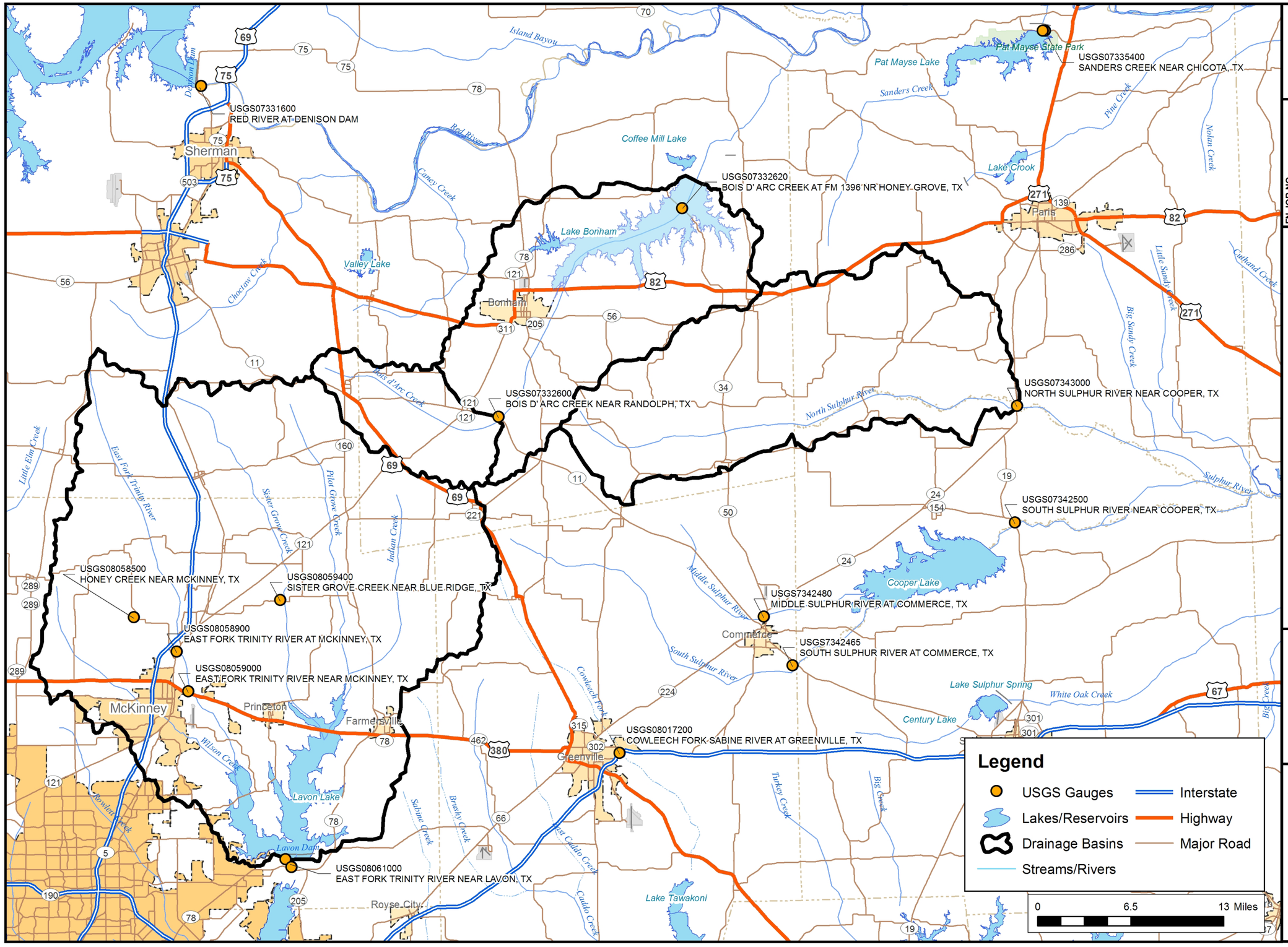
Lower Bois d'Arc Creek Reservoir will be located on Bois d'Arc Creek in Fannin County. The watershed is in the Red River Basin. Figure 4.1 shows the location of the reservoir, along with the location of selected USGS stream gauges and selected watershed boundaries. The reservoir will have a drainage area of 327 square miles. Other reservoirs in the Bois d'Arc Creek watershed include Lake Bonham, which serves as the water supply for the City of Bonham, and Lake Crockett and Coffee Mill Lake, which are recreation lakes. Lake Pat Mayse is located on Sanders Creek, which is adjacent to the Bois d'Arc Creek watershed.

4.1 Hydrologic Data

4.1.1 Flow Data

Table 4.1 lists the USGS stream gauges near the Lower Bois d'Arc Creek Reservoir site and their period of record (United States Geological Survey). Until recently, the Bois d'Arc Creek near Randolph gauge was the only source of historical data within the watershed. This gauge measured flows from about 22 percent of the proposed reservoir's watershed from December 1962 to September 1985. A new USGS gauging station (station 07332620 Bois d'Arc Creek at FM 1396 near Honey Grove, Texas) is located just above the dam site and began collecting data on June 23, 2006. At this time there are not sufficient data from the gauge to be used for hydrologic analyses. Seven of the gauges in Table 4.1 are primary control points in one of the Texas Commission on Environmental Quality (TCEQ) Water Availability Models (WAM) and have naturalized flow data available in addition to historical data.

Historical flows at the Bois d'Arc Creek near Randolph gauge (7332600) are equivalent to naturalized conditions because there are no water rights or significant return flows above the gauge. However, because of the limited period of record of the gauge, naturalized flows in the watershed must be estimated from other sources for much of the simulation period. In order to determine the best way to estimate flows in the Bois d'Arc Creek watershed, Freese and Nichols conducted a statistical comparison of flows at the



North Texas Municipal Water District

Stream Gauge Locations and Key Drainage Areas

FN JOB NO	NTD06128
FILE Planning_location_map_BME.mxd	
DATE	May 2006
SCALE	1:415,000
DESIGNED	GGJ
DRAFTED	HEO

Figure 4.1

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Fort Worth, Texas 76109-4895
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Table 4.1
USGS Stream Gauge Locations near the Lower Bois d'Arc Creek Reservoir Site

Gauge Number	Gauge Name	Start Date	End Date	Overlap with Randolph Gauge	Basin	County	Naturalized Flow	Drainage Area (mi^2)	Comments
7331600	Red River at Denison Dam nr Denison, TX	Jan-24	Sep-89	Yes	Red	Grayson	Yes	33,784	10/34 to 9/61 published as nr Colbert. Measures outflow from powerhouse.
		Dec-96	Current						
7332600	Bois D Arc Ck nr Randolph, TX	Dec-62	Sep-85	--	Red	Fannin	No	72	No known regulation or diversion
7332620	Bois d'Arc Creek at FM 1396 nr Honey Grove, TX	June-06	Current	No	Red	Fannin	No	n/a*	New gauge just above damsite
7335400	Sanders Ck nr Chicota, TX	Oct-67	Sep-86	Yes	Red	Lamar	No	175	Outflow from Pat Mayse Lake
7335500	Red River at Arthur City	Jul-36	Current	Yes	Red	Lamar	Yes	38,595	
7342465	S Sulphur Rv at Commerce, TX	Oct-91	Current	No	Sulphur	Hunt	No	150	No known regulation or diversion
7342480	Middle Sulphur Rv at Commerce, TX	Oct-91	Current	No	Sulphur	Hunt	No	44.1	No known regulation or diversion
7342500	S Sulphur Rv nr Cooper, TX	Jun-42	Current	Yes	Sulphur	Delta	Yes	527	Since 1991 regulated by Lake Chapman
7343000	N Sulphur Rv nr Cooper, TX	Oct-49	Current	Yes	Sulphur	Lamar	Yes	276	Historical flow very close to naturalized flow
8017200	Cowleech Fk Sabine Rv at Greenville, TX	Mar-59	Current	Yes	Sabine	Hunt	Yes	77.7	
8058500	Honey Ck nr McKinney, TX	Aug-51	Sep-73	Yes	Trinity	Collin	No	39	
8058900	E Fk Trinity Rv at McKinney, TX	Oct-75	Current	Yes	Trinity	Collin	No	164	
8059000	E Fk Trinity Rv nr McKinney, TX	Sep-49	Sep-75	Yes	Trinity	Collin	Yes	190	
8059400	Sister Grove Ck nr Blue Ridge, TX	Jul-75	Sep-01	Yes	Trinity	Collin	No	83.1	Discharge may include NTMWD Texoma imports
8059500	Sister Grove Ck nr Princeton, TX	Sep-49	Jan-75	No	Trinity	Collin	No	113	
8060000	E Fk Trinity Rv abv Pilot Grove nr Lavon, TX	Mar-49	Sep-53	No	Trinity	Collin	No	324	
8061000	E Fk Trinity Rv nr Lavon, TX	Oct-53	Sep-89	Yes	Trinity	Collin	Yes	770	Flow regulated by Lake Lavon
8061500	E Fk Trinity Rv nr Rockwall, TX	Oct-24	Sep-54	No	Trinity	Rockwall	No	840	

* The drainage area is not available at this time.

Randolph gauge to available naturalized flows at nearby gauges, as well as estimated historical inflows into Lake Pat Mayse. These comparisons showed that flows in the main stem of the Red River had relatively poor correlation with flows at the Randolph gauge. The best estimator of flows at the Lower Bois d'Arc Creek dam site appears to be the North Sulphur River near Cooper gauge (7343000) in the Sulphur River Basin. This watershed is adjacent to the Lower Bois d'Arc Creek watershed, has a similar drainage area, and has a similar east-west orientation. Therefore flows from the North Sulphur gauge were used to estimate flows into Lower Bois d'Arc Creek Reservoir when the Randolph gauge is unavailable. The South Sulphur River near Cooper gauge was used early in the analysis period before the North Sulphur gauge became available. More detailed information regarding the comparison of flows may be found in Appendix F.

Even though there was a reasonable correlation between the Randolph gauge and adjacent watersheds in the Trinity and Sulphur Basins, the statistical comparisons also demonstrated that using drainage area ratios could either underestimate or overestimate flows at the dam site. An analysis of the long-term relationship between rainfall and runoff in the adjacent drainage areas show that the amount of runoff produced increases significantly from west to east across the area. Therefore, adjustment factors based on average runoff per square mile were used to estimate flows at the dam site. More information on these factors, as well as the final flows developed for the analysis, may be found in Appendix F.

Table 4.2 shows Consensus Bypass Criteria (Texas Water Development Board, 2001) calculated using the naturalized flows at the Lower Bois d'Arc Creek dam site discussed above. The monthly flows were distributed to daily values using historical average daily flows at the North Sulphur River near Cooper gauge. When the North Sulphur gauge was not available, the South Sulphur River near Cooper was used.

4.1.2 Evaporation and Area-Capacity Data

Evaporation data for the proposed reservoir were developed from historical data from the Texas Water Development Board and U.S. Geological Survey. Area and capacity data are based on a recent survey of the reservoir site. Additional information may be found in Appendix F.

Table 4.2
Consensus Bypass Criteria for Lower Bois d'Arc Creek Reservoir

Values in cfs													
Reservoir Storage	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Average**
Greater than 80% [a]	25.5	44.9	38.2	31.5	28.9	11.9	1.7	0.2	0.5	1.7	7.8	19.5	17.5
Between 80% and 50% [b]	7.3	15.8	13.4	11.2	8.5	1.7	0.1	0.0	0.0	0.0	0.8	2.3	5.0
Below 50% [c]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Values in acre-feet per month													
Reservoir Storage	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Greater than 80% [a]	1,568	2,515	2,348	1,873	1,779	706	105	12	30	103	467	1,201	12,707
Between 80% and 50% [b]	447	884	827	664	520	100	4	0	0	0	47	144	3,637
Below 50% [c]	0	0	0	0	0	0	0	0	0	0	0	0	0

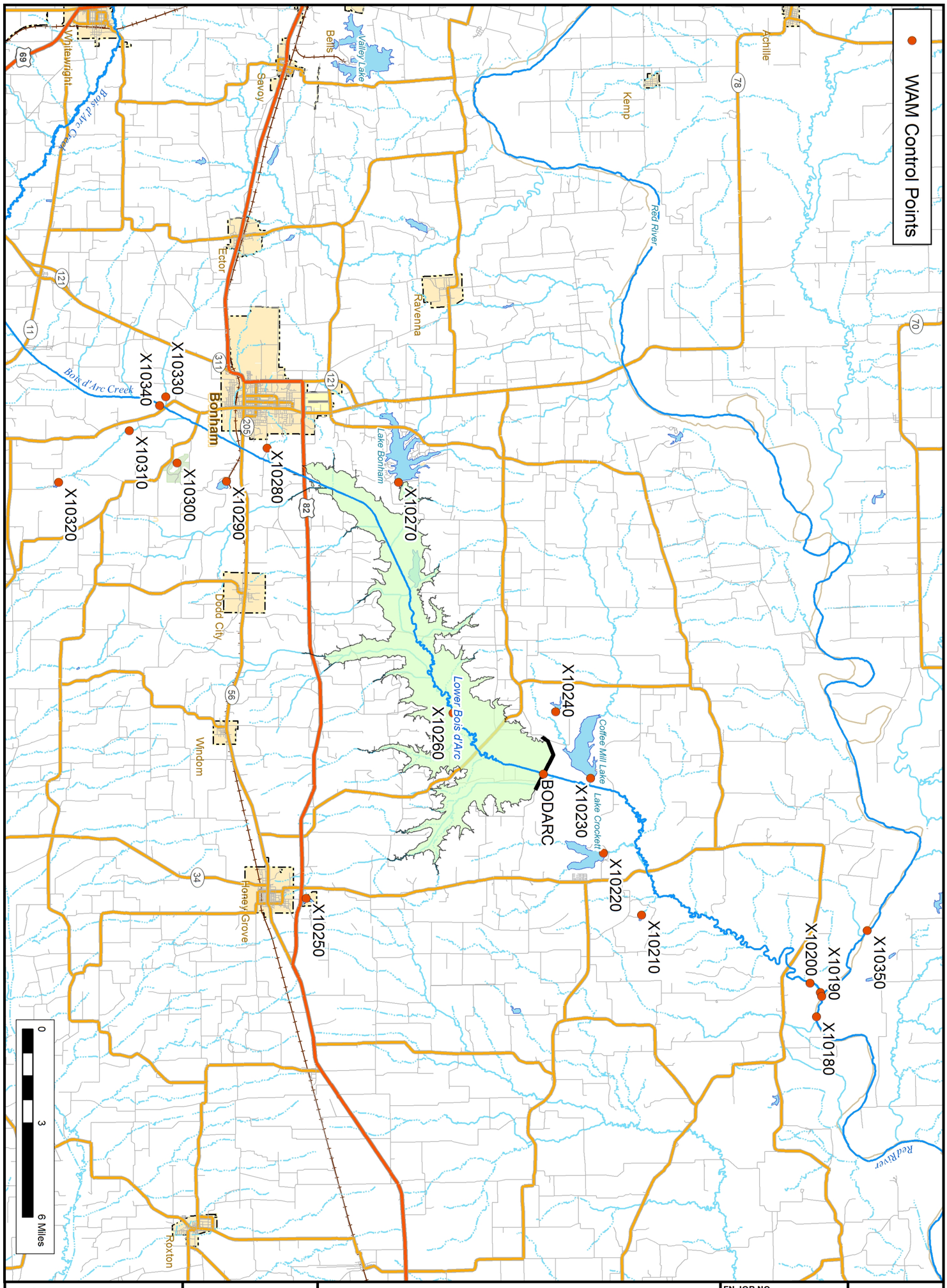
a Based on median of daily naturalized flows
b Based on 25th percentile of daily naturalized flows
c Seven-day low flow with a 2-year recurrence interval (7Q2)

4.2 Yield of the Project

The TCEQ Red River WAM was used to calculate the yield of this project (Texas Commission on Environmental Quality, 2006(a)). The yield studies were conducted using the June 2005 version of the Water Rights Analysis Package (WRAP), the model used in the TCEQ WAM program (Wurbs, 2005).

The TCEQ Red River WAM estimates flows in the Bois d'Arc Creek watershed on incremental flows between the Red River at Denison Dam and Red River at Arthur City gauges, multiplied by drainage area ratios. However, as discussed in the previous section, there is a relatively poor correlation between incremental flows on the main stem of the Red River and flows at the Randolph gauge. Therefore, a new primary control point was added to the Red River WAM at the Lower Bois d'Arc Creek damsite with flows calculated using the method discussed in Section 4.1. Flows at this control point were developed based on the best data available (flows at the Randolph gauge when available, with flows on the North Sulphur River near cooper used when the Randolph gauge was not operating and flows at the South Sulphur River at Cooper gauge used when neither the Randolph or North Sulphur flows were available). The modified WAM uses flows from this new primary control point for all secondary control points within the Bois d'Arc Creek watershed. More information on the hydrology for the new primary control point may be found in Appendix F.

