EXECUTIVE SUMMARY

2006 REGION C WATER PLAN

JANUARY 2006

Executive Summary

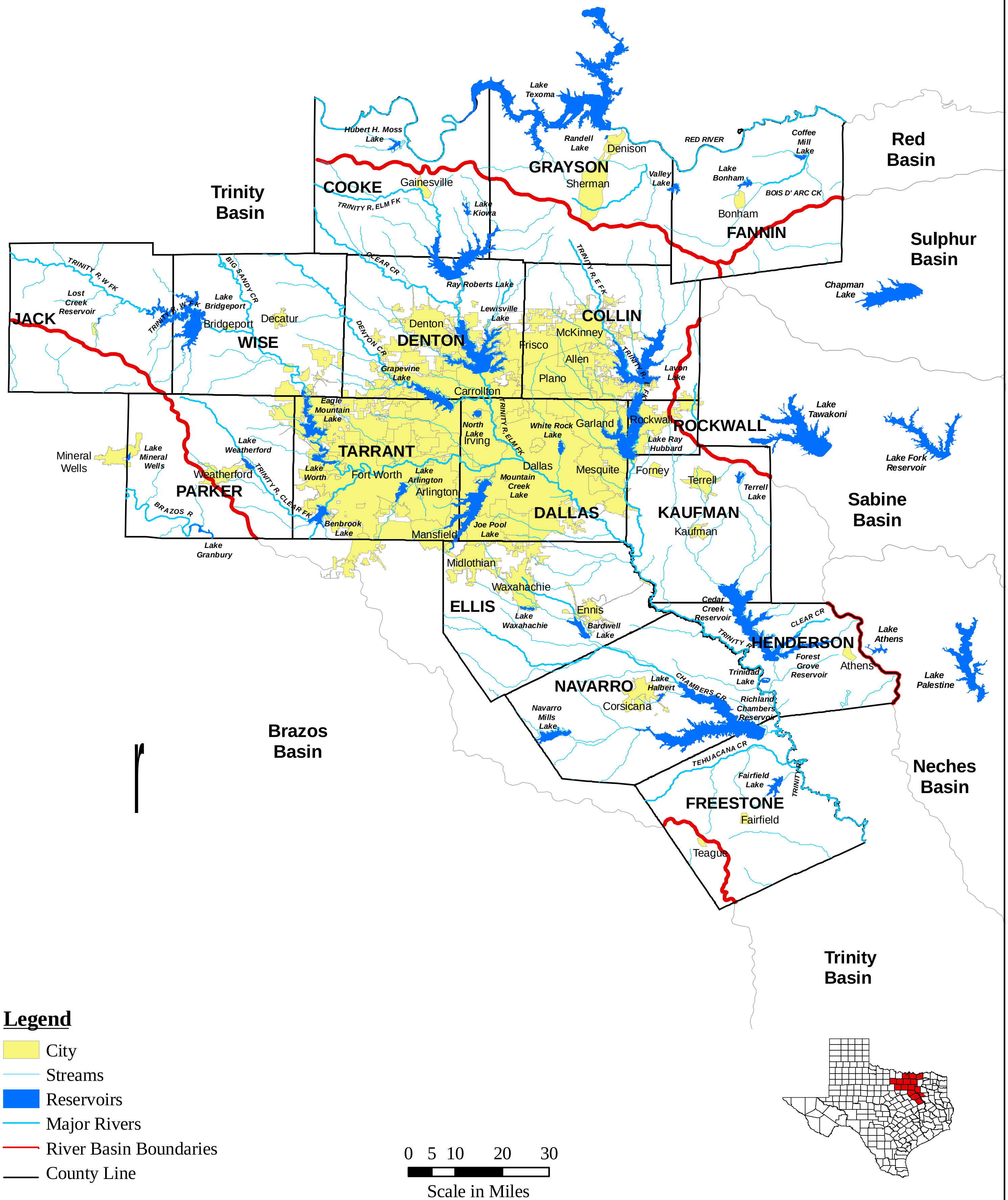
This report presents the *2006 Region C Water Plan* developed in the second round of the Senate Bill One regional water planning process. Region C covers all or part of 16 North Central Texas counties, as shown in Figure ES.1. The report presents the results of a five-year planning effort to develop a plan for water supply for the region through 2060.

The Region C water plan was developed under the direction of the 19-member Region C Water Planning Group. This regional water plan was adopted by the Region C Water Planning Group on December 5, 2005 and presented to the Texas Water Development Board in January 2006.