In order to model the proposed reservoir, a new control point named BODARC was added to the Red River WAM between X10200 and X10260 (see Figure 4.2). This control point has a drainage area of 327 square miles. New evaporation records were calculated based on data from the Texas Water Development Board. A new set of storage volume and water surface area records (SV and SA records) were added to the model. These records were based on a new topographic survey of the reservoir site. A detailed table relating storage and water surface area to elevation may be found in Appendix F.



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W S N E

North Texas Municipal Water District

Lower Bois d'Arc and Red River WAM Control Points

FN JOB NO	NTD06128
FILE	Planning_control_points.mxd
DATE	April 2006
SCALE	1:190,080
DESIGNED	GGJ
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4.2

Figure

Table 4.3
Water Rights Potentially Impacted by Lower Bois d'Arc Creek Reservoir Project

Water Rights above Reservoir

WAM Control Point (s)	WAM Water Right ID	WAM Group ID	WR Number	Curtailed Under RR Compact	Owner Name	Amount (Ac-Ft/Yr)	Use	Priority Date	Reservoir Name	Reservoir Capacity (Ac-Ft)	Stream Name	County
X10340	60204921001	A4921	CA 4921	N	Paul & Florence Keahey	109	Irr	12/31/1937			Bois d'Arc Crk & Cooper Crk	Fannin
X10330	60204921002											
X10320	60204922301	A4922	CA 4922	N	Ray Joe Riley & Mary Taylor	362	Irr	12/17/1965			Davis Crk	Fannin
X10310	60204922001											
X10300	60204924301		CA 4924	N	Texas Parks & Wildlife Dept		Rec	12/8/1969		470	Unnamed Tributary of Bois d'Arc Crk	Fannin
X10290	60204923301	A4923	CA 4923	N	Canoe Lake Dev Corp Inc	20	Mun	11/4/1974	City Lake	245	Unnamed Tributary of Bois d'Arc Crk	Fannin
	60204923302						Rec					
X10270	60204925301	A4925	CA 4925	N	Bonham, City of	5,340	Mun, Rec	1/3/1966	Lake Bonham	13,000	Timber Crk	Fannin
	60204925302											
X10260	60204926101		CA 4926	N	Ray Joe Riley Trustee Et Al	520	Irr	8/17/1966			Bois d'Arc Crk	Fannin
X10250	60204927301		CA 4927	N	City of Honey Grove		Rec	2/7/1972		324	Honey Grove Crk	Fannin
						6,351				14,039		

Water Rights below Reservoir on Bois d'Arc Creek

WAM Control Point (s)	WAM Water Right ID	WAM Group ID	WR Number	Curtailed Under RR Compact	Owner Name	Amount (Ac-Ft/Yr)	Use	Priority Date	Reservoir Name	Reservoir Capacity (Ac-Ft)	Stream Name	County
X10190	10204228002		P 3924/A 4228	Y	Paul Crawford Et Al	320	Irr	7/5/1982			Bois d'Arc Crk	Lamar
X10200	60204920001		CA 4920	Y	Pilgrims Pride Corp & Randolph R Gillum Et Ux	640	Irr	2/21/1979			Bois d'Arc Crk	Fannin
						960				0		

Water Rights below Reservoir on Main Stem of the Red River

WAM Control Point (s)	WAM Water Right ID	WAM Group ID	WR Number	Curtailed Under RR Compact	Owner Name	Amount (Ac-Ft/Yr)	Use	Priority Date	Reservoir Name	Reservoir Capacity (Ac-Ft)	Stream Name	County
X10170	10204209001	A4209	P 3888/A 4209	Y	Landrum R & Ronald B Hicks	200	Irr	5/3/1982			Unnamed Tributary	Lamar
X10180	10204209002										Red River	
X10160	60204930001		CA 4930	Y	Ledbetter-Rhode Farm & Ranch	48	Irr	5/19/1959			Red River	Lamar
Not in WAM			P 5617/A 5617		Woerner Land Corporation	1,900	Irr	8/31/1998		2.41	Red River	Lamar
X10140	10205276001		P 5276/A 5276	Y	Woerner Land Corporation	2,535	Irr	1/26/1990			Red River	Lamar
Y10370	60204941002	A4941	CA 4941	Y*	Nolan Butts Et Ux & Charles C Taylor Et Ux	885	Irr	9/17/1970			Unnamed Tributary and Red River	Lamar
	60204941003					2,085	Irr	1/4/1982				
Y10360	60204941301							9/17/1970	Lake Womack	750		
	60204941302											
Y10220	60204946002	A4946	CA 4946	Y	Atlee M Kohl Et Al	1,000	Irr	6/11/1979			Red River	Red River
Y10120	10204392002		P 4058/A 4392	Y	J C Dodson	500	Irr	8/29/1983			Red River	Bowie
Y10110	60204953002		CA 4953	Y	Guy W Farris Co-Trustee Et Al	750	Irr	6/30/1953			Red River	Bowie
Y10080	60204954002		CA 4954	Y	John Wayne Ward & Three Sides Land Co Ltd	1,875	Irr	7/31/1952			Red River	Bowie
Y10060	60204956001		CA 4956	Y	Cranfill Dairy Farms Inc	81	Irr	7/15/1959			Red River	Bowie
Y10040	10205632001		P 5632/A 5632	Y	John Knosby Et Al	800	Irr	6/1/1999			Red River	Bowie
Y10050	60204957003		CA 4957	Y	Joe Conner Hart	67	Irr	12/31/1954			Red River	Bowie
Y10020	60204959002		CA 4959	Y	Texarkana Riverbend Plantation	2,556	Irr	3/6/1978			Red River	Bowie
						15,282				752		

* Only diversions from Red River are subject to curtailment under the Red River Compact. Depletions from Lake Womack watershed are not subject to curtailment.

Using the modified Red River WAM and the Consensus Method bypass criteria (required by the Texas Water Development Board for regional water planning) from Table 4.2, the firm yield of the proposed Lower Bois d'Arc Creek Reservoir is 126,200 acre-feet per year.

4.3 Impacts of the Project on Other Water Rights

The impact of the proposed Lower Bois d'Arc Creek Reservoir can be determined by comparing the reliability of existing water rights. Table 4.3 is a listing of water rights in the Bois d'Arc Creek watershed, as well as water rights below the confluence of Bois d'Arc Creek and the Red River (TCEQ, 2006(b)). However, the WAM model may show impacts on other water rights not directly located below the proposed reservoir, so all water rights were included in the reliability analysis. Using the standard WRAP reliability measurements, there is no change in mean shortage, period reliability, or volume reliability for any permitted diversion right in the Red River WAM. The proposed reservoir causes no injury to existing water rights. A detailed comparison of reliability with and without the reservoir may be found in Appendix G.

4.4 Water Quality Analysis

The water in the proposed Lower Bois d'Arc Creek Reservoir is expected to be of good quality, with mean TDS of 221 mg/L. Table 4.4 is a summary of water quality modeling of TDS, chloride and sulfate concentrations in the proposed reservoir. More detailed information on expected water quality in the reservoir may be found in Appendix H.

Table 4.4
Estimated Water Quality of the Proposed Lower Bois d'Arc Creek Reservoir

Mean Cl (mg/L)	Mean SO4 (mg/L)	Mean TDS (mg/L)	Max 1-yr Running Avg Cl (mg/L)	Max 1-yr Running Avg SO4 (mg/L)	Max 1-yr Running Avg TDS (mg/L)
19	38	221	29	58	330

References for Chapter 4

Texas Commission on Environmental Quality. 2006(a). Red River Basin Water Availability Model, obtained from Kathy Alexander of TCEQ on March 28, 2006.

Texas Commission on Environmental Quality. 2006(b). Water Rights Database, http://www.tceq.state.tx.us/permitting/water_supply/water_rights/wr_databases.html, downloaded June 6, 2006.

Texas Water Development Board. 2001. Exhibit B Guidelines for Regional Water Plan Development.

Texas Water Development Board. 2004. *Water Conservation Best Management Practices*, prepared for the Water Conservation Implementation Task Force, Report 362, November 2004.

United States Geological Survey: *Water Resources Data – Texas*, published annually.

United States Geological Survey: USGS Surface Water Data for Texas, available on-line at http://waterdata.usgs.gov/tx/nwis/sw.

Wurbs, Ralph A. 2005. *Water Rights Analysis Package (WRAP) Reference Manual*, Texas Water Resource Institute Report 255.

5. EXISTING ENVIRONMENTAL CONDITIONS OF THE PROJECT AREA

The following sections discuss environmental issues that must be addressed for an application for a water right permit as prescribed by the Texas Water Code. The information will form the basis for TCEQ's environmental review of the proposed Lower Bois d'Arc Creek Reservoir project. Studies are ongoing and information will be updated as new data become available. This information and additional studies will be used to address the requirements of the required Section 404 permit and Section 401 water quality certification. In the following sections the term "project area" refers to the area of the conservation pool that will be inundated. The data presented will be supplemented by on-the-ground verification as reservoir studies continue.

5.1 Archeological Resources

Archeological studies for new reservoir projects are generally coordinated through the Corps of Engineers and the Texas Historical Commission as part of the Section 404 permitting process. The following studies will probably be needed to comply with the requirements of Section 106 of the National Historic Preservation Act and the Antiquities Code of Texas. Specific requirements will be determined through consultation and coordination with the Corps of Engineers and the Texas Historical Commission as the Section 404 permit process progresses.

5.1.1 Archival Research

Archival research will concentrate on primary sources to obtain information on early historic settlement and historic period Indian occupations. These data can be found in museums, maps and surveyors' field notes, and State Archives. The archival information can help locate historic sites and help interpret sites that are found.

5.1.2 Geomorphology

A geomorphic history of the Lower Bois d'Arc Creek basin will be reconstructed to describe the depositional history of the valley in order to identify potential locations of buried sites and their ages. Included in this study would be backhoe testing to examine soil profiles and obtain samples for radiocarbon dating. Results of this effort will help develop the most appropriate approach for the archeological survey.

5.1.3 Archeological Survey

The project area should be surveyed considering the results of the geomorphology study using appropriate methods (e. g., shovel test, backhoe trenches, etc.) based on the types of landforms encountered. The survey will follow the standards listed in the Secretary of the Interior's Standards and Guidelines and the Chapter 26 Rules of Practice and Procedure for the Antiquities Code of Texas.

5.1.4 Avocational Collections

An experienced regional professional archeologist will contact private citizens with collections of artifacts from the region of the project area. Information from the collections and interviews can provide additional information that can be used to guide the other studies.

5.1.5 Testing and Data Recovery

If sites are discovered, it will be necessary to determine eligibility for the National Register. A research design for testing eligibility will be coordinated with the Corps of Engineers and Texas Historical Commission. Sites that are determined eligible and cannot be preserved or avoided will need to be mitigated through data recovery which could require extensive excavations and documentation.

5.2 Instream Uses

5.2.1 Bois d'Arc Creek

The Texas Commission on Environmental Quality (30 TAC 297.1) defines instream use as "the beneficial use of instream flows for such purposes including, but not limited to, navigation, recreation, hydropower, fisheries, game preserves, stock raising, park purposes, aesthetics, water quality protection, aquatic and riparian wildlife habitat, freshwater inflows for bays and estuaries, and any other instream use recognized by law." A review of available resources was performed in order to determine the instream uses associated with Bois d'Arc Creek.

According to the Texas Natural Resources Code §21.001(3), a "navigable stream" means a stream which retains an average width of 30 feet from the mouth up. In order to determine whether Bois d'Arc Creek meets the requirements of this definition, a field investigation and stream survey will need to be performed. Currently, this information is not available. On the

other hand, a review of the Tulsa District Corps of Engineers list of navigable waters subject to regulation under Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) reveals that Bois d'Arc Creek is not listed as a navigable water of the U. S.

According to the 1979 Texas Parks and Wildlife Department (TPWD) publication, *An Analysis of Texas Waterways,* there is a two-mile stretch of Lower Bois d'Arc Creek immediately above the confluence with the Red River that maintains an average width of 75 feet and normally has enough water to support recreational use. The report notes that the fishing is good and that there are good camping areas where Bois d'Arc Creek passes through the Caddo National Grasslands.

The Texas Commission on Environmental Quality (TCEQ), charged with the responsibility of maintaining and enhancing the waters in the state, has divided surface waters in the state of Texas into numbered segments for the purpose of organizing water quality data and designated water uses and classifications. This information is used to describe the status and trends of the state's waters.

The main segment (as classified by TCEQ) contained within the project area is 0202A – Bois d'Arc Creek (unclassified water body) (TCEQ, 2002). The state's Water Quality Inventory maintains data for every stream segment on chemical and physical parameters, contaminants such as metals, organics, pathogens, and nutrients. Segment fact sheets also provide descriptions, concerns, and information on designated water uses. A description of the various uses that TCEQ rates for designated segments within the state follows:

- Aquatic Life Use - focuses on the ability of waters to support aquatic life. The aquatic life use category has ratings of limited, intermediate, high or exceptional based on physical, chemical and biological characteristics as well as the prevalence and magnitude of toxic chemicals in the water and sediment. The Texas Surface Water Quality Standards include numerical criteria (as maximum instream concentrations) for 39 toxic pollutants in order to protect aquatic life;
- Contact Recreation Use - includes recreational activities involving a significant risk of ingestion, including wading by children, swimming, water skiing, diving and surfing. This use is assigned to all water bodies except special cases but it is not a guarantee that the water is completely free of disease-causing organisms. A coliform density of 400 colonies/100ml is used as a screening level;
- Noncontact Recreation Use – includes recreational pursuits not involving a significant risk of water ingestion, such as fishing, commercial and recreational boating, and limited body contact incidental to shoreline activity. The noncontact recreation use for

these water bodies is protected by the same coliform screening levels assigned to contact recreational waters;

- Fish Consumption Use - human health criteria found in the Texas Surface Water Quality Standards are used to protect the fish consumption use. The standards identify levels at which certain toxic substances dissolved in water pose a significant risk that these toxics may accumulate in the tissues of aquatic species.
- Public Water Supply - this use is assigned for those segments that are to be used as a source for public water systems. The indicators used to measure the safety or usability for drinking water includes the presence or absence of substances such as metals or pesticides. The concentration of dissolved solids is also measured since treatment to remove them from drinking water is expensive.

These uses are rated as fully supporting, partially supporting, or not supporting of the use depending upon the percentage of samples that exceed the screening criteria levels. TCEQ conducts use attainability analyses to determine whether the designated uses listed above are appropriately set and whether those uses are impaired. The analysis identifies the causes of use impairments and the results typically bring about changes in use assignments that are reflected in revisions to the Texas Surface Water Quality Standards.

The designated water uses assigned by the TCEQ for segment 0202A – Bois d'Arc Creek (unclassified water body) are aquatic life (Intermediate Aquatic Life Use), contact recreation, and fish consumption use. The aquatic life and contact recreation uses for this segment are classified as "fully supporting," while the fish consumption use was not assessed. In addition, this segment is classified as "fully supporting" for overall use (TCEQ, 2002).

No evidence could be found supporting instream uses associated with hydropower or game preserves for Bois d'Arc Creek. Uses associated with park purposes, aesthetics, water quality, aquatic and riparian wildlife habitat, and freshwater inflows for bays and estuaries are discussed in other sections of the report.

5.2.2 Pilot Grove Creek

Pilot Grove Creek is a tributary of Lake Lavon in the Trinity River Basin. Its headwaters are in Grayson County, south of the City of Tom Bean, and the stream flows south through Collin County to Lake Lavon. Water quality and flow data on Pilot Grove Creek are available for specific sampling episodes from 1986 through July 1987 (USGS, 1986, 1987). Measured

flow in the creek ranged from 11 cfs to over 800 cfs. Total dissolved solids averaged approximately 260 mg/l over this period.

The state water quality monitoring program shows no impairment for Pilot Grove Creek. More recent data collected in the Pilot Grove Creek arm of Lake Lavon are similar to the water quality data reported by the USGS in the mid 1980s. The uses for this segment were not directly assessed, but since there are no known impairments it likely supports aquatic life, contact recreation and water supply. Due to the variable flow in the creek, it does not support non-contact recreational activities such as boating or rafting.

5.2.3 Lake Lavon

Lake Lavon is major water supply reservoir in Collin County. Instream uses for this water source include aquatic life, contact recreation, non-contact recreation, fish consumption and public water supply. The state water quality monitoring program shows no impairment for Lake Lavon.

5.3 Wetlands and Waters of the United States

It is the policy of TCEQ (TAC Title 30 Rule §297.53, Habitat Mitigation) to “achieve" no net loss “of wetland functions and values” that include “water quality protection through sediment catchment and filtration, storage plans for flood control, erosion control, groundwater recharge, and other uses.” Mitigation to offset adverse impacts of lost functions and values is also required.

Section 404 of the Clean Water Act (CWA) of 1977 authorizes the Secretary of the Army, acting through the Corps of Engineers, to issue permits for the discharge of dredged or fill material into waters of the U. S., including some wetlands. Waters of the U. S. are those waters used in interstate or foreign commerce, subject to ebb and flow of tide, and all interstate waters including wetlands. Waters of the U.S. are further subdivided and may include waters such as intrastate lakes, rivers, streams, mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, natural ponds, or impoundments of waters, tributaries of waters, and territorial seas. Jurisdictional boundaries for waters of the U.S. are defined in the field as the ordinary high water marks, which is that line on the shore established by the fluctuations of water and indicated by physical characteristics such as clear, natural lines impressed on the bank,

shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas.

Activities that result in the dredging and/or filling of "jurisdictional waters" are regulated under Section 404 of the CWA. The Corps of Engineers has the responsibility to authorize permitting under the Nationwide Permits, Regional General Permits, or an Individual Permit. The development of Lower Bois d'Arc Creek Reservoir will require a permit from the Corps of Engineers under Section 404 of the CWA. The stream is not defined as navigable under Section 10 of the Rivers and Harbors Act, but is considered waters of the U.S. based on ordinary high water marks. Identified waters of the U.S. that lie within the project area include, but are not limited to, streams, open waters, and wetlands.

Waters of the U.S. located in the project area were calculated from a number of different sources of information using ESRI™ ArcGIS software. Open water and streams were adapted from the National Hydrographic Dataset (NHD) and edited with the foundation of current imagery to obtain stream lengths, classifications, and/or water area. USGS topographic quads were used to cross-check both open waters and streams in the project area. Recent construction of ponds was noted and incorporated into the cover type database as open water.

5.3.1 Streams

The Corps of Engineers divides streams into three different types: ephemeral, intermittent, and perennial. Each of these stream types exhibits an ordinary high water mark. The difference among them is their respective hydrology. During a normal year, a perennial stream has flowing water all year long. The stream flow is primarily comprised of a base flow from groundwater, since the water table is perched above the stream level. Precipitation augments the base flow. Intermittent streams occur in areas where the groundwater table fluctuates above and below the stream bed, flowing only during periods of the year when groundwater provides water for stream flow or during storms. During dry periods, intermittent streams may not have flowing water. An ephemeral stream only flows during, and for a short period after, precipitation events. Groundwater is not a source of water for the stream, since ephemeral stream beds are located above the water table year-round. Runoff from rainfall is the primary source of water for flow in an ephemeral stream.

The streams contained within the project area are Bois d'Arc Creek and its tributaries, which are classified as perennial and intermittent stream segments. Approximate total lengths of stream by type within the project area are shown in Table 5.1.

Bois d'Arc Creek eventually empties into the Red River that flows east through Louisiana to the Atchafalaya River and the Gulf of Mexico. The confluence of Bois d'Arc Creek with the Red River is located approximately 11 miles (20.08 stream miles) to the northeast of the proposed dam location. The Red River is classified by the Corps of Engineers as navigable water from the U.S. Highway 71 Bridge at the Texas-Arkansas state line upstream to the Oklahoma-Arkansas state line and from Denison Dam on Lake Texoma upstream to Warrens Bend, approximately 7.25 miles north-northeast of Marysville, in Cooke County, Texas.

Table 5.1
Stream Types and Length in Miles Located in the Project Area

	Type	Stream Miles
Natural	Perennial	41.4
	Intermittent	75.0
Channelized	Perennial	5.7
	Intermittent	5.3
Total		**127.3**

5.3.2 Open Waters

Deepwater aquatic habitats, or open waters, are those areas that are permanently inundated to a depth greater than 6.6 feet, or a depth less than or equal to 6.6 feet, if there is no rooted emergent or woody vegetation.

Based on infrared aerial photography, approximately 200 open water areas within the project area can be classified as ponds, stock tanks, and small lakes. These are scattered throughout the site and range in size from less than 0.1 acre to 4.59 acres (Table 5.2). No open waters over 5 acres were delineated in the project area.

Table 5.2
Area of Open Waters in the Project Area Divided into Size Classes

Open Water Size	**Area (Acres)**
<1.00 Acres	49.6
1.00 – 5.00 Acres	45.6
>5.00	0.0
Total	**95.2 Acres**

5.3.3 Wetlands

The Corps of Engineers (*Federal Register* 1982) and the Environmental Protection Agency (EPA) (*Federal Register* 1980) jointly define wetlands as "Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." Wetlands generally include swamps, marshes, bogs, and similar areas (Environmental Laboratory, 1987). Wetlands within the project area will be delineated using available information including aerial photography, U. S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) maps, Natural Resource Conservation Service (NRCS) Soil Surveys, state and county hydric soil lists, and U. S. Geological Survey (USGS) topographic maps.

These areas will be verified by subsequent field visits to confirm the boundaries and extents of wetlands, in addition to substantiating that the areas meet the three regulatory wetland indicators (hydrology, soils, and vegetation) which must be met for an area to be classified as wetland. This information will be provided as studies continue.

5.4 Terrestrial Vegetation

5.4.1 Vegetational Area Descriptions

The proposed project area is located in north-central Fannin County. Two of the ten vegetational areas of Texas**,** the Blackland Prairies and the extreme northwestern limit of the Post Oak Savannah (Hatch et al., 1990), occur in Fannin County. The Blackland Prairies vegetational area encompasses approximately 70 percent of southern Fannin County with the Post Oak Savannah / Red River Area occupying the remaining 30 percent of the county, and being restricted to the north near the Red River floodplain. Descriptions of the above mentioned

vegetational areas and some of the more common grasses, forbs, and woody species expected to occur on these sites are given below.

The Blackland Prairie of Texas is a well-defined band stretching roughly three hundred miles from the Red River (Oklahoma border) south to near San Antonio. Topographically, the Blackland Prairie is a nearly level to gently rolling dissected plain; elevations range from about 300 to 800 feet (92 to 244 meters). Roughly speaking, the Blacklands are bounded on the north by the Red River, on the east by the Post Oak Savannah (also called the Oak-hickory) vegetational area, and on the west by the East Cross Timbers and the Lampasas Cut Plain (Diggs et al., 1999).

Although there is considerable variation in the communities of the Blacklands, common dominant grasses of this tall grass prairie ecosystem, prior to and briefly after European settlement, included species such as little bluestem *(Schizachyrium scoparium)*, big bluestem (*Andropogon gerardii)*, Indiangrass (*Sorgastrum nutans)*, switchgrass (*Panicum virgatum)*, eastern gamagrass (*Tripsacum dactyloides)*, tall dropseed (*Sporobolus compositus)*, Texas cupgrass (*Eriochloa sericea)*, Florida paspalum (*Paspalum floridanum)*, and longspike tridens (*Tridens strictus)*. Some of the common forbs include species such as prairie acacia (*Acacia angustissima* var. *hirta*), heath aster (*Aster ericoides*), prairie-bishop (*Bifora americana*), prairie bluet (*Hedyotis nigricans*), black-eyed susan (*Rudbeckia hirta*), and prairie-petunia (*Ruellia humilis*) (Diggs et al., 1999).

It has been well documented that very little remains of the true tall grass prairie ecosystem that once occurred throughout the Blackland Prairie. In fact, estimates of the destruction of this ecosystem range from 98% to 99.9%. Much of this community was destroyed through agricultural practices, i.e. - farming and ranching, dating back to as early as the mid to late 1800's (Diggs et al., 1999). Large areas that were once tall grass prairie are now covered by crops or other introduced and now naturalized species including King Ranch bluestem (*Bothriochloa ischaemum*), Bermuda grass (*Cynodon dactylon*), and Johnson grass (*Sorghum halapense*). These practices, coupled with the loss of natural disturbances such as fire and grazing by the buffalo, have resulted in the majority of this loss. However, losses still occur today through urbanization and invasion of woody and introduced species (Diggs et al., 1999). Site visits performed (April 2006) throughout the proposed project area have confirmed these

reports. Effectively, no native tall grass prairie habitat was observed during these site visits and none could be identified using aerial photography.

Although prairie once predominated, some wooded areas were also natural components of the Blackland Prairie region. Examples include bottomland forests and wooded ravines along the larger rivers and streams, and mottes or clumps in protected areas or on certain soils (Gehlbach, 1988; Nixon et al., 1990; Diamond and Smeins, 1993). Kennemer (1987) indicated that Texas ash (*Fraxinus texensis)*, shin oak (*Quercus sinuata* var. *breviloba)*, and cedar elm (*Ulmus crassifolia)* were dominants. Other noteworthy woody plants include Texas redbud (*Cercis canadensis* var. *texensis)*, ash juniper (*Juniperus ashei)*, Texas mulberry (*Morus microphylla)*, and Texas buckeye (*Ungnadia speciosa)*. Depending on slope and moisture conditions, characteristic species may also include sugarberry (*Celtis laevigata)*, Texas persimmon (*Diospyros texana)*, elbowbush (*Forestiera pubescens)*, possumhaw (*Ilex decidua)*, eastern red cedar (*Juniperus virginiana)*, hoptree (*Ptelea trifoliate)*, Buckley oak (*Quercus buckleyi)*, and Plateau live oak (*Quercus fusiformis)* (Gehlbach, 1988).

As with the true tall grass prairie, bottomland hardwood forests declined significantly following European settlement. These ecosystems have reportedly been lost at an accelerated rate over the past 50 years in southern states (Gosselink and Lee, 1989), with only about 20 million hectares (49,400 million acres) remaining out of an historical area of over 100 million hectares. Most of the loss has reportedly occurred because of clearing for row crop production, although hydrologic modification by water resource development (especially flood control projects) has also had an important impact (Gosselink and Lee, 1989). The bottomland hardwood ecosystem in Texas prior to European settlement once extended over 6.5 million ha; it is estimated that less than 40 percent of this original extent still remains (Frye, 1986), with only a few small and isolated patches of old growth scattered amongst the floodplains of the eastern third of the state.

The *Bottomland Hardwood Protection Plan* (1984) developed by the USFWS identified approximately 3,911 acres of forest adjacent to Bois d'Arc Creek as being priority bottomland hardwood forest (Priority 4). A Priority 4 area is considered "moderate quality bottomlands with minor waterfowl benefits" and is the second lowest value assigned (out of 5). Preliminary site visits performed (April 2006) throughout the proposed project area confirmed that bottomland

hardwood forest habitat as described in the abovementioned report is present but is restricted to the land immediately adjacent to the creeks and streams. However, no old growth bottomland forests were observed, and based on species composition, the bottomland forests appear to be of low to moderate value and in an early to mid-successional stage. Further review of aerial photography within the project area indicates that much of what may have formerly been bottomland hardwood forests have been cleared for agricultural uses.

The Red River Area is a narrow band of vegetation found on the primarily sandy soils adjacent to the Red River in the northeastern portion of North Central Texas, specifically in the northern parts of Lamar, Fannin, and Grayson counties (Diggs et al., 1999). The vegetation in this region is quite different from the vegetation of the rest of North Central Texas. At least part of this band is often classified as part of the Post Oak Savannah (Correll & Johnston 1970; Hatch et al. 1990). Such a classification is justified because a significant component of the vegetation more typically associated with eastern or southeastern Texas extends west along the Red River in microhabitats with special soil or moisture conditions. Even components of the Pineywoods, characteristic of extreme eastern Texas, can be found in this area (Diggs et al., 1999).

In Fannin County, there are still isolated pockets of eastern Texas vegetation. Species reaching their known western limits there include southern red oak (*Quercus falcata*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*), blackgum (*Nyssa sylvatica*), sassafras (*Sassafras albidum*), narrow-leaf wood-oats (*Chasmanthium laxum var. sessiliflorum*), yellow thistle (*Cirsium horridulum*), American burnweed (*Erechtites hieraciifolia*), jewelweed (*Impatiens capensis*), bulbous woodrush (*Luzula bulbosa*), Indianpipe (*Monotropa uniflora*), Canadian lousewort (*Pedicularis Canadensis*), whiteleaf mountainmint (*Pycnanthemum albescens*), slender Indiangrass (*Sorghastrum elliottii*), and narrow-leaved chain fern (*Woodwardia areolata*) (Diggs et al., 1999).

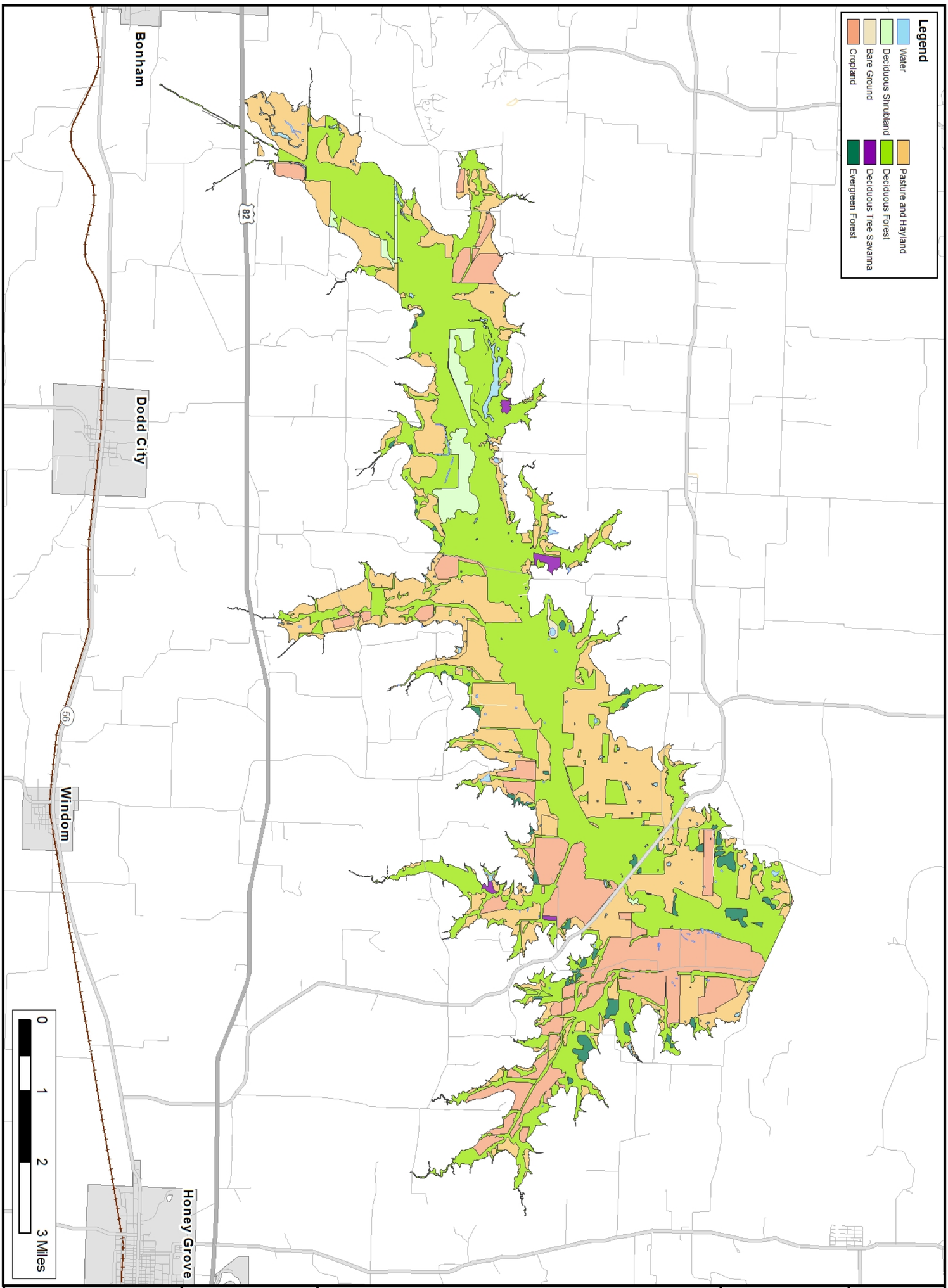
5.4.2 Vegetation and Land Use Mapping

Figure 5.1 and Table 5.3 summarize the results of a preliminary land cover map for Lower Bois d'Arc Creek Reservoir. The methodology used in developing this map is described in Appendix I. It is important to note that this is a preliminary cover type classification based mainly on aerial photograph interpretations with limited field verification due to restricted access. As access to the properties within the study area becomes more available, these numbers

will be updated with more accurate information. USFWS descriptions of these cover types are described below:

Figure 5.1 HEP Cover Types

- Barren Land. The Barren Land type has less than 1% total vegetation cover. It includes sand dunes, rock outcrops, snow fields, etc.
- Evergreen Forest. The Forest type is dominated by trees (taller than 5 m), with a tree canopy cover of at least 25%. Evergreen types are those in which at least 50% of the total canopy of the dominant stratum (layer) consists of species that retain green foliage throughout the year.
- Deciduous Forest. The Deciduous types are those in which at least 50% of the total canopy of the dominant stratum (layer) consists of species that completely shed their foliage during part of the year.
- Deciduous Shrubland. The Shrubland type is dominated by shrubs (including small trees shorter than 5 m), and has a shrub canopy cover of at least 25%. The Deciduous types are those in which at least 50% of the total canopy of the dominant stratum (layer) consists of species that completely shed their foliage during part of the year.
- Herbaceous Wetland. The Herbaceous Wetland type is dominated "…by erect, rooted, herbaceous hydrophytes…", including "…areas where mosses and lichens cover substrates other than rock…" (Cowardin et al., 1979, p.21) and "…plants that grow principally on or below the surface of the water for most growing seasons in most years." (Cowardin et al., 1979, p.16). It has a total vegetation cover (excluding… "pioneer species that briefly invade wetlands when conditions are favorable…") (Cowardin et al., 1979, p.13) of greater than 30 percent. Note, this includes the "Emergent Wetland" and "Moss-Lichen Wetland" classes, and the "Aquatic Bed" class (when it occurs in wetlands) of Cowardin et al., 1979.
- Forested Wetland. The Forested Wetland type is dominated by woody vegetation that is 6 m (20 feet) tall or taller. It has a total vegetation cover greater than 30%.
- Scrub-Shrub Wetland. The Scrub-Shrub Wetland type is dominated by woody vegetation less than 6 m (20 feet) tall. It has a total vegetation cover greater than 30%.
- Deciduous Tree Savanna. The Tree Savanna type has a canopy cover of trees (taller than 5 m) between 5% and 25%, but has a total canopy cover of all vegetation of at least 25%. The area between trees is typically dominated by grasses or other herbaceous vegetation. The Deciduous types are those in which at least 50% of the total canopy of the dominant stratum (layer) consists of species that completely shed their foliage during part of the year.
- Pasture and Hayland. The Pasture and Hayland type is dominated by perennial grasses and forbs (usually legumes), native or introduced, that are mowed at least once per year or periodically plowed and planted primarily for livestock grazing. These areas are usually dominated by one or a few species of grasses or legumes. This type excludes native rangeland.