The *2006 Region C Water Plan* includes the following chapters:

1. Description of Region C
2. Population and Water Demand Projections
3. Analysis of Water Supply Currently Available to Region C
4. Identification, Evaluation and Selection of Water Management Strategies
   - 4A. Comparison of Current Water Supply and Projected Water Demand
   - 4B. Water Conservation and Reuse of Treated Wastewater Effluent in Region C
   - 4C. Methodology for Evaluation and Selection of Water Management Strategies
   - 4D. Evaluation of Major Water Management Strategies
   - 4E. Recommended Water Management Strategies for Wholesale Water Providers
   - 4F. Recommended Water Management Strategies for Water User Groups by County
5. Impacts of Recommended Water Management Strategies
6. Water Conservation and Drought Management Recommendations
7. Description of How the Regional Water Plan is Consistent with Long-Term Protection of the State's Water Resources, Agricultural Resources, and Natural Resources
8. Unique Stream Segments, Unique Reservoir Sites, and Legislative Recommendations
9. Infrastructure Funding Recommendations
10. Plan Approval Process and Public Participation

Figure ES.1
Region C and Major Outside Water Supplies
Currently Used in Region C



This Executive Summary focuses on current water needs and supplies in Region C, the projected need for water, the identification and selection of recommended water management strategies, and the costs and impacts of the selected strategies. Other elements of the plan are covered in the main text and the appendices.

ES.1 Current Water Needs and Supplies in Region C

As of the 2000 census, the population of Region C was 5,254,722, which represents 25.2 percent of Texas' total population. The two most populous counties in Region C, Dallas and Tarrant, have 70 percent of the region's population. Region C is heavily urbanized, with 81 percent of the population located in cities with populations in excess of 20,000 people.

Physical Setting

Most of Region C is in the upper portion of the Trinity River Basin, with smaller parts in the Red, Brazos, Sulphur, and Sabine River Basins. Figure ES.1 shows the major streams in Region C. Precipitation increases west to east in the region. The average runoff in the region increases from the west to the east, while evaporation is higher in the western part of Region C. The patterns of rainfall, runoff, and evaporation result in more abundant water supplies in the eastern part of Region C than in the west.

Thirty-four reservoirs in Region C have conservation storages in excess of 5,000 acre-feet. These reservoirs and others outside of Region C provide most of the region's water supply. Aquifers in the region include the Trinity, Carrizo-Wilcox, Woodbine, Nacatoch, and Queen City.

Water Use

Water use in Region C has increased significantly in recent years, primarily in response to increasing population and municipal demand. The regional water use in the year 2000 was 1,380,556 acre-feet. It is interesting to note that Region C, with 25.2 percent of Texas' population, had only 8.2 percent of the state's water use in 2000. About 85 percent of the current water use in Region C is for municipal supply, followed by manufacturing use and steam electric power generation.

Current Sources of Water Supply

Over 90 percent of the water use in Region C is supplied by surface water, but groundwater is an important source of supply, especially in rural areas. Most of the surface water supply in Region C comes from major reservoirs, including reservoirs in the region and reservoirs outside of Region C that supply water for the region. The Trinity aquifer is by far the largest source of groundwater in Region C, with the Woodbine, Carrizo-Wilcox and other minor aquifers also used. The current use of groundwater exceeds the reliable long-term supply available in some parts of Region C.

Over half of the water used for municipal supply in Region C is discharged as treated effluent from wastewater treatment plants, making wastewater reclamation and reuse a potentially significant source of additional water supply for the region. At present, only a fraction of the region's treated wastewater is actually reclaimed and reused in the region. Many of the region's water suppliers are considering reuse projects. It is clear that the reuse of treated wastewater will be a significant source of future water supplies for Region C.

Water Providers in Region C

Water providers in Region C include 35 wholesale water providers and 351 water user groups. In 2000, the three largest wholesale water providers in Region C (Dallas Water Utilities, Tarrant Regional Water District, and North Texas Municipal Water District) provided 75 percent of the water used in the region. Cities and towns provide most of the retail water service in Region C.