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W S N E

North Texas Municipal Water District
Proposed Lower Bois D'Arc Creek Reservoir

HEP Cover Types

FN JOB NO	NTD06128
FILE	CoverTypesWR.mxd
DATE	September 2006
SCALE	1:85,000
DESIGNED	BME
DRAFTED	BME

5.1

Figure

- Cropland. The Cropland type is utilized for the growth of agricultural crops that are planted and harvested annually, excluding pasture and hayland.
- Water (Lacustrine). "The Lacustrine [cover type] includes wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% areal coverage; and (3) total area exceeds 8 ha (20 acres). Similar wetlands and deepwater habitats totaling less than 8 ha are also included in the Lacustrine System if an active waveformed or bedrock shoreline feature makes up all of part of the boundary, or if the water depth exceeds 2 m (6.6 feet) at low water. Lacustrine waters may be tidal or nontidal, but ocean-derived salinity is always less than 0.5 [parts per thousand]." (Cowardin et al., 1979, p.11-12). (Note that only the "Limnetic" subsystem of Cowardin et al., 1979, is a "Deepwater Habitat". The "Littoral" subsystem is included in "Wetlands".)

Table 5.3

Summary of HEP Cover Types within the Conservation Pool (534 ft. msl) of the Proposed Lower Bois d'Arc Creek Reservoir

Cover Type	Acres[1]	Percent
Barren Land	20	0.1%
Cropland	2,400	14.5%
Deciduous Forest	7,910	47.9%
Deciduous Shrubland	400	2.4%
Deciduous Tree Savanna	60	0.4%
Evergreen Forest	260	1.6%
Pasture and Hayland	5,300	32.1%
Water (Lacustrine)	180	1.1%
TOTAL	**16,530**	**100%**

1. Acres by cover type are rounded up to the nearest 10 acres.

5.5 Wildlife and Fisheries

5.5.1 Wildlife

A wide variety of wildlife species is known to occur in this location due to the size of the project area and the variety of terrestrial habitat types that can be found in the region. The Blackland Prairie is habitat for more than 500 native faunal taxa including 327 species of birds (Schmidly et al., 1993). The Bois d'Arc Creek watershed, including its channels, tributaries,

wetlands, open water areas, grasslands, upland and bottomland forests, supports a variety of wildlife species by providing water, cover, food, and den or nesting sites. A few of the bird species which are known to occur in the area include migratory warblers (Family Parulidae), a variety of sparrows (Family Emberizidae), Eastern meadowlark (*Sturnella magna*), Western meadowlark (*Sturnella neglecta*), mourning dove (*Zenaida macroura*), American crow (*Corvus brachyrhynchos*), red-tailed hawk (*Buteo jamaicensis*), red-shouldered hawk (*Buteo lineatus*), American kestrel (*Falco sparverius*), herons and egrets (Family Ardeidae), mallard (*Anas platyrhynchos*), wood duck (*Aix sponsa*), blue-winged teal (*Anas discors*), green-winged teal (*Anas crecca*), lesser scaup (*Aythya affinis*), great-tailed grackle (*Quiscalus mexicanus*), scissor-tailed flycatcher (*Tyrannus forficatus*), eastern kingbird (*Tyrannus tyrannus*), loggerhead shrike (*Lanius ludovicianus*), red-winged blackbird (*Agelaius phoeniceus*), swallows (Family Hirundinidae), blue jay (*Cyanocitta cristata*), Carolina chickadee (*Poecile carolinensis*), downy woodpecker (*Picoides pubescens*), red-bellied woodpecker (*Melanerpes carolinus*), wild turkey (*Meleagris gallopavo*), and barred owl (*Strix varia*).

Some of the more common amphibians, reptiles, and mammals within the area include a variety of frogs (*Rana spp.*), toads (*Bufo spp.*), snakes (Family Colubridae and Viperidae), water and box turtles (Family Emydidae), eastern cottontail (*Sylvilagus floridanus*), hispid cotton rat (*Sigmodon hispidus*), fulvous harvest mouse (*Reithrodontomys fulvescens*), Virginia opossum (*Didelphis virginiana*), common raccoon (*Procyon lotor*), white-tailed deer (*Odocoileus virginianus*), bobcat (*Lynx rufus*), American beaver (*Castor canadensis*), nutria (*Myocastor coypus*), striped skunk (*Mephitus mephitus*), red fox (*Vulpes vulpes*), and coyote (*Canis latrans*).

5.5.2 Fisheries

Bois d'Arc Creek rises in the eastern portion of Grayson County near Whitewright, Texas, and flows in a northeasterly direction across Fannin County to enter the south bank of the Red River. TPWD (1974) described the creek as generally running clear over a predominantly sandy substrate and supporting a diverse assemblage of fish species. However, a reconnaissance report prepared by the Corps of Engineers (2000) noted that in 1927, local interests organized three drainage districts, and the upper two-thirds of Bois d'Arc Creek was modified through construction of a straight channel. The report also noted losses to the riparian corridor and

associated stream bank vegetation from agricultural practices that have resulted in siltation of the stream, bank caving, and elevated stream temperatures.

A review of available fisheries data and other literature from Bois d'Arc Creek, portions of the Red River, Sulphur River, and nearby reservoirs was performed to determine the fish species that are expected to occur within Bois d'Arc Creek. A summary of that information follows.

A survey that was conducted in 1982 found over 20 species of fish in Bois d'Arc Creek, including spotted gar (*Lepisosteus oculatus)*, common carp *(Cyprinus carpio)*, river carpsucker *(Carpiodes carpio)*, channel catfish *(Ictalurus punctatus)*, golden shiner *(Notemigonus crysoleucas)*, smallmouth buffalo *(Ictiobus bubalus)*, red shiner *(Cyprinella lutrensis)*, largemouth bass *(Micropterus salmoides)*, white crappie *(Pomoxis annularis)*, freshwater drum *(Aplodinotus grunniens)*, western mosquitofish *(Gambusia affinis)* , and several sunfish *(Lepomis spp.)* species (TPWD, 2000).

A more recent survey, *An Assessment of the Biological Integrity of the Eastern Red River Basin in Texas,* was completed in 1998 by the Red River Authority. In this study, Rapid Bioassessment methodologies were used for the quantification of a biological integrity score using Rapid Bioassessment Protocols. This was done for 10 monitoring stations located in the eastern Red River Basin in Texas. Two of the 10 monitoring stations were located on Bois d'Arc Creek, one five miles downstream of US 82 and the other at FM 100. Each sampling site was classified as being in Limited (<35), Intermediate (35-40), High (41-48), or Exceptional (>48) condition. The calculated Index of Biological Integrity (IBI) scores for both locations in Bois d'Arc Creek were 35, giving them an Intermediate classification. Fish species collected include the bullhead minnow (*Pimephales vigilax)*, Texas shiner *(Notropis amabilis)*, red shiner, western mosquitofish, bluegill *(Lepomis macrochirus)*, longear sunfish *(Lepomis megalotis)*, largemouth bass, common carp, warmouth *(Lepomis gulosus)*, blackstripe topminnow *(Fundulus notatus)*, and yellow bullhead *(Ameiurus natalis).*

After completing the review of available fisheries data and identifying the fish species that are known to occur in Bois d'Arc Creek, a more thorough review at the species level was performed to determine preferences for habitat types and to determine if the species could survive in riverine and lacustrine environments. As part of this review, personnel from TPWD

were contacted to provide survey reports prepared as part of their Statewide Freshwater Fisheries Monitoring and Management Program. Survey reports from Lake Coffee Mill, Lake Davy Crockett, Lake Texoma, and Bonham City Lake were reviewed to determine if species from Bois d'Arc Creek have also been documented from these local impoundments. Eleven of the 15 identified species or groups (73.33%) have been documented from these reservoirs according to the TPWD survey reports. (It is important to note that these survey reports completed by TPWD deal primarily with sport fish and important prey species. As such, not all species of fish collected or observed during the surveys are reported or discussed in the reports.) All species or groups (100%) have been documented from other lacustrine habitats, or their ability to survive in a lacustrine environment has been determined. A summary of this information is provided in Table 5.4.

Based on the species identified in Table 5.4, it is apparent that a majority of the fish assemblage in Bois d'Arc Creek is comprised of generalist species, able to survive in both riverine and lacustrine habitats. The finding of mainly generalist species and the ability of these species to survive in two completely different aquatic environments comes as no surprise. One reason is that species that inhabit streams with large environmental variability (such as the species found in Bois d'Arc Creek) have evolved to cope with disturbance in areas where environmental conditions can be extreme and somewhat unpredictable (Poff and Ward, 1990). In addition, Poff and Allan (1995) noted that although habitats in warm water prairie streams can be spatially homogenous, highly dynamic flow regimes (frequent spates and seasonal drying) cause strong temporal variation in habitat characteristics. In such streams, generalist species that can use a variety of habitats are common and may comprise a large component of the assemblage. Similar results have been found in other studies performed in the same geographical area. Gelwick and Morgan (2000) and Morgan (2002) examined fish habitat utilization on the basis of visually classified mesohabitats (pool, riffle, run, and backwater) identified within the mainstem of the Sulphur River. Both studies reported the fish species within the riverine communities to be habitat generalists. Based on the presence of mainly generalist species within Bois d'Arc Creek and their documented capability of survival in lacustrine habitats, it is doubtful that negative impacts to the fisheries population will result from the proposed project.

Table 5.4
Bois d'Arc Creek Fish Species, Their Preferred Habitat, and Documented Occurrence in Lacustrine Environments

Fish Species	Preferred Habitat	Species Accounts from Local Reservoirs	Reliable Observation or Documentation of Species Occurrence / Survival from Lacustrine Environment
Spotted Gar	The spotted gar requires clear, quiet water with abundant aquatic vegetation. It occurs in backwater areas of rivers, lakes and wetlands. Like other gar species, it is tolerant of warm water with low dissolved oxygen levels. They spawn in shallow, warm water. The spotted gar is also known to enter brackish water (Pflieger 1975, Trautman 1981, Page and Burr, 1991).	Lake Coffee Mill.	Yes
Common Carp	Common carp exploit large and small manmade and natural reservoirs, and pools in slow or fast moving streams. They prefer larger, slower-moving bodies of water with soft sediments but they are tolerant and hardy fish that thrive in a wide variety of aquatic habitats (Page and Burr, 1991; Froese and Pauly, 2002).	Bonham City Lake, Lake Texoma, Lake Coffee Mill, Lake Davy Crockett.	Yes
River Carpsucker	The river carpsucker is highly ubiquitous, occurring in streams and rivers of every size and physical-chemical constitution. It also seems to do well in many reservoirs (Miller and Robison, 1973). Abundant in quiet, silt-bottomed pools and backwaters of rivers and larger creeks having low to moderate gradient. Frequently in impoundments. In Oklahoma, prefers relatively shallow water with little organic matter and large biomass of tubificids (Sublette et al. 1990).	Lake Texoma.	Yes
Channel Catfish	Channel catfish seem to do equally well in streams, rivers, lakes, and ponds. In streams and rivers, they often spend the days in deep pools, under logs and other cover, or in holes in stream banks, venturing out to feed in shallower water at night (Miller and Robison, 1973).	Bonham City Lake, Lake Texoma, Lake Coffee Mill, Lake Davy Crockett.	Yes
Golden Shiner	The golden shiner is basically an inhabitant of quiet waters, being common in larger impoundments, large natural lakes, and in the quieter pools of sluggish streams. It prefers clear waters with much vegetation but can withstand moderate siltation (Miller and Robison, 1973). Common to abundant in ponds and lakes, often in sluggish sections of streams and rivers (NatureServe, 2006).		Yes

Fish Species	Preferred Habitat	Species Accounts from Local Reservoirs	Reliable Observation or Documentation of Species Occurrence / Survival from Lacustrine Environment
Smallmouth Buffalo	Smallmouth buffalo typically inhabit large rivers, preferring deep, clear, warm waters with a current. They frequent low velocity areas, such as pools, creek mouths, and backwaters of large rivers. Smallmouth buffalo can also do well in large reservoirs or lakes and their standing crop increases as the storage ratio decreases (Edwards and Twomey, 1982).	Lake Texoma.	Yes
Red Shiner	The red shiner is very common and widespread and can survive in a wide variety of habitats (Miller and Robison, 1973). The red shiner inhabits perennial rivers, streams, canals, lakes, and ponds as well as ephemeral habitats with high turbidity and few competing species (Sublette et al., 1990).		Yes
Largemouth Bass	Largemouth bass seek protective cover such as logs, rock ledges, vegetation, and man-made structures. They prefer clear quiet water, but will survive quite well in a variety of habitats. It is a highly successful lake and pond fish in Oklahoma but can also do well in the deeper, quiet pools of large streams (Miller and Robison, 1973).	Bonham City Lake, Lake Texoma, Lake Coffee Mill, Lake Davy Crockett.	Yes
White Crappie	White Crappie prefer larger ponds, reservoirs, and rivers. They are tolerant of a wide variety of conditions, including areas of silt and turbidity. This species is usually found near structure such as fallen trees, stumps, docks, rocks, and aquatic vegetation (Ohio Department of Natural Resources, Division of Wildlife, 2005). Because of their tolerance levels, the white crappie has proved to be one of the most successful and prolific of Oklahoma centrarchids. It can be found in almost all kinds of waters (Miller and Robison, 1973).	Bonham City Lake, Lake Texoma, Lake Coffee Mill, Lake Davy Crockett.	Yes
Freshwater Drum	The freshwater drum is most common in the deeper pools of rivers and in many lakes. While they can tolerate turbid waters, they seem to do best in clear waters, especially lakes, and grow fastest in smaller impoundments (Miller and Robison, 1973).	Bonham City Lake, Lake Texoma, Lake Coffee Mill.	Yes

Fish Species	Preferred Habitat	Species Accounts from Local Reservoirs	Reliable Observation or Documentation of Species Occurrence / Survival from Lacustrine Environment
Western Mosquitofish	Western mosquitofish can be found in river channels, margins, backwaters, springs, marshes, and artificial habitats of all kinds (Minckley et al., 1991). Often in shallow, often stagnant, ponds and the shallow edges of lakes and streams where predatory fishes are largely absent and temperatures are high. Most abundant in shallow water with thick vegetation (NatureServe, 2006). Inhabits standing to slow-flowing water; common in vegetated ponds and lakes, backwaters and quiet pools of streams. Frequents brackish water (Page and Burr, 1991).		Yes
Bullhead Minnow	The bullhead minnow prefers pools, backwaters, and quiet runs of small to large rivers having continuous flow and low to moderate gradient, over sand, silt, or gravel; most common in medium-sized rivers; also in some reservoirs; tolerant of turbidity; avoids rapid currents (NatureServe, 2006).		Yes
Texas Shiner	The Texas shiner typically prefers runs and pools of clear springs and headwater tributaries, where it may be very common, sometimes in limited numbers in larger streams. Water usually clear and substrate typically of sand, gravel, and rubble (NatureServe, 2006).		Yes
Blackstripe Topminnow	The blackstripe topminnow prefers small to large, lowland, low-gradient streams and sloughs with water of moderate to high turbidity; quiet water of creeks, rivers, lakes, swamps, drainage ditches, highwater pools of rivers, and ponds (NatureServe, 2006).		Yes
Yellow Bullhead	The yellow bullhead prefers shallow weedy parts of clear warm lakes, ponds, or slow-moving streams or canals. More tolerant of pollution than are most other ictalurids (NatureServe, 2006).	Bonham City Lake, Lake Davy Crockett.	Yes
Sunfish spp.	Most sunfish species inhabit quiet waters, such as sluggish stream reaches, pools, wetlands and lakes. Many favor the cover of macrophytes and woody debris (EPA, 2006).	Bonham City Lake, Lake Texoma, Lake Coffee Mill, Lake Davy Crockett.	Yes

5.6 Endangered and Threatened Species

The Texas Endangered Species Act gives the Texas Parks and Wildlife Department the authority to establish a list of fish and wildlife that are endangered or threatened with statewide extinction. As defined by the statute, "fish and wildlife" excludes all invertebrates except mollusks and crustaceans. No person may capture, trap, take, or kill or attempt to capture, trap, take, or kill listed fish and wildlife species without a permit. Plants are not protected by these provisions. Endangered, threatened or protected plants may not be taken from public land for commercial sale or taken from private land for commercial purposes without a permit. Laws and regulations pertaining to endangered or threatened animal species are contained in Chapters 67 and 68 of the Texas Parks and Wildlife Department (TPWD) Code and Sections 65.171 - 65.184 of Title 31 of the Texas Administrative Code (T.A.C.). Laws and regulations pertaining to endangered or threatened plant species are contained in Chapter 88 of the TPWD Code and Sections 69.01 - 69.14 of the T.A.C.

The Texas Endangered Species Act does not protect wildlife species from indirect take (e.g., destruction of habitat or unfavorable management practices). The TPWD has a Memorandum of Understanding with every state agency to conduct a thorough environmental review of state initiated and funded projects, such as highways, reservoirs, land acquisition, and building construction, to determine their potential impact on state endangered or threatened species.

Section 7 of the federal Endangered Species Act requires federal agencies to consult with the USFWS to ensure that actions they authorize, fund, or carry out will not "jeopardize" listed species. Under Section 9 of the same act, it is unlawful for a person to "take" a listed species. Under the federal definition "take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect or attempt to engage in any such conduct." Included in the definition of harm are habitat modifications or degradation that actually kills or injures a species or impairs essential behavioral patterns such as breeding, feeding or sheltering.

The TPWD lists state and federally listed threatened/endangered species that are known to occur or potentially could occur in Fannin County (Table 5.5). The various habitat requirements are also included. Substantial adverse effects to threatened/endangered species, or their habitats, are not expected from the Lower Bois d'Arc Creek Reservoir. Future

investigations will determine if any endangered or threatened species, or their preferred habitat, are present within the study area, any anticipated effects, and any other pertinent information as related to this project.

The USFWS list of protected species occurring or with the potential to occur in Fannin County (USFWS, 2006) includes the bald eagle (*Haliaeetus leucocephalus*), proposed for delisting, (threatened); least tern (*Sterna antillarum*), endangered; and Louisiana black bear (*Ursus americanus luteolus*), threatened.

Table 5.5

Federal and State Listed Threatened/Endangered Species of Fannin County

	Species	Federal Status	State Status	Description of Suitable Habitat
Birds	American Peregrine Falcon *Falco peregrinus anatum*	DL	E	Found in open country habitats, including tundra, mountainous and coastal areas, and marshes; usually near water. Also in open forested areas. Cliffs are used for nest sites.
	Arctic Peregrine Falcon *Falco peregrinus tundrius*	DL	T	Nests in tundra regions; migrates through Texas; winter inhabitant of coastlines and mountains from Florida to South America. Open areas, usually near water.
	Baird's Sparrow *Ammodramus bairdii*	—	—	Found in short-grass prairie habitats with small shrubs; during migration and winter, also frequents open grasslands and weedy fields.
	Bald Eagle *Haliaeetus leucocephalus*	AD, T	T	Nests and winters near rivers, lakes and along coasts; nests in tall trees or on cliffs near large bodies of water.
	Cerulean Warbler *Dendroica cerulea*	—	—	Found in mature deciduous forests, often in riparian situations; during migration, frequents a wider diversity of woodland habitats.
	Eskimo Curlew *Numenius borealis*	E	E	Found in tundra habitats, and in grasslands, pastures, or plowed fields; may also frequent marshes or mudflats.
	Henslow's Sparrow *Ammodramus henslowii*	—	—	Found in grassy fields and meadows, usually with a weedy and/or shrubby component.
	Interior Least Tern *Sterna antillarum athalassos*	—	E	Nests along sand and gravel bars within braided streams and rivers; also known to nest on man-made structures.
	Mountain Plover *Charadrius montanus*	—	—	Found in open grasslands and short-grass prairie habitats; also in plowed fields or sandy deserts. Nests on the ground; nest is a simple scrape or depression which is sometimes lined with rootlets or dried grasses.

	Species	Federal Status	State Status	Description of Suitable Habitat
	Wood Stork *Mycteria americana*	—	T	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds; breeds in Mexico and birds move into the Gulf states in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960.
Reptiles	Alligator Snapping Turtle *Macrochelys temminckii*	—	T	Deep water of rivers, canals, lakes, and oxbows; also swamps, bayous, and ponds near deep running water; sometimes enters brackish coastal waters; usually in water with mud bottom and abundant aquatic vegetation; may migrate several miles along rivers; active March-October; breeds April-October.
	Texas Garter Snake *Thamnophis sirtalis annectens*	—	—	Usually found in wet or moist microhabitats, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August
	Texas Horned Lizard *Phrynosoma cornutum*	—	T	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; sandy to rocky soil.
	Timber/Canebrake Rattlesnake *Crotalus horridus*	—	T	Swamps, floodplains, upland woodlands, riparian zones, abandoned farmland; prefers dense ground cover, i.e. grapevines or palmetto.
Insects	American Burying Beetle *Nicrophorus americanus*	E	—	Varies widely from oak-hickory and coniferous forest ridge tops or hillsides to riparian corridors and valley floor pastures; extremely xeric, saturated, or loose sandy soils unsuitable; adults primarily above ground, eggs in soil adjacent to buried carcass, teneral adults overwinter in soil.
Fishes	Blackside Darter *Percina maculata*	—	T	Clear, gravelly streams; prefers pools with some current, or even quiet pools, to swift riffles.
	Blue Sucker *Cycleptus elongatus*	—	T	Usually inhabits channels and flowing pools with a moderate current; bottom type usually consists of exposed bedrock, perhaps in combination with hard clay, sand, and gravel; adults winter in deep pools and move upstream in spring to spawn on riffles.
	Creek Chubsucker *Erimyzon oblongus*	—	T	Small rivers and creeks of various types; seldom in impoundments; prefers headwaters, but seldom occurs in springs; young typically in headwater rivulets or marshes; spawns in river mouths or pools, riffles, lake outlets, upstream creeks.

	Species	Federal Status	State Status	Description of Suitable Habitat
	Goldeye *Hiodon alosoides*	—	—	Spawns spring to July in shallow firm-bottomed backwaters or gravel shoals in tributaries, eggs semibuoyant drift downstream or to quiet water; adults in quiet turbid water of medium to large lowland rivers, small lakes, marshes and muddy shallows connected to them; young feed on microcrustaceans and other inverts; adults on surface water insects, also frogs, fishes, and small mammals.
	Orangebelly Darter *Etheoostoma radiosum*	—	—	Spawns February to mid-April, eggs buried in gravel riffles and raceways; post-larvae in quiet water, move to faster water during maturation; adults range from high gradient streams to sluggish lowland streams; headwaters only, gravel and rubble riffles with moderate to high current preferred; young feed mainly on copepods and cladocerans, adults on mayfly and fly larvae.
	Paddlefish *Polyodon spathula*	—	T	Prefers large, free-flowing rivers, but will frequent impoundments with access to spawning sites; spawns in fast, shallow water over gravel bars; larvae may drift from reservoir to reservoir.
	Shovelnose Sturgeon *Scaphirhynchus platorynchus*	—	T	Open, flowing channels with bottoms of sand or gravel; spawns over gravel or rocks in an area with a fast current; never more than a rare occurrence in Rio Grande.
	Western Sand Darter *Ammocrypta clara*	—	—	Clear to slightly turbid water of medium to large rivers that have moderate to swift currents, primarily over extensive areas of sandy substrate.
Mollusks	Fawnsfoot (Common) *Truncilla donaciformis*	—	—	Small and large rivers especially on sand, mud, rocky mud, and sand and gravel, also silt and cobble bottoms in still to swiftly flowing waters; Red (historic), Cypress (historic), Sabine (historic), Neches, Trinity, and San Jacinto River basins.
	Pimpleback (Common) *Quadrula pustulosa*	—	—	Small streams to larger rivers, and associated with nearly every bottom type except deep shifting sands; Red River downstream of Lake Texoma and possibly Big Cypress Bayou and lower Sulphur river basins.
	Pistolgrip *(Tritogonia verrucosa*)	—	—	Stable substrate, rock, hard mud, silt, and soft bottoms, often buried deeply; east and central Texas, Red through San Antonio River basins.
	Plain Pocketbook *(Lampsilis cardium*)	—	—	Small creeks and large rivers, flowing waters, occasionally oxbows or slackwater areas of sandy-bottomed rivers and reservoirs on sand, sand-gravel, or sand-mud but not typically in dense beds; Red and Cypress River basins.

	Species	Federal Status	State Status	Description of Suitable Habitat
	Rock-pocketbook (*Arcidens confragosus*)	—	—	Mud, sand, and gravel substrates of medium to large rivers in standing or slow flowing water, may tolerate moderate currents and some reservoirs, east Texas, Red through Guadalupe River basins.
	Wabash Pigtoe (*Fusconaia flava*)	—	—	Creeks to large rivers on mud, sand, and gravel from all habitats except deep shifting sands; found in moderate to swift current velocities; east Texas River basins, Red through San Jacinto River basins; elsewhere occurs in reservoirs and lakes with no flow.
	White Heelsplitter (*Lasmigona complanata*)	—	—	Typically large rivers and streams with sluggish, turbid waters, on mud or mud-gravel bottoms; also smaller streams and reservoirs usually deep in soft mud or occasionally among rocks; quiet areas of otherwise swift streams; Red River with unsuccessful introductions into the upper Trinity River System.
Mammals	Black Bear *Ursus americanus*	T – by similarity of appearance (east); not listed (west)	T	The Louisiana black bear is a habitat generalist and often overwinters in hollow cypress trees either in or along sloughs, lakes, or riverbanks in bottomland habitats. Constituent elements of black bear habitat include hard and soft mast, escape cover, denning sites, corridor habitats, and some freedom from disturbance by man.
	Plains Spotted Skunk *Spilogale putorius interrupta*	—	—	Catholic in habitat; open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie.
	Red Wolf *Canis rufus* (extirpated)	E	E	Formerly known throughout eastern half of Texas in brushy and forested areas, as well as coastal prairies. It appears that in Texas, red wolves are now extinct.

E - Listed Endangered
T – Listed Threatened
AD - Proposed Delisting
DL – Delisted

" — " – Rare or Species of Concern, but no regulatory listing status

Data Sources: U.S. Fish and Wildlife Service, Texas Parks and Wildlife Department and survey of project area. Updated 5-04-05.

5.7 Water Quality

5.7.1 Bois d'Arc Creek

Historical water quality parameters for Bois d'Arc Creek are summarized in Table 5.6. See Appendix H for data used in calculating mean and median values.

Table 5.6
Water Quality in Bois d'Arc Creek at FM 100

	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
Mean	31	60	343
Median	12.2	43	285

An analysis of the potential water quality on Lower Bois d'Arc Creek Reservoir was performed by modeling historical water quality data from Bois d'Arc Creek and similar tributaries of the Red River in northern Texas counties to estimate concentrations of total dissolved solids, chloride, and sulfate. (See Appendix H.)

In summary, the predicted water quality parameters for the proposed reservoir are shown in Table 5.7. The mean concentrations in the reservoir are somewhat lower than the mean stream concentrations because most of the inflow to a reservoir occurs from high flow events, which generally have lower than average concentrations of chloride, sulfate and TDS.

Table 5.7
Estimates of Water Quality in Proposed Lower Bois d'Arc Creek Reservoir

Mean Cl (mg/L)	Mean SO4 (mg/L)	Mean TDS (mg/L)
19	38	221

5.7.2 Pilot Grove Creek

Water quality data for Pilot Grove Creek is available for selected sampling episodes in 1986 and 1987. The sampling location (USGS Gauge 08059300) is in Collin County, approximately 3.2 miles south of the City of Blue Ridge. The mean and median concentrations for total dissolved solids, chlorides and sulfates are shown in Table 5.8. The water quality in this stream is generally good with dissolved solid concentrations similar to those measured in Bois d'Arc Creek. Chloride and sulfate concentrations are well below the drinking water standards.

Table 5.8
Water Quality Measurements in Pilot Grove Creek

Date	Streamflow Instantaneous (cfs)	Dissolved Solids (mg/l)	Chloride (mg/l)	Sulfate (mg/l)
1/7/1986	15	320	11	22
2/6/1986	189	160	4.5	16
4/1/1986	17	300	9.5	18
5/10/1986	803	140	3.6	13
7/8/1986	11	290	8	20
4/17/1987	19	320	13	29
6/2/1987	69	260	6.1	17
7/21/1987	13	280	11	17
Mean		**259**	**8.3**	**19**
Median		**285**	**8.8**	**18**

5.8 Groundwater Resources

The aquifer system underlying Fannin County is the Trinity/Woodbine, which is composed of four units that are confined and separated by relatively impermeable clay and carbonate units. From youngest to oldest, the aquifer units are: the Woodbine Formation, the Paluxy Formation, the Hensell Member, and the Hosston Member. The Paluxy Formation, the Hensell Member, and the Hosston Member are the three aquifer units which encompass the Trinity portion of the Trinity/Woodbine aquifer system (R.W. Harden & Associates, Inc., 2004).

The youngest aquifer unit in the Trinity/Woodbine aquifer system is the Woodbine Formation. In Fannin County, the Woodbine Formation completely overlies the Trinity Aquifer. This formation outcrops along the Red River in northern Fannin County. In the vicinity of the proposed Lower Bois d'Arc Creek Reservoir site, the top of the Woodbine Formation lies between 500 and 1,000 feet below the ground surface. Historical water levels range from 200 to 250 feet msl, which is about 300 feet below the ground surface.

The Woodbine Aquifer is the primary source of groundwater in Fannin County. Small amounts of water are used from the underlying Trinity Aquifer, but generally the shallower Woodbine Formation is used. The proposed Lower Bois d'Arc Creek Reservoir would have little to no interactions with the Woodbine Aquifer because it does not overlie the recharge zone and there is over 500 feet of confining layer between the two water sources.

References for Chapter 5

Correll, D.S. and Johnston. 1970. *Manual of the Vascular Plants of Texas*. Texas Research Foundation, Renner.

Diamond, D.D. and F.E. Smeins. 1993. "The native plant communities of the Blackland Prairie." In: M.R. Sharpless and J.C. Yelderman, eds. *The Texas Blackland Prairie, land, history, and culture*. Pp. 66-81. Baylor Univ. Program for Regional Studies, Waco, TX.

Diggs, G. M., Lipscomb R. J, and O'Kennon, B. L. 1999. Illustrated flora of North Central Texas. Botanical Research Institute of Texas, Fort Worth, Texas, USA.

Edwards, E. A., and K. Twomey. 1982. Habitat suitability index models: smallmouth buffalo. U.S. Department of Interior Fish Wildlife Services. FWS/OBS – 82/10.13. 28pp.

Environmental Laboratory. 1987. *Corps of Engineers Wetlands Delineation Manual, Technical Report* Y-87-1, U.S. Army Engineer Waterways Experiment Station. Vicksburg, MS.

Environmental Protection Agency (EPA). 2006. Biological Indicators of Watershed Health. http://www.epa.gov/bioindicators/html/fish_sunfish.html

Flores, R.R. and Wasinger, B. 2004. *Texas Water Law Glossary: The changing face of water rights in Texas.* State Bar of Texas, San Antonio.

Froese, R., and D. Pauly. 2002. *FISHBASE*. World Wide Web electronic publication. www.fishbase.org.