ES.2 Projected Need for Water

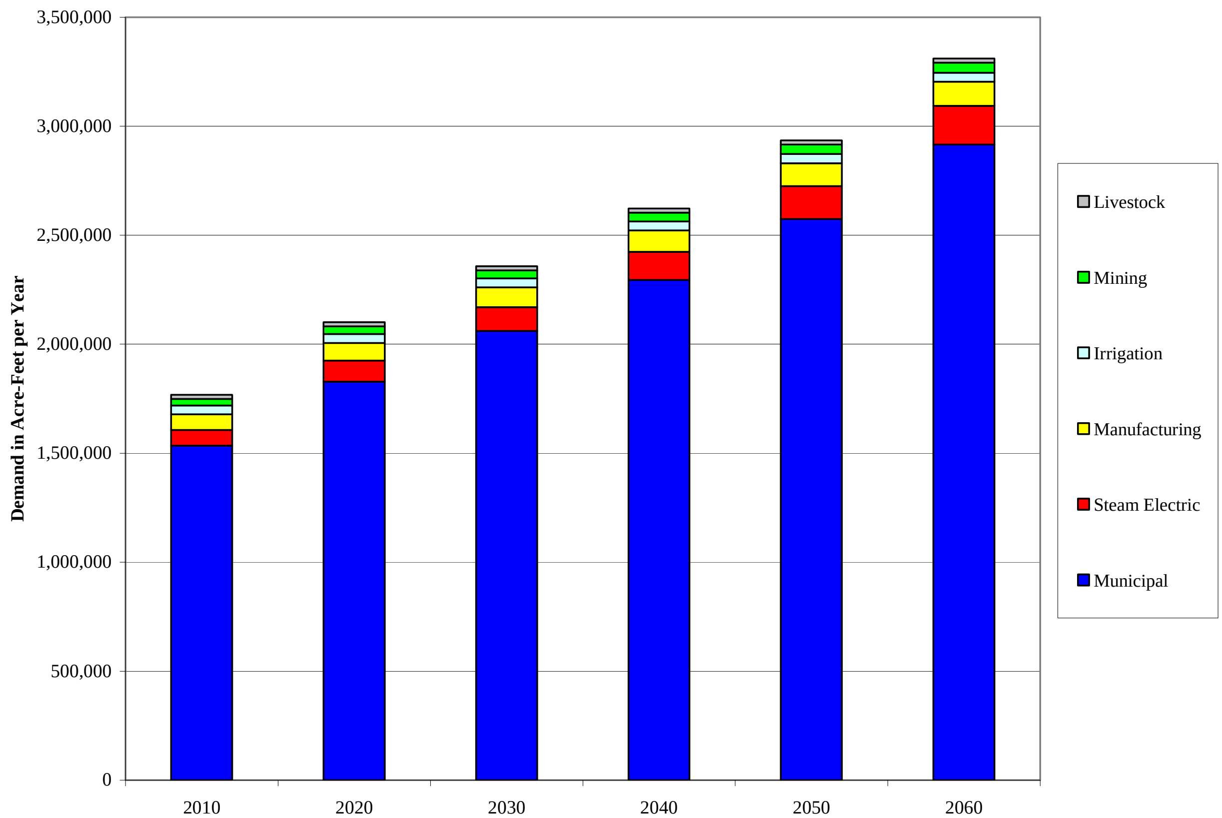
Population Projections

The population of Region C is projected to grow from 5,254,722 in the year 2000 to 9,093,847 in 2030 and 13,087,849 in 2060. These region-wide projections match regional numbers provided by the Texas Water Development Board, as required by TWDB planning guidelines. This projection reflects a substantial slowing in the rate of growth that has been experienced in Region C over the last 50 years. The projected 2030 population is 0.5 percent lower than an independent projection by the North Central Texas Council of Governments, indicating extremely close agreement. The distribution of the projected population by county and city is discussed in Chapter 2.

Demand Projections

Figure ES.2 shows the projected demands for water in Region C, which increase to 2.4 million acre-feet per year in 2030 and 3.3 million acre-feet per year in 2060. As has been the case historically, municipal demands are projected to make up the majority of the water use in Region C.