Frye, K. 1986. *Roadside Geology of Virginia*. Mountain Press Publishing Company, Missoula, Montana. 278 pp.

Gehlbach, F.R. 1988. Forests and woodlands of the northeastern balcones escarpment. In: B.B. Amos and F.R. Gehlbach, eds. *Edwards Plateau vegetation: Plant ecological studies in central Texas*. Pp. 57-77. Baylor Univ. Press, Waco, TX.

Gelwick, F.P. and Morgan, M. N. 2000. Microhabitat use and community structure of fishes downstream of the proposed George Parkhouse I and Marvin Nichols I reservoir sites on the Sulphur River, TX. Texas Water Development Board Contract No. 98-483-234. Texas A&M University, Department of Wildlife and Fisheries Sciences, College Station, TX 77843-2258. 124.

Gosselink, J. G. and Lee, L. C. 1989. Cumulative impact assessment in bottomland hardwood forests. *Wetlands* 9:89-174.

Harden, R.W. & Associates, Inc. 2004. *Northern Trinity/ Woodbine Aquifer Groundwater Availability Model*, prepared for the Texas Water Development Board, August 2004.

Hatch, S.L., K.N. Gandhi, and L.E. Brown. 1990. Checklist of the vascular plants of Texas. Texas Agric. Exp. Sta. Misc. Publ. 1655:1-158.

Kennemer, G.W. 1987. A quantitative analysis of the vegetation on the Dallas County White Rock Escarpment. Sida, Bot. Misc. 1:1-10.

Miller, R. J. and H. W. Robison. 1973. The fishes of Oklahoma. Oklahoma State University Press, Stillwater. 246 pp.

Minckley, W. L., G. K. Meffe, and D. L. Soltz. 1991. Conservation and management of short-lived fishes: the cyprinodontoids. Pages 247-82 in W. L. Minckley and J. E. Deacon (editors). *Battle Against Extinction: Native Fish Management in the American West*. University of Arizona Press, Tucson, Arizona.

Morgan, M.N. 2002. *Habitat Associations of Fish Assemblages in the Sulphur River, Texas*. Master's thesis. Texas A7M University, College Station, Texas.

NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.7. NatureServe, Arlington, Virginia. http://www.natureserve.org/explorer. (Accessed: March 28, 2006).

Nixon, E.S., G.A. Sullivan, S.D. Jones, G.D. Jones, and J.K. Sullivan. 1990. *Species Diversity of Woody Vegetation in the Trinity River Basin, Texas.* Castanea 55:97-105.

Ohio Department of Natural Resources, Division of Wildlife, 2005. http://www.dnr.state.oh.us/wildlife/fishing/aquanotes-fishid/wcrappie.htm

Page, L.M. and B.M. Burr, 1991. *A field guide to freshwater fishes of North America north of Mexico*. Houghton Mifflin Company, Boston. 432 pp.

Pflieger, W. L. 1975. *The Fishes of Missouri*. Missouri Department of Conservation. 343 pp.

Poff, N.L. and Allan, J.D. 1995. "Functional organization of stream fish assemblages in relation to hydrologic variability," *Ecology* 76: 606-627.

Poff, N.L. and Ward, J.V. 1990. "Physical habitat template of lotic systems: recovery in the context of historical pattern of spatiotemporal heterogeneity," *Environmental Management*. Vol. 14, No. 5: 629-645.

Red River Authority. 1998. *An Assessment of the Biological Integrity of the Eastern Red River Basin in Texas*, Wichita Falls, TX. http://www.rra.dst.tx.us/

Schmidly, D.J., K.T. Wilkins, and J.N. Derr. 1993. Biogeography. Pp. 319-356. In: *Biology of the heteromyidae*. Edited by H.H. Genoways and J.H. Brown. Amer. Soc. Of Mammologists, Special Publication No. 10, Provo.

State of Texas, 2006. Texas Statutes: Natural Resources Code, Chapter 21: surveys and field notes. Subchapter A: general provisions. http://www.capitol.state.tx.us/statutes/nrtoc.html.

Sublette, J. E., M. D. Hatch, and M. Sublette. 1990. *The fishes of New Mexico*. University of New Mexico Press, Albuquerque, New Mexico.

Texas Commission on Environmental Quality (TCEQ). 2002. 2002 Texas Water Quality Inventory and 303(d) List. http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/02twqi/twqi02.html

Texas Natural History Collections. 2005. Specimen Detail: *Notropis amabilis*. The University of Texas at Austin. http://www.npl.utexas.edu/tnhc/databases/Fish/na_searches/nadetail.asp?TNHC=1358

Texas Parks and Wildlife Department (TPWD). 1974. *An analysis of Texas waterways: a report on the physical characteristics of rivers, streams, and bayous in Texas*. Conducted by Harold J. Belisle and Ron Josselet. Austin: Dept. of Agricultural Communications, Texas Agricultural and Extension Service, 1974. 240 p. ill., maps.

Texas Parks and Wildlife Department (TPWD). 2000. *Ecologically significant river and stream segments of Region C, regional water planning area*: http://www.tpwd.state.tx.us/publications/pwdpubs/pwd_rp_t3200_1059a/

Texas Parks and Wildlife Department (TPWD). 2002. Performance report as required by Federal Aid in Sport Fishing Restoration Act, Texas: federal aid project F-30-R-27: statewide freshwater fisheries monitoring and management program: 2001 survey report: Lake Coffee Mill.

Texas Parks and Wildlife Department (TPWD). 2002. Performance report as required by Federal Aid in Sport Fishing Restoration Act, Texas: federal aid project F-30-R-27: statewide freshwater fisheries monitoring and management program: 2001 survey report: Lake Davey Crockett.

Texas Parks and Wildlife Department (TPWD). 2005. Performance report as required by Federal Aid in Sport Fishing Restoration Act, Texas: federal aid project F-30-R-30: statewide freshwater fisheries monitoring and management program: 2004 survey report: Bonham City Reservoir.

Texas Parks and Wildlife Department (TPWD). 2005. Performance report as required by Federal Aid in Sport Fishing Restoration Act, Texas: federal aid project F-30-R-30: statewide freshwater fisheries monitoring and management program: 2004 survey report: Texoma Reservoir.

Texas Parks and Wildlife Department (TPWD). 2005. *An Analysis of Bottomland Hardwood Areas at Three Proposed Reservoir Sites in Northeast Texas*. Final report to Texas Water Development Board for the fulfillment of interagency agreement No. 97-483-211. http://www.tpwd.state.tx.us/publications/pwdpubs/pwd_rp_t3200_1057a/#anchor163890

Trautman, M.B. 1981. The fishes of Ohio. Ohio State University Press. 782 pp.

U.S. Army Corps of Engineers (USACE). 2000. Bois d'Arc Creek Basin: Section 905(b) (WRDA) Analysis.

U.S. Fish and Wildlife Service (USFWS). 1981. *Ecological Services Manual: Standards for the development of habitat suitability index models*. Appendix E, Part 103 ESM, Release Number 1-81.

U.S. Fish and Wildlife Service (USFWS). 2006. List of protected species, downloaded from http://www.fws.gov/ifw2es/endangeredspecies/lists/ListSpecies.cfm

Wilde, G.R., Weller, R.R., Smith, C.D., and R. Jimenez, Jr. 1996. *A Review of the Distribution and Status of Fishes in the Red River Basin upstream from Lake Texoma*. Department of Range, Wildlife, and Fisheries Management, Texas Tech University, Lubbock, Texas.

6. IMPACTS OF THE PROPOSED PROJECT

The Texas Water Code (Chapter 11) requires that the environmental effects of issuing a water right be considered. Resources that are required to be assessed are fish and wildlife habitat (§11.152); water quality (§11.150); bays and estuaries (§11.147 and §11.1491); and instream uses (§11.147). Additional requirements are also found in the Texas Administrative Code, Title 30 - fish and wildlife habitat (§297.53); water quality (§297.54); bays and estuaries (§297.55); and instream uses (§297.56).

TCEQ requires that the environmental assessment include "the project site as well as potentially impacted habitat upstream, adjoining, and downstream of the project site" and to mitigate adverse impacts to fish and wildlife habitat after considering any beneficial benefits of the project. It is also the policy of TCEQ to achieve no net loss of wetland functions and values that include "water quality protection through sediment catchment and filtration, storage plans for flood control, erosion control, groundwater recharge, and other uses."

Water right permit reviews shall examine both direct and indirect impacts to terrestrial and riparian habitats, as well as long and short-term effects to the watershed or ecoregion that may result from the permitted activity.

The following discussion of impacts of the Lower Bois d'Arc Creek Reservoir project is preliminary and will be supplemented after more studies are completed, including wetland delineations and classifications; Habitat Evaluation Procedures (HEP) studies; and functional assessments.

6.1 Archeological Resources

The impacts of the proposed Lower Bois d'Arc Creek Reservoir will be evaluated based on the studies outlined after consultation with the Corps of Engineers and Texas Historical Commission. An evaluation to estimate potential impacts will include a search of the Texas Historical Commission database of known cultural resource sites and listings found in the National Register of Historic Sites and Texas Archeological Landmarks.

6.2 Instream Uses

6.2.1 Bois d'Arc Creek

Impacts to instream uses will be from the conversion of ephemeral, intermittent, and perennial stream habitats to a reservoir environment. The uses of aquatic life, contact recreation, noncontact recreation, and fish consumption will all be enhanced and expanded. The public water supply use will be greatly enhanced by the construction and operation of the Lower Bois d'Arc Creek Reservoir.

Impacts to instream uses downstream of the dam will be mitigated through environmental flow releases and proposed stream restoration of Bois d'Arc Creek below the dam. These activities are included in the design of the project to compensate for losses of stream function and wildlife habitat, and when completed may enhance instream uses below the dam. A stream flow study is planned to assess the current conditions and potential impacts from the project.

6.2.2 Pilot Grove Creek

Impacts to instream uses from the conveyance of water from Lower Bois d'Arc Creek Reservoir to Lake Lavon are expected to be minimal. Pilot Grove Creek has the ability to convey the requested quantity of water. Previous measurements of stream flow in the creek exceeded 800 cfs. With a discharge of 236 mgd, the maximum additional flow in Pilot Grove Creek will be less than 370 cfs. The proposed discharge location will be approximately 3 to 7 miles upstream from Lake Lavon, in the lower reach of the stream that has a larger carrying capacity and can accommodate the additional flow. NTMWD will not release water to Pilot Grove Creek when the creek is in flood conditions.

The water from Lower Bois d'Arc Creek Reservoir is expected to be of similar quality to the water in Pilot Grove Creek. The additional water will provide enhanced habitats for aquatic and wildlife along the stream segment.

6.2.3 Lake Lavon

The conveyance of water from Lower Bois d'Arc Creek Reservoir through Lake Lavon will not have negative impacts to the lake. The quality of water from Lower Bois d'Arc Creek Reservoir will enhance the quality in Lake Lavon.

The water from Lower Bois d'Arc Creek Reservoir will be diverted at existing diversion locations on Lake Lavon. The quantities diverted will be tracked through NTMWD's accounting plan and will not exceed the volume of water released to Pilot Grove Creek less carriage losses.

6.3 Wetlands and Waters of the U. S.

Impacts to wetlands and waters of the U. S. will be the conversion of streams and wetlands to reservoir open water habitats. Quantification of the areal extent, functions, and values of these waters will be made as part of ongoing and planned future studies and impact assessments. Preliminary desktop estimates of the lengths of streams that will be inundated are based on the USGS National Hydrographic Dataset:

- Unchannelized Perennial Streams, 41.4 miles
- Unchannelized Intermittent Streams, 75.0 miles
- Channelized Perennial Streams, 5.7 miles
- Channelized Intermittent Streams, 5.3 miles

There are also approximately 95 acres of ponds, stock tanks and small lakes identified in the National Hydrographic Dataset that will be inundated by the proposed reservoir.

Impacts to wetlands will be determined after on-the-ground delineations are completed.

6.4 Terrestrial Vegetation

Impacts to terrestrial vegetation will be direct inundation of approximately 16,526 acres by the proposed reservoir. An evaluation of impacts by using a multi-agency HEP study is planned. Based on preliminary desktop cover type delineations for the area within the conservation pool boundaries (~ 16,526 acres), approximately 48 percent is deciduous forest, 32 percent pasture/hayland, and 15 percent cropland with small percentages of shrubland, tree savannah and evergreen forest. Characteristic species and community characteristic will be further quantified during the HEP study performed to evaluate habitat values.

6.5 Wildlife and Fisheries

6.5.1 Lower Bois d'Arc Creek Reservoir

Impacts to wildlife and fisheries from the Lower Bois d'Arc Creek Reservoir will be evaluated during ongoing and planned future studies. A HEP study and instream flow studies are planned to help quantify the impacts to wildlife and fisheries and their habitats.

6.5.2 Pilot Grove Creek

No adverse impacts to Pilot Grove Creek are anticipated. The fish fauna in the creek is probably very similar to that found in Sister Grove Creek, which is used to transport water from Lake Texoma to Lake Lavon. Thirty-four species of fish have been documented in Sister Grove Creek with red shiner, western mosquitofish, bullhead minnow and inland silverside being the most abundant (Meador *et. al*., 1990).

6.6 Endangered and Threatened Species

Based on a preliminary review of the proposed Lower Bois d'Arc Creek Reservoir area of inundation and vicinity, no impacts to endangered or threatened species are expected.

6.7 Impacts of Lower Bois d'Arc Creek Reservoir on Downstream Water Quality

The primary impact of the construction of the reservoir on downstream mineral concentrations will be to reduce the observed variability in these parameters. Water released from the reservoir during wet weather conditions will likely have higher mineral content than that entering the stream as direct runoff. However, low-flow releases from the reservoir to meet downstream environmental needs will likely have a lower mineral content than the naturally occurring low flows within the stream.

There could also be changes to temperature, dissolved oxygen, suspended sediment, and other water quality parameters. Further data collection and modeling will be needed to more accurately predict future water quality.

6.8 Groundwater Resources

Lower Bois d'Arc Creek Reservoir is not located over the recharge zone for any major or minor aquifer in Texas, and is not expected to have any significant direct impact on groundwater resources. By providing surface water supply to replace current groundwater use in Fannin

County, the project will indirectly reduce groundwater use from the Woodbine Aquifer. This should result in increased water levels in the aquifer in comparison to levels without the project.

6.9 Bays and Estuaries

Bois d'Arc Creek is a tributary of the Red River and eventually flows into the Atchafalaya River and the Gulf of Mexico. The proposed Lower Bois d'Arc Creek Reservoir is located greater than 200 miles from the coast and therefore permit conditions to maintain beneficial inflows to an affected bay and estuary system are not required. Any impacts due to Lower Bois d'Arc Creek Reservoir on coastal Louisiana and the Gulf of Mexico would be so small as to be insignificant.

6.10 Flooding

Lower Bois d'Arc Creek Reservoir will have minimal impacts on flooding on Bois d'Arc Creek upstream of the proposed reservoir. Studies have shown that for rainfalls greater than or equal to the 10-year event, the reservoir does not add to flood levels upstream from the Highway 82 Bridge. Minor increases in Bois d'Arc Creek water surface elevation are expected for lesser rainfalls. However, this has no impact to flooding in the area. This issue will be examined in greater detail during project development.

References for Chapter 6

Meador, M.R., B.E. Arambala and L.G. Hill. 1990. "Fish Assemblage Structure in an Intermittent Texas Stream," *Texas Journal of Science*, 42(2): 159-165.

7. PROPOSED MITIGATION OF IMPACTS

The potential impacts of the project identified to date are based primarily on readily available literature, mapping, and remote sensing data. Detailed field studies involving the appropriate resource agencies are being planned to refine and quantify the potential impacts of the proposed project. The results of these studies will form the basis for preparation of a detailed compensatory mitigation plan to offset adverse impacts to fish and wildlife habitat, including streams, wetlands and adjacent areas. The mitigation plan will likely encompass several components including, but not necessarily limited to, the following measures:

- Stream restoration and riparian enhancement
- Wildlife habitat area enhancement
- Caddo National Grassland enhancements
- Water quality protection considerations
- Establishment of a waterfowl management area
- Deed restrictions or conservation easements for land preservation and protection

NTMWD is committed to working together with local entities and the resource agencies in developing the mitigation plan. The detailed mitigation plan will be developed and submitted separately upon completion of the studies necessary to define the project impacts. The ultimate goal of the mitigation plan will be to compensate for losses of fish and wildlife habitat after considering benefits of the project and to satisfy the TCEQ policy of achieving no net loss of wetland functions and values.

8. OTHER INFORMATION FOR TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

8.1 Information Required for an Interbasin Transfer Application

As part of this water right application, NTMWD is seeking an interbasin transfer permit to use water from the Lower Bois d'Arc Creek Reservoir to serve existing and future customers in the Trinity, Sabine and Sulphur River Basins. This chapter presents information required for an interbasin transfer permit.

8.1.1 Contract Price for Water

Because NTMWD is the intended owner of the proposed Lower Bois d'Arc Creek Reservoir, there is no contract price for the water.

8.1.2 Categories of Use and Detailed Description of Uses and Users

The NTMWD intends to use the water from the Lower Bois d'Arc Creek Reservoir for wholesale and retail service to its member cities and customers. Existing and future customers include municipal and industrial water users. The NTMWD's current sources of supply include Lake Lavon, Lake Texoma, Lake Chapman, Lake Bonham, and the reuse of treated wastewater effluent discharged into the Lake Lavon watershed. Additional water provided by Lower Bois d'Arc Creek Reservoir will be used to meet the growing demands of the NTMWD's member cities and customers. Table 8.1 lists the existing and potential future NTMWD member cities and customers by the river basin in which they are located. Note that some water users are located in more than one basin.

8.1.3 Costs of Diverting, Conveying, Distributing, Supplying, and Treating the Water

The total capital cost to develop the Lower Bois d'Arc Creek Reservoir project and raw water transmission system to NTMWD is $533 million. On an annual basis, the cost to divert and convey the raw water to NTMWD is $1.26 per 1,000 gallons ($409 per acre-foot). After the debt service is paid, the raw water costs are reduced to $0.20 ($65 per acre-foot). The cost to treat and distribute the water to NTMWD customers is $0.65 per 1,000 gallons. During repayment of the debt service, the total cost of water from Lower Bois d'Arc Creek Reservoir to NTMWD customers is estimated at $1.91 per 1,000 gallons ($621 per acre-foot).

Table 8.1
NTMWD Customers and Member Cities

Water User Group	County Name(s)
Trinity River Basin	
Allen	Collin
Celina [a.]	Collin
College Mound WSC	Kaufman
Crandall	Kaufman
Culleoka WSC	Collin
Danville WSC	Collin
East Fork SUD	Collin, Dallas, Rockwall
Fairview	Collin
Farmersville	Collin
Forney	Kaufman
Forney Lake WSC	Kaufman, Rockwall
Frisco	Collin, Denton
Garland	Dallas
Gastonia-Scurry WSC	Kaufman
Hackberry	Denton
Heath	Rockwall
Howe [a.]	Grayson
Josephine	Collin
Kaufman	Kaufman
Lavon WSC	Collin, Rockwall
Leonard [a.]	Fannin
Little Elm	Denton
Lowry Crossing	Collin
Lucas	Collin
McKinney	Collin
Melissa	Collin
Mesquite	Dallas
Milligan WSC	Collin
Murphy	Collin
N. Collin WSC	Collin
Nevada WSC	Collin
New Hope	Collin
Oak Grove	Kaufman
Parker	Collin
Plano	Collin, Denton

Table 8.1 (continued)

Water User Group	County Name(s)
Trinity River Basin (continued)	
Princeton	Collin
Prosper	Collin, Denton
Richardson	Collin, Dallas
Rockwall	Rockwall
Rowlett	Dallas, Rockwall
Sachse	Collin, Dallas
Saint Paul	Collin
South Grayson County WSC [a.]	Collin, Grayson
Sunnyvale	Dallas
Terrell	Kaufman
The Colony (part) - 10%	Denton
Trenton [a]	Fannin
Van Alstyne [a.]	Grayson
Weston [a.]	Collin
Wylie	Collin, Dallas, Rockwall
Sulphur River Basin	
Honey Grove [a]	Fannin
Leonard [a.]	Fannin
Sabine River Basin	
Caddo Basin SUD	Collin
Cash WSC	Hunt, Rockwall
Nevada WSC	Collin
Royse City	Collin, Rockwall
Red River Basin	
Bonham	Fannin
Ector [a]	Fannin
Honey Grove [a]	Fannin
Howe [a.]	Grayson
Savoy [a]	Fannin
Southwest Fannin County SUD	Fannin

Notes: [a.] Potential future customer

8.1.4 Impact on User Rates

The project is a relatively inexpensive source of water for the District. The estimated costs indicate that existing water user rates would increase by $0.06 per 1,000 gallons, which is about 6 percent higher than existing rates. Alternative strategies would have a greater impact to water user rates.

8.2 Information the Texas Commission on Environmental Quality Is Required to Consider For an Interbasin Transfer Under Texas Water Code §11.085

8.2.1 Water Needs and Available Supplies in the Red River Basin

The Texas Water Development Board data supporting the 2007 Texas state water plan shows that the Red River Basin has a total of 2.2 million acre-feet per year of water that is currently available to users in the basin (Texas Water Development Board, 2006). Of that amount, 443,640 acre-feet per year are surface water and 8,908 acre-feet per year is wastewater reuse. The remainder is groundwater.

The *2006 Region C Regional Water Plan* (Freese and Nichols, *et al*., 2006a) shows reservoirs of over 5,000 acre-feet of conservation storage located in the Red River Basin in Region C to include Moss, Texoma, Randell, Valley, Bonham and Coffee Mill. Moss Lake is used by the City of Gainesville as a water supply. The Red River Authority, the Greater Texoma Utility Authority, City of Denison, the NTMWD, and TXU Electric use water from Lake Texoma. Lake Randell is used by the City of Denison for water supply. Valley Lake, located in Fannin County, is used by TXU Electric. The City of Bonham uses Lake Bonham for water supply. Coffee Mill is a recreational reservoir owned by the U.S. Department of Agriculture in Fannin County.

In Region C, the total water currently available for water supply in the Red River Basin is reported to be 193,240 acre-feet per year. Most of this supply is from surface water (173,790 acre-feet per year). The remaining 19,450 acre-feet per year of currently available supply is groundwater.

There are 40 counties located in the Red River Basin in Texas. These include Archer, Armstrong, Baylor, Bowie, Briscoe, Carson, Castro, Childress, Clay, Collingsworth, Cooke, Cottle, Crosby, Deaf Smith, Dickens, Donley, Fannin, Floyd, Foard, Gray, Grayson, Hale, Hall,

Hardeman, Hemphill, King, Knox, Lamar, Montague, Motley, Oldham, Parmer, Potter, Randall, Red River, Roberts, Swisher, Wheeler, Wichita, and Wilbarger.

Red River Basin Counties in Region A

The counties of Armstrong, Carson, Childress, Collingsworth, Donley, Gray, Hall, Hemphill, Oldham, Potter, Randall, Roberts and Wheeler are located the Red River Basin in Region A of the State Water Plan. The *2006 Panhandle Planning Area Regional Water Plan* reports that water demands for Region A will be met by using a combination of conservation, new groundwater resources, and existing groundwater and reuse. By 2060, these four elements will provide 96% of their total future water use. The remaining 4% will be met from existing surface water. Future water demands in the Red River Basin in the Panhandle Planning Area will be met by conservation and groundwater. There are no new surface water supplies planned. Lower Bois d'Arc Creek Reservoir is not a potential water source for Region A.

Red River Basin Counties in Region B

Region B consists of the counties of Archer, Baylor, Clay, Cottle, Foard, Hardeman, King, Montague, Wichita and Wilbarger, all of which are located in the Red River Basin. The 2006 Region B Water Plan reports that the projected shortages for Region B will be met through conservation, existing surface water, new groundwater and wastewater reuse. There are no new surface water supplies planned in Region B. Of the additional water to be used by Region B, 65% is obtained from existing surface water sources. Less than 2% is associated with new groundwater sources. Lower Bois d'Arc Creek Reservoir is not a potential source for Region B.

Red River Basin Counties in Region C

Cooke, Fannin and Grayson Counties are the only counties in Region C that are located in the Red River Basin. According to the *2006 Region C Water Plan*, the region is projected to meet future water demands by the following methods: 52% from existing surface water, 28% from conservation and reuse of water, 18% from new reservoirs, 2% from existing groundwater, and less than 1% from new groundwater.

Cooke County

Cooke County's current groundwater use exceeds the Region C estimated long-term reliable supply. According to the regional water plan, the county has a projected shortage in 2060 of 6,708 acre-feet per year. The projected shortages in the Red River Basin are 216 acre-feet per year, and will be met through conservation, existing surface water and redistribution of

groundwater supplies. Recommended strategies to meet the remainder of the county's needs also include expanded use of existing surface water, new surface water and purchasing water from the Upper Trinity River Water District. The City of Gainesville has developed and is currently using Moss Lake for surface water supply. Moss Lake can provide surface water supply to Cooke County water users, and has a yield of 4,500 acre-feet per year. The City of Gainesville has notified other water providers in Cooke County of its willingness to make surface water available from Moss Lake to meet future water demands throughout the county, which is consistent with the *2006 Region C Water Plan*. Additional supplies to the county may be available through the Greater Texoma Utility Authority. As part of the Water Resources Development Act of 1986, 50,000 acre-feet of storage in Lake Texoma has been reserved for the Greater Texoma Utility Authority. Cooke County is in the Greater Texoma Utility Authority service area.

Fannin County

According to information adopted by the *2006 Region C Water Plan*, Fannin County will have a projected shortage of 9,196 acre-feet per year for municipal and industrial water use. In the Red River Basin, the projected shortages in 2060 total 5,924 acre-feet per year. Conservation, new surface water and groundwater are recommended to meet these needs. There is a projected surplus of water for irrigation and steam electric power demands. Two potential reservoirs in Fannin County, the Lower Bois d'Arc Creek Reservoir and Lake Ralph Hall, are proposed to be developed for long-term needs in Fannin County and needs outside of the county. Other sources of future water for the county include water from Lake Texoma through the Greater Texoma Utility Authority. Fannin County is in the Greater Texoma Utility Authority service area, and an additional 50,000 acre-feet of storage in Lake Texoma has been reserved for the Authority as a part of the Water Resources Development Act of 1986.

Grayson County

The current groundwater use in Grayson County exceeds the Region C estimated long-term reliable supply. By 2060, the county is projected to have shortages totaling 26,028 acre-feet per year. In the Red River Basin, the shortage is projected at 17,210 acre-feet per year. Much of the shortage is associated with limitations of existing infrastructure and water treatment. Conservation and existing surface water are the primary recommended strategies for the county. It is anticipated that most water users in Grayson County will utilize surface water from Lake Texoma to meet their future needs. The City of Denison currently uses water from Lake Texoma

to supplement Lake Randell. Denison currently provides the City of Pottsboro with water primarily from Lake Randell, supplemented, as necessary, with water from Lake Texoma. Sherman currently uses water from Lake Texoma provided by the Greater Texoma Utility Authority. Also a portion of the additional 50,000 acre-feet of storage in Lake Texoma that has been reserved for the Greater Texoma Utility Authority as a part of the Water Resources Development Act of 1986 will be available for use in Grayson County. Grayson County is in the Greater Texoma Utility Authority service area.

Red River Basin Counties in Region D

Bowie, Lamar and Red River are the only counties in Region D that are located in the Red River Basin. The projected shortages for the region in 2060 total 93,727 acre-feet per year, with shortages of 7,824 acre-feet per year in the Red River Basin. Recommended water management strategies to meet Region D's water needs consist of existing surface water and new groundwater. By 2060, the projected demands in Region D will be met with 84% existing surface water, 9% groundwater and 7% reuse. There is no new surface water recommended to be developed. The Lower Bois d'Arc Creek Reservoir is not projected to be a source of supply for the Red River Basin counties in Region D.

Red River Basin Counties in Region G

The county of Knox is the only county in Region G that is located in the Red River Basin. This area has no dependency on the Red River Basin for surface water.

Red River Counties in Region O

Region O includes the counties of Briscoe, Castro, Crosby, Deaf Smith, Dickens, Floyd, Hale, Motley, Palmer and Swisher, which are located in the Red River Basin. Region O is largely an agricultural area with significant irrigation water demands. In the Red River Basin, the 2060 projected shortages total 565,004 acre-feet per year. Of that amount, over 99% is associated with irrigation shortages. Less than 1,500 acre-feet per year is associated with municipal needs in the Red River Basin. The 2006 Region O Water Plan recommends conservation and new groundwater to meet these needs. No new surface water is recommended to be developed in the Red River Basin. On a region-wide basis, Region O plans to meet its future water demands with 74% from groundwater, 18% from conservation, 5% from surface water and 3% from reuse. Lower Bois d'Arc Creek Reservoir is not a potential source for Region O.

8.2.2 Availability of Feasible and Practicable Alternatives in the Receiving Basin

The *2006 Region C Water Plan* evaluated 24 potentially feasible water supply strategies for the NTMWD. These strategies include conservation, reuse, connections to existing supplies, and development of additional groundwater and surface water supplies. These alternatives are discussed in more detail in Sections 3.2, 3.3 and 3.4. The NTMWD is working toward implementing the recommended projects in the order recommended by the Region C Water Plan. The recommended order of implementation is based on feasibility, costs, time needed to implement each option, and other issues. In addition to the NTMWD's conservation efforts (including additional reuse from the Wilson Creek Wastewater Treatment Plant), the following projects will be implemented prior to the Lower Bois d'Arc Creek Reservoir:

- Interim Treated Water Purchase from Dallas Water Utilities
- Interim Purchase of Lake Texoma Water from the Greater Texoma Utility Authority
- Upper Sabine Basin Supply
- Additional Lake Lavon Yield
- East Fork Reuse Project
- New Supply from Lake Texoma.

These projects will help to meet the growing NTMWD customer demands but will not be sufficient to support the projected growth in the NTWMD service area beyond 2020. Several of these strategies are interim measures that will be implemented by NTMWD until additional new supplies are developed. Other strategies, such as the new supply from Lake Texoma are also dependent upon the District developing new water sources. For this strategy, higher quality water from other sources is needed for blending with water from Lake Texoma. Until new sources are developed, the additional supply from Lake Texoma is limited. In order to support the projected growth of its customers, the NTMWD must develop new surface water supplies.

8.2.3 Amount and Purposes of Use in the Receiving Basin

The NTMWD proposes to impound 367,609 acre-feet in the Lower Bois d'Arc Creek Reservoir, and divert 175,000 acre-feet per year for use in the Trinity, Red, Sulphur, and Sabine River Basins for municipal, industrial, and agricultural purposes of use. The NTMWD is the intended user of the water diverted from Lower Bois d'Arc Creek Reservoir under this application.

8.2.4 Proposed Water Conservation and Drought Contingency Measures

The NTMWD has adopted a *Water Conservation and Drought Contingency Plan*, amended in 2006, and has developed model water conservation and model drought contingency plans for its member cities and customers (Freese and Nichols, 2006b). As stated in Section 1.3, the NTMWD does not have direct contact with the end users of water, so the District focuses its conservation efforts on maximizing reuse, raising public awareness, providing technical assistance to member cities and customers who have direct contact with water users, conducting operations to treat and deliver water efficiently and minimizing water losses, and monitoring drought conditions and implementing drought response measures. The model water conservation and drought contingency plans for member cities and customers were developed as guides for those entities to develop and implement plans to meet their specific needs and situations. Section 1.3 contains more detailed discussion of NTMWD's conservation and drought contingency efforts.

Reuse projects by NTMWD and conservation by NTMWD customers will be implemented to reduce the water needs from other sources by 232 mgd. These projects will be developed to extend the life of current sources and increase the efficiency of current use. However, even if recommended target conservation goals are met, current sources are not enough to support the rapid growth. Lower Bois d'Arc Creek Reservoir is one of the multiple sources of water proposed to be developed by NTMWD. Once built, the project will provide about 112 million gallons per day, or 25% of the District's total demand in 2020 and 15% of the demand in 2060.

8.2.5 Proposed Methods to Put the Water to Beneficial Use

The water diverted from the Lower Bois d'Arc Creek Reservoir under this application will benefit the receiving basins by supporting municipal and economic growth. Water from the Lower Bois d'Arc Creek Reservoir will meet approximately 11% of the projected NTMWD water demand in 2060. This projected demand is made up of municipal, industrial, and agricultural uses. The projected increase in demand is due to growth in the NTMWD service area, which is expected to more than double in population over the next 50 years.

To address the increases in demands, NTMWD has implemented a wide variety of conservation measures, which include:

- The largest operating wastewater reuse program in the State
- Plans to develop additional reuse through the East Fork Reuse Project
- Development of a water conservation and drought contingency program for the District and model plans for its customers
- Implementation of a major drought information and response campaign in 2006, including a $4 million public outreach and education program in 2005 and 2006, with continued financial support for 2007.

By 2060, over one-fourth of the District's water supply will be from conservation savings and reuse. The District's conservation efforts represent the highest practicable levels of conservation, and the water from the Lower Bois d'Arc Creek Reservoir is needed to meet projected shortfalls after accounting for the conservation savings realized from these efforts.