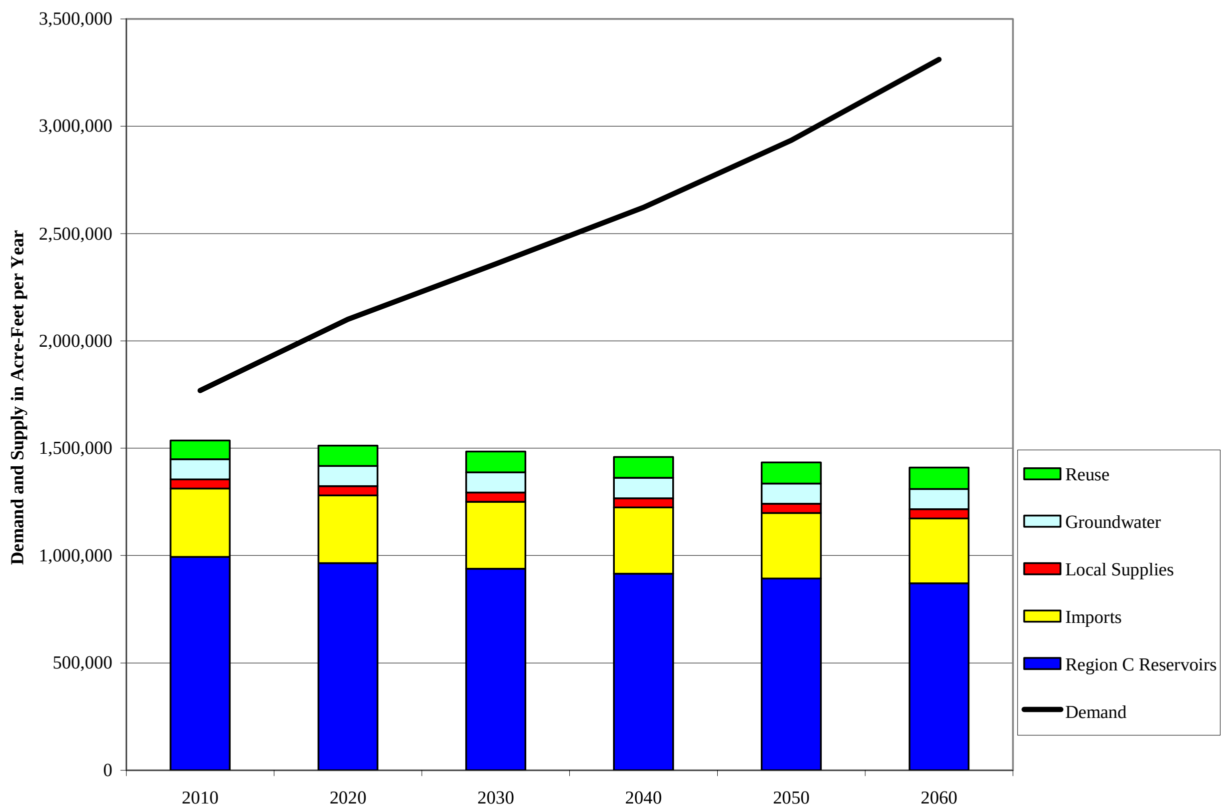
Figure ES.2
Projected Region C Demands



The Comparison of Supply and Demand

Figure ES.3 shows a comparison of supplies currently available to Region C and projected demands. Currently available supplies decline slightly over time due to sedimentation in reservoirs, reaching less than 1.4 million acre-feet per year by 2060. With the projected 2060 demand of 3.3 million acre-feet per year, the region has a shortage of 1.9 million acre-feet per year by 2060. There are about 500,000 acre-feet per year in supplies committed to Region C that are not yet connected. Meeting the projected shortage and leaving a reasonable surplus of planned supplies over projected needs will require the development of significant new water supplies for Region C over the next 55 years.

Figure ES.3
Comparison of Currently Available Supplies and Projected Demands



Socio-Economic Impacts of Not Meeting Projected Water Needs

The Texas Water Development Board has conducted a preliminary analysis of the impacts of not meeting the projected demands. The analysis indicates that a severe drought occurring in a single year would:

- Reduce the projected 2060 population by 1,007,000, a reduction of 7.7 percent.
- Reduce the projected 2060 employment by 691,060 jobs, a reduction of 17 percent.
- Reduce the projected income in 2060 by $58.8 billion, a reduction of 21 percent.

The lost income and tax revenues from failing to take steps to provide sufficient water for the projected growth in Region C are nearly $161 billion.

ES.3 Identification and Selection of Water Management Strategies

The Region C Water Planning Group identified and evaluated a wide variety of potentially feasible water management strategies in developing this plan. Water supply availability, costs and environmental impacts were determined for conservation and reuse efforts, the connection of existing supplies, and the development of new supplies. Almost every strategy suggested to the region during the planning process was analyzed.

As required by TWDB regulations, the evaluation of water management strategies was an equitable comparison of all feasible strategies and considered the following factors:

- Evaluation of quantity, reliability, and cost of water delivered and treated
- Environmental factors
- Impacts on other water resources and on threats to agricultural and natural resources
- Other factors deemed relevant by the planning group (including consistency with the plans of water providers in the region)
- Consideration of interbasin transfer requirements and third party impacts of voluntary redistributions of water.

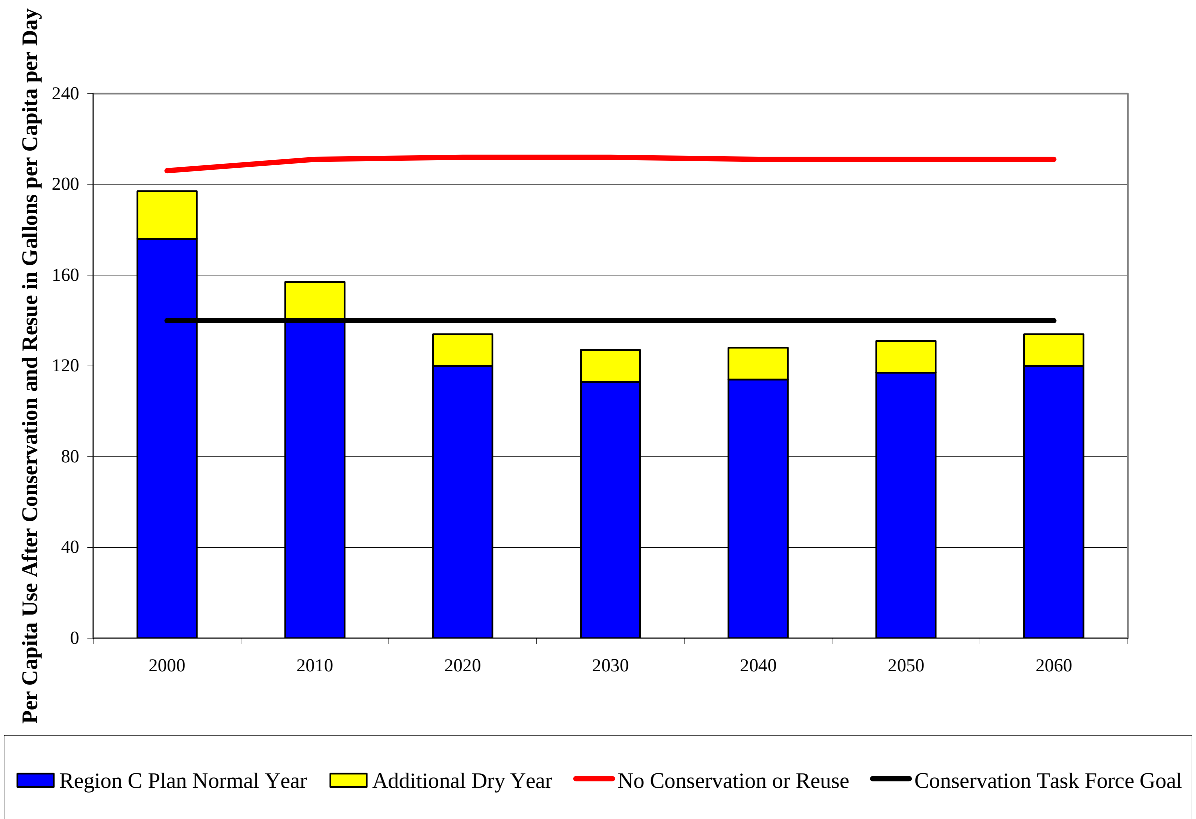
Water Conservation and Reuse

The Region C Water Planning Group considered 23 municipal water conservation strategies suggested as best management practices by the Conservation Implementation Task Force and selected 16 as potentially feasible for Region C. A detailed estimate of cost and savings for the 16 potentially feasible strategies resulted in a recommended water conservation program for Region C that accomplishes the following:

- Including the 242,000 acre-feet per year of conservation built into the demand projections (for low flow plumbing fixtures and efficient power plants), a total conservation and reuse of 1.3 million acre-feet per year by 2060, 37 percent of the region's demand without conservation.
- A reduction in dry-year per capita municipal use for the region (after crediting for reuse) from 197 gpcd in 2000 to less 140 gpcd by 2020.

Figure ES.4 shows the change in per capita use over time in Region C if the recommended water conservation and reuse measures in the plan are fully implemented. Chapter 6 includes a more detailed discussion of conservation and reuse for the region.

Figure ES.4
Projected Per Capita Municipal Use in Region C
with Full Implementation of Planned Conservation and Reuse



Recommended Water Management Strategies

Table ES.1 lists the major recommended water management strategies for Region C. (Major water management strategies are those supplying over 60,000 acre-feet per year or involving the construction of a reservoir.) Figure ES.5 shows the location of the proposed major water management strategies, which will provide 2.25 million acre-feet per year in new supplies for the region. In total, the Region C plan includes water management strategies to develop 2.7 million acre-feet per year of new supplies, for a total available supply of 4.1 million acre-feet per year in 2060. The supply is about 20 percent greater than the projected demand, leaving a reasonable reserve to provide for difficulties developing strategies in a timely manner, droughts worse than the drought of record, and greater than expected growth.

Figure ES.6 shows the comparison of supply and demand for Region C with the development of new supplies. Figure ES.7 shows the makeup of the 4.1 million acre-feet per year of supplies proposed for the region in 2060. One third of the supply is already available to the region from surface water and groundwater in 2005; one quarter is developed from conservation and reuse efforts, one-quarter is from the connection of existing supplies, and slightly less than one-fifth is from the development of new reservoirs. The plan includes only four major new reservoirs (compared to more than 25 developed to supply water for Region C over the last 55 years.)

Cost of the Proposed Plan

Most of the new supplies for Region C will be developed by the major wholesale water providers in the region. Table ES.2 shows the amount of new supply proposed for the five largest wholesale water providers in Region C and the cost to develop that supply. The total cost of implementing all of the water management strategies in the plan is $14 billion. The specific recommended water management strategies recommended for wholesale water providers and water user groups are discussed in sections 4D, 4E, and 4F of the report.

Table ES.1
Recommended Major Water Management Strategies

Strategy	Supplier	Supply (Acre-Feet per Year)	Supplier Capital Cost
Toledo Bend Reservoir	NTMWD	200,000	$886,002,000
	TRWD	200,000	$1,035,188,000
Marvin Nichols Reservoir	NTMWD	174,840	$534,125,000
	TRWD	280,000	$1,482,167,000
	UTRWD	35,000	$142,761,000
TRWD 3rd Pipeline & Reuse	TRWD	188,765	$626,347,000
Lower Bois d'Arc Ck. Res.	NTMWD	123,000	$399,190,000
Lake Fork Reservoir	DWU	120,000	$362,916,000
Oklahoma Water	NTMWD	50,000	$128,898,000
	TRWD	50,000	$287,349,000
	UTRWD	15,000	$60,967,000
Lake Palestine	DWU	111,460	$414,447,000
New Lake Texoma (Blend)	NTMWD	113,000	$201,829,000
Lake Fastrill	DWU	112,100	$569,170,000
Wright Patman Lake - Flood Pool	DWU	112,100	$572,036,000
East Fork Reuse Project	NTMWD	102,000	$288,879,000
Return Flows above DWU Lakes	DWU and UTRWD	79,605	$0
Southside (Lake Ray Hubbard) Reuse	DWU	67,253	$200,333,000
Lewisville Lake Reuse	DWU	67,253	$191,439,000
Lake Ralph Hall and Reuse	UTRWD	50,740	$211,153,000
Region C Total		**2,252,116**	**$8,595,196,000**

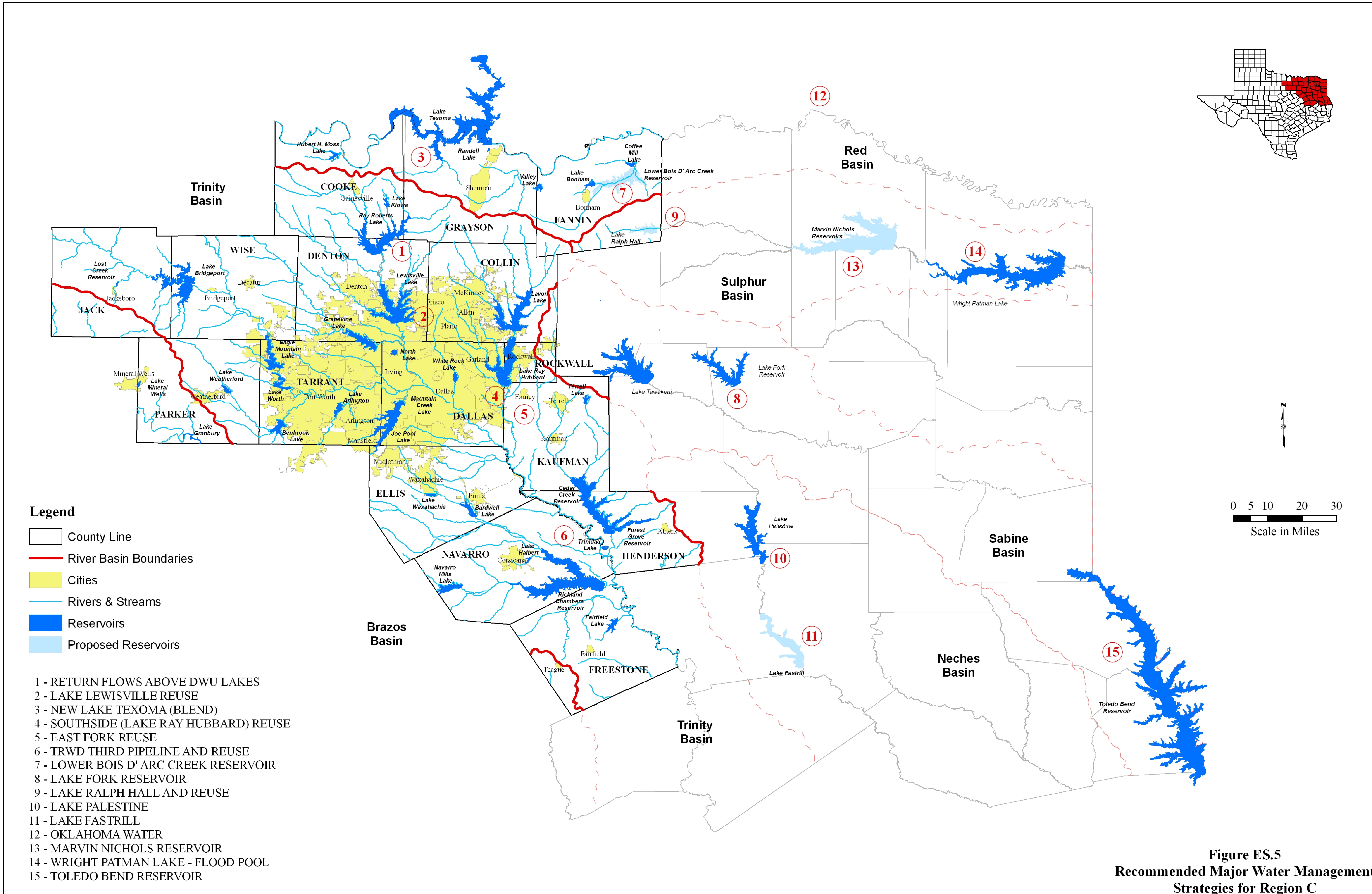


Figure ES.5
Recommended Major Water Management Strategies for Region C

Figure ES.6
Supply and Demand for Region C with the Development of New Supplies

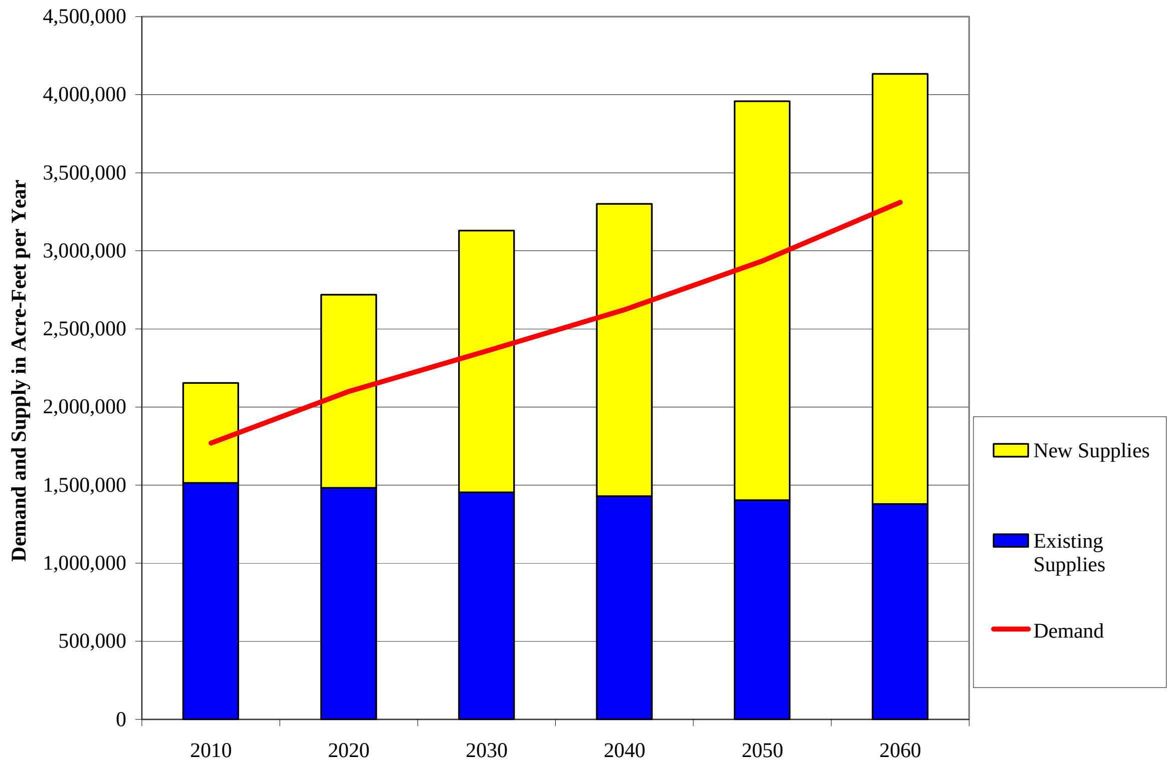


Figure ES.7
Sources of Water Available to Region C as of 2060

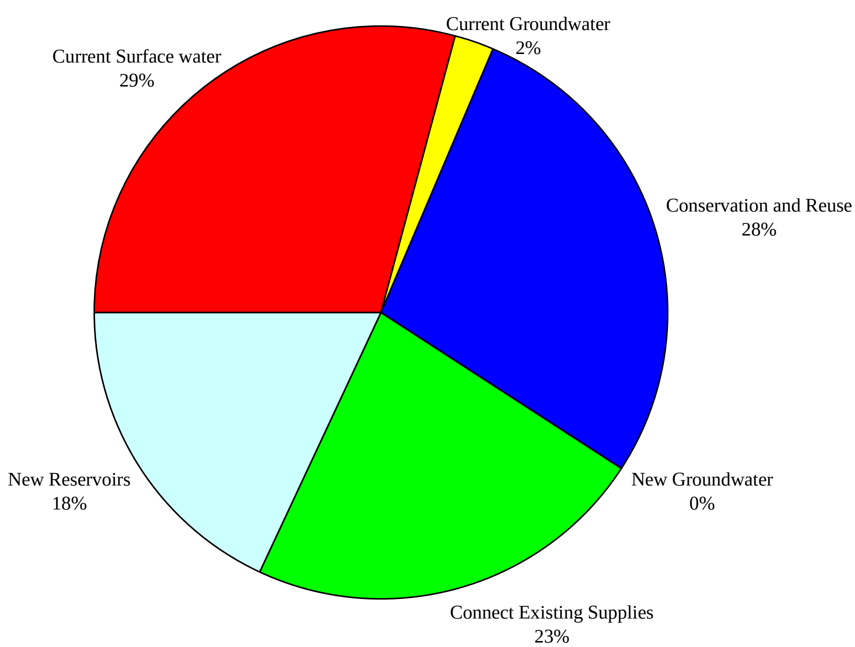


Table ES.2
2060 Supplies for the Largest Wholesale Water Providers in Region C

Wholesale Water Provider	2060 Supplies (Acre-Feet per Year)			% of Total Supply from Conservation and Reuse	Cost of Strategies (Millions)
	Currently Available	New Strategies	Total		
Dallas Water Utilities	422,647	758,328	1,180,975	26.2%	$2,811
Tarrant Regional Water District	394,049	698,558	1,092,607	24.6%	$3,562
North Texas Municipal Water District	254,020	792,355	1,046,375	25.7%	$3,848
City of Fort Worth	249,483	429,987	679,470	24.1%	$783
Trinity River Authority	96,060	225,076	321,136	59.1%	$340
Upper Trinity Regional Water District	41,265	155,413	196,678	27.2%	$858
Total					**$12,202**

Note: Supplies do not total because of overlaps. For example, Tarrant Region Water District supplies Fort Worth and the Trinity River Authority, Dallas Water Utilities supplies Upper Trinity Regional Water District, etc.

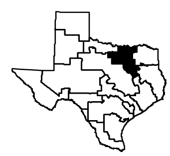
2006
Region C
Water Plan

Thomas C. Gooch, P.E.

January 2006

Prepared for

Region C Water
Planning Group



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2006 Region C Water Plan

JANUARY 2006

Prepared for

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2006 REGION C WATER PLAN

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Introduction

In 1997, the 75th Texas Legislature passed Senate Bill One, legislation designed to address Texas water issues. With the passage of Senate Bill One, the legislature put in place a grass-roots regional process to plan 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.

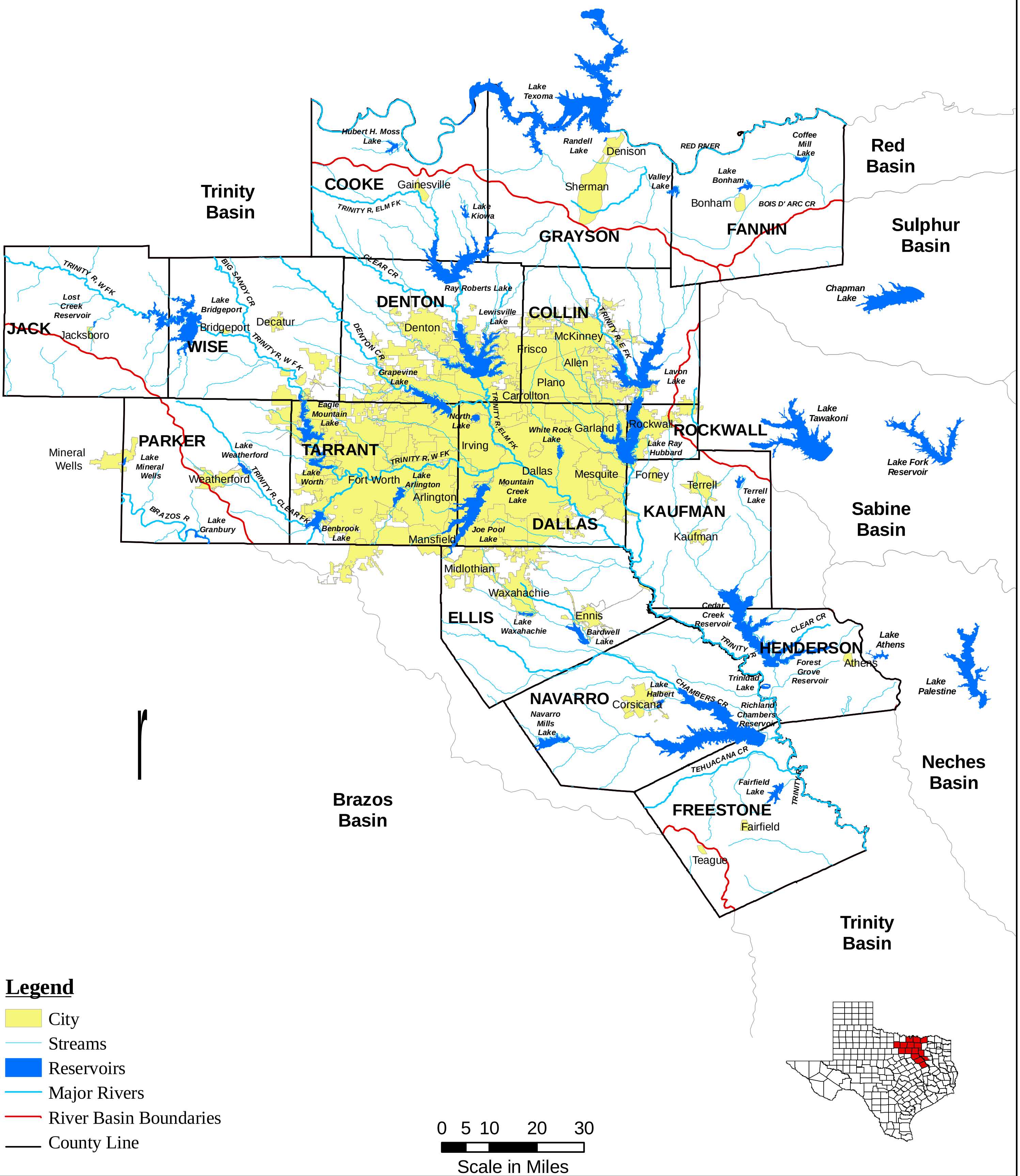
In 2001, the 77th Texas Legislature passed Senate Bill Two, which included the funding mechanism to continue the regional water planning effort. Senate Bill One calls for the regional water plans to be updated every five years. Senate Bill Two provided the funding for the first update to the regional water plans. The Texas Water Development Board refers to the current round of regional water planning as Senate Bill One Second Round.

This report gives the results of the Second Round planning process for Region C, one of the regions created to implement Senate Bill One. The results of the first round of the Senate Bill One planning effort for Region C can be found in the 2001 *Region C Water Plan* [(1)]. Figure I.1 is a map of Region C, which covers all or part of 16 counties in North Central Texas. As Figure I.1 shows, Region C includes all of Cooke, Grayson, Fannin, Jack, Wise, Denton, Collin, Parker, Tarrant, Dallas, Rockwall, Kaufman, Ellis, Navarro, and Freestone Counties and the part of Henderson County that is in the Trinity Basin. The area covered by Region C is the same as in the first round of Senate Bill One planning.

The regional water planning groups created pursuant to Senate Bill One are in charge of the regional planning process [(2)]. Each regional planning group includes representatives of 11 designated interest groups. Table I.1 shows the members of the Region C water planning group and the interests they represent. The Region C Water Planning Group hired a team of consultants to conduct technical analyses and prepare the regional water plan under the super-

[(1)] Numbers in parentheses match references listed at the end of this chapter and in Appendix A.

Figure I.1
Region C and Outside Water Supplies Designated as Special