The Lower Bois d'Arc Creek Reservoir will also provide water in Fannin County in the Red and Sulphur River Basins. Population in Fannin County is expected to increase to from 31,000 to 83,000 in 2060. The main source of surface water supply for Fannin County is Lake Bonham, which is adequate to meet Bonham's water needs only until 2020.

The City of Bonham is a NTMWD customer. The NTMWD is committed to provide treated water to Bonham and other Fannin County entities that become customers of the NTMWD. The NTMWD will provide treated surface water from Lower Bois d'Arc Creek Reservoir to customers in Fannin County as needed and requested by area water providers.

The Lower Bois d'Arc Creek Reservoir Water Supply Project would include a raw water pipeline to the NTMWD service area, infrastructure necessary to serve Fannin County customers, and one or more water treatment plants. Treated water distribution systems will be developed as needed to meet customer demands. The proposed Lower Bois d'Arc Creek Reservoir will help ensure that water needs in Fannin County are met and will bring economic benefits to the County.

8.2.6 Projected Economic Impact in Each Basin

The NTMWD retained the Institute of Applied Economics at the University of North Texas to produce an economic analysis of the impacts of the proposed Lower Bois d'Arc Creek Reservoir (Appendix K). The report, published in September 2004, was developed using project costs developed in 2004. While the project costs have changed slightly, the conclusions remain

the same and indicate that the new reservoir will bring economic growth to the Fannin County area within the Red River Basin in the following ways:

- Construction of Reservoir and Water Transmission Facilities – will create job opportunities for approximately 1,000 people per year over the four to five year construction period, resulting in approximately $580 million in increased economic activity for Fannin County and surrounding areas.
- Continued Operation and Maintenance – will create 20 full-time jobs per year, resulting in $3,726,000 in increased economic activity per year.
- Recreation – will create 344 jobs per year, resulting in $22,015,000 in increased economic activity per year.
- Construction of New Homes – will create 133 jobs per year over the 30-year development period, resulting in $13,450,000 in increased economic activity per year.
- New Resident Spending in Fannin County – will create 545 jobs per year, resulting in $75,725,000 in increased economic activity per year.
- New Industrial and Commercial Activities – will create 1,607 jobs over a 10-year period, resulting in $138,710,000 in total increased economic activity.
- Tax Revenue – at full development, the taxable value of new homes will be approximately $326.2 million. The loss of taxable value of inundated land will be approximately $11.9 million. Therefore, the net increase in taxable value will be approximately $314.3 million. This will generate $1.9 million per year to county and almost $5 million per year to local school districts under current law.

The economic impact in the receiving basins will also be positive. The water diverted from the Lower Bois d'Arc Creek Reservoir will benefit the receiving basins by supporting municipal and economic growth in the NTMWD service area. The *2006 Region C Water Plan* states that the Texas Water Development Board conducted a preliminary analysis of the economic impacts of not meeting the projected demands in Region C. The analysis indicates that a severe one-year drought would reduce the projected 2060 population of the region by 1,007,000, or 7.7%. It would also reduce the projected 2060 employment and income by 691,060 jobs (17%) and $58.8 billion (21%). Failure to provide sufficient water to support growth in Region C would result in lost income and tax revenues of nearly $161 billion between now and 2060.

8.2.7 Projected Impacts in Each Basin on Existing Water Rights

The hydrologic and water rights analyses discussed in Section 4 and Appendix G shows that the impacts to water rights in the Red River Basin from the Lower Bois d'Arc Creek

Reservoir are negligible, if any. The analysis found no change in mean shortage, period reliability, or volume reliability for any permitted diversion right in the Red River WAM.

There are no impacts associated with the interbasin transfer to water rights in the Trinity or Sabine River Basins. The water from the project will be delivered directly to a water treatment plant in the Trinity River Basin or will be passed through Lake Lavon for subsequent diversion and treatment by NTMWD. This will have no impacts to Trinity River Basin water rights. Treated water delivered to the Sabine River Basin will have no impacts to Sabine River Basin water rights.

8.2.8 Projected Impacts in Each Basin on Instream Uses

Red River Basin. Impacts to instream uses will be from conversion of ephemeral, intermittent, and perennial stream habitats to a reservoir environment. The uses of aquatic life, contact recreation, noncontact recreation, and fish consumption will all be enhanced and expanded. The public water supply use will be greatly enhanced by the construction and operation of the Lower Bois d'Arc Creek Reservoir.

Projected impacts on instream uses downstream of the proposed reservoir are expected to be mitigated through environmental flow releases included in the design of the reservoir project. A stream flow study is planned to further assess the potential impacts to instream uses in the Lower Bois d'Arc Creek watershed. Impacts to the instream uses in the Red River are expected to be negligible.

Trinity River Basin. The proposed project will transport water from Lower Bois d'Arc Creek Reservoir to a water treatment plant north of the Town of Princeton in Collin County. The project will include releases to Pilot Grove Creek to convey raw water through Lake Lavon for subsequent treatment near Wylie, Texas. There are no changes of instream uses in the Trinity River Basin, and the additional water may enhance existing uses of aquatic life, contact recreation, noncontact recreation, and fish consumption. The public water supply use in the Trinity River Basin will be greatly enhanced by the construction and operation of the Lower Bois d'Arc Creek Reservoir.

Sabine River Basin. Treated water from Lower Bois d'Arc Creek Reservoir will be delivered to the Sabine River Basin through the District's distribution system. Wastewater return

flows, if treated in the Sabine River Basin, may be returned to the Sabine River Basin. These flows are expected to be small and will have no change to the existing instream uses in the Sabine River Basin. The return flows may enhance existing uses through the additional water.

8.2.9 Projected Impacts in Each Basin on Water Quality

Red River Basin. The water quality in the Lower Bois d'Arc Creek watershed is generally good. The variability observed in mineral concentrations in the stream is due to differences in high flow and low flow conditions. The proposed Lower Bois d'Arc Creek Reservoir will likely reduce the observed variability in mineral parameters (chloride, sulfate and TDS) in Bois d'Arc Creek downstream of the reservoir. There would be minimal impacts to the Red River downstream of the project. The water quality in the reservoir is expected to be higher quality than measured in the stream due to capturing water during high flow events.

Trinity River Basin. The Lower Bois d'Arc Creek Reservoir will have no negative impacts to water quality in the Trinity River Basin, and may actually improve water quality. The water of the proposed reservoir is expected to have similar quality to Pilot Grove Creek, Lake Lavon and Lake Chapman, and better quality than Lake Texoma. As a result, the water quality of the return flows associated with the District's water sources is expected to improve with the use of water from Lower Bois d'Arc Creek Reservoir, which will improve the quality of water in the Trinity River Basin.

Sabine River Basin. The Lower Bois d'Arc Creek Reservoir will have no negative impacts to water quality in the Sabine River Basin

8.2.10 Projected Impacts in Each Basin on Aquatic and Riparian Habitat

Red River Basin. It is expected that the proposed reservoir will enhance aquatic life in the lake environment, and expand riparian habitat along the lake shoreline and downstream in the mitigation corridor.

Trinity River Basin. The Lower Bois d'Arc Creek Reservoir will provide additional fresh water to Lake Lavon, which will enhance aquatic life in the lake. There will be no impacts to riparian habitat along Pilot Grove Creek or other streams in the Trinity River Basin. The additional flows to Pilot Grove Creek will not exceed the stream's carrying capacity.

Sabine River Basin. The water from Lower Bois d'Arc Creek Reservoir will have no negative impacts to aquatic life or riparian habitats in the Sabine River Basin. The return flows may enhance existing aquatic life through the additional water.

8.2.11 Projected Impacts in Each Basin on Bays and Estuaries

Red River Basin. The proposed Lower Bois d'Arc Creek Reservoir is located more than 200 miles from the coast and any impacts due to the proposed reservoir on coastal Louisiana and the Gulf of Mexico are negligible.

Trinity River Basin. Water from Lower Bois d'Arc Creek Reservoir will be transported to the Trinity River Basin for municipal, industrial and agricultural use. Unused water associated with this water source would be returned to the Trinity River Basin. The likelihood of this water reaching the bays and estuaries along the Texas Gulf Coast is small. However, any water that does make it to the coast would have positive impacts to Texas bays and estuaries.

Sabine River Basin. Water from Lower Bois d'Arc Creek Reservoir will be transported to the Sabine River Basin for municipal and industrial use. Unused water associated with this water source would be returned to the Sabine River Basin. The likelihood of this water reaching the bays and estuaries along the Texas Gulf Coast from the upper reaches of the Sabine River is small. However, any water that does make it to the coast would have positive impacts to Texas bays and estuaries.

8.2.12 Proposed Mitigation or Compensation to the Basin of Origin

The Lower Bois d'Arc Creek Reservoir will provide a reliable water source to Fannin County and in the Red and Sulphur River Basins, as well as customers of NTMWD in the Trinity and Sabine River Basins. The proposed project will generate $580 million in increased economic activity in the Red and Trinity River Basins during construction, supporting over 1,400 full-time equivalent jobs. After construction, the increased economic activities are expected to average $125 million per year in the Red River Basin. The project will also provide recreational facilities for residents and visitors.

- Potential elements of a mitigation plan to compensate for permanent unavoidable losses to waters of the U. S., terrestrial wildlife habitat, and other natural resources and functions due to the proposed Lower Bois d'Arc Creek Reservoir are discussed in Section 7.

8.3 Interbasin Transfer Under Texas Water Code §11.085 (v)(4)

As part of this water right application, NTMWD is seeking an interbasin transfer permit pursuant to §11.085 (v)(4) to use water from the Lower Bois d'Arc Creek Reservoir to serve existing and future customers in the Sulphur River Basin in Fannin County. The NTMWD customers listed in Table 8.1 in the Sulphur River Basin include the cities of Honey Grove and Leonard, which are both located in Fannin County. The City of Honey Grove is also partially located in the Red River Basin.

8.4 Information Required for Authorizations to Use Bed and Banks

NTMWD's application seeks to authorize the use of the bed and banks of Pilot Grove Creek to deliver water pumped from Lower Bois d'Arc Creek Reservoir to Lake Lavon. NTMWD would deliver water by pipeline from Lower Bois d'Arc Creek Reservoir to Pilot Grove Creek, discharging in the reach shown on Figure 8.1. From the pipeline discharge, water would flow by gravity 3 to 7 miles in the channel of Pilot Grove Creek to the headwaters of Lake Lavon.

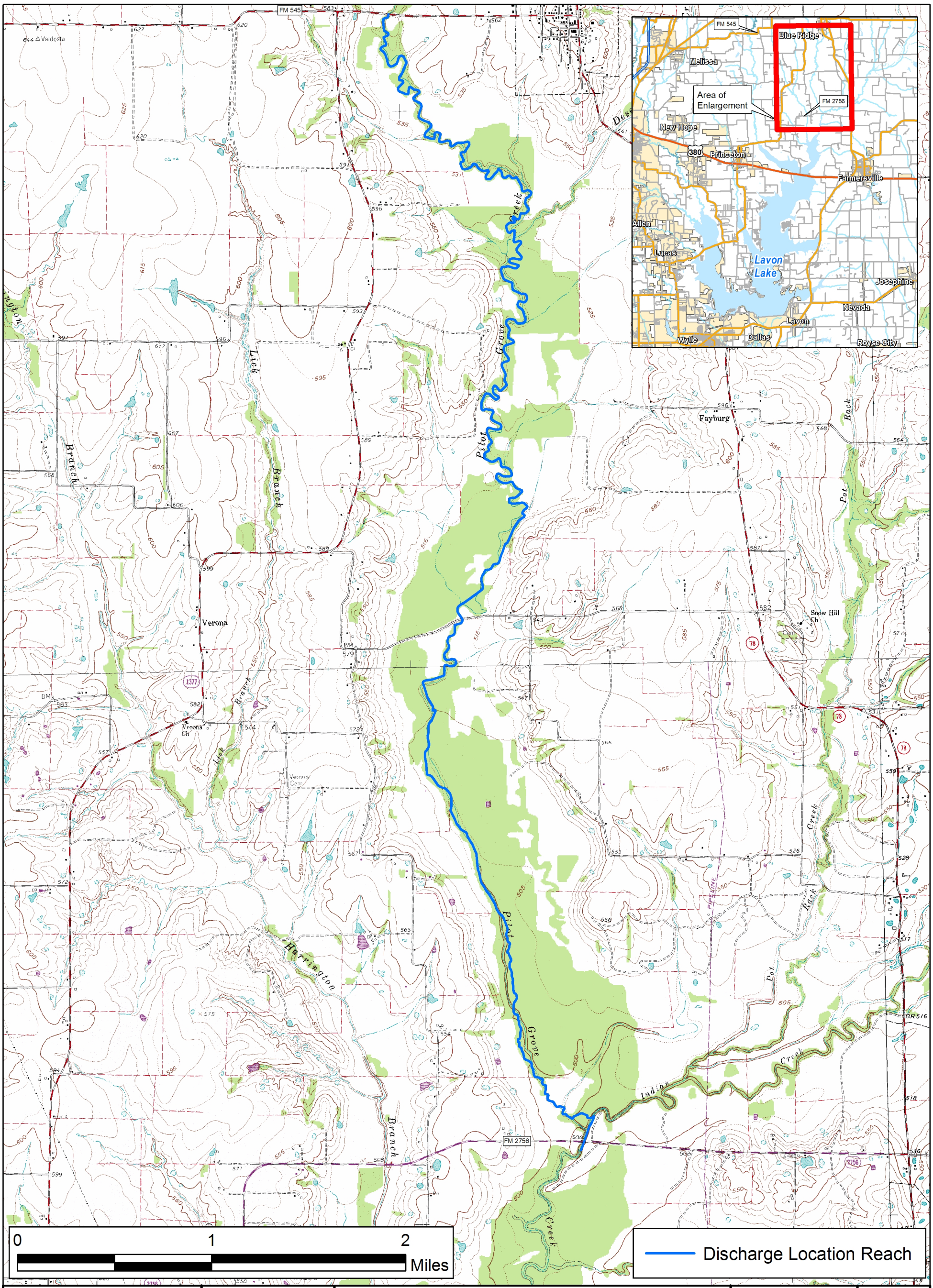
8.4.1 Water Quality

The water quality of Pilot Grove Creek and the expected quality of water from Lower Bois d'Arc Creek Reservoir are discussed in Section 5.7 of this report. Both sources have good quality water, with the discharged water of similar quality to the receiving stream (Pilot Grove Creek). There are no anticipated impacts to the water quality in Pilot Grove Creek. The water from Lower Bois d'Arc Creek Reservoir is of higher or similar quality to the water in Lake Lavon. The water from Lower Bois d'Arc Creek Reservoir may improve the water quality in Lake Lavon.

8.4.2 Carriage Losses

Channel Gain and Loss Investigations of Texas Streams was published by the Texas Board of Water Engineers in 1960. The report describes a 1954 investigation of the losses associated with the delivery of water from the Red River to Lake Dallas under different delivery rates. Over a stream length of 34 miles, the losses varied from 5.8 percent to 8.0 percent (depending on the rate of flow) and averaged 6.7 percent (Texas Board of Water Engineers, 1960).

In general, channel losses tend to be higher in arid areas and lower in humid areas. In Texas, channel losses generally decrease from west to east. The streams by which water from Lake Chapman is delivered to the headwaters of Lake Lavon are east of the delivery from the Red River to Lake Dallas studied in *Channel Gain and Loss Investigations of Texas.* Losses will also generally be a lower percentage of flow in a downstream reach with more steady flow. Pilot Grove Creek has more steady flow than most of the stream reach studied in *Channel Gain and Loss Investigations of Texas*. Based on relative stream channel lengths, the losses from the Lower Bois d'Arc Creek Reservoir pipeline discharge to the headwaters of Lake Lavon would be about 1.4 percent in 7 miles (and about 0.6 percent in three miles) even if losses per mile were the same as those studied in 1954. Given the expectation for lower losses in Pilot Grove Creek compared to the losses in the streams studied in 1954, the channel losses in Pilot Grove Creek will be minimal.



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North Texas Municipal Water District

Location Map for Discharge to Pilot Grove Creek

FN JOB NO	NTD06128
FILE	DischargeLocation.mxd
DATE	November 8, 2006
SCALE	1:30,000
DESIGNED	BME
DRAFTED	BME

8.1

Figure

References for Chapter 8

Freese and Nichols, Inc. 2006(a). *2006 Region C Water Plan*, prepared for the Region C Water Planning Group.

Freese and Nichols, Inc. 2006(b). *Water Conservation and Drought Contingency Plan*, prepared for the North Texas Municipal Water District.

Texas Board of Water Engineers, 1960. Bulletin 5807 D: *Channel Gain and Loss Investigations, Texas Streams, 1918-1958*, prepared in cooperation with the U.S. Geological Survey, April 1960.

Texas Water Development Board. 2006. Regional Water Planning Database (DB07), http://www.twdb.state.tx.us/data/db07, downloaded August 25, 2006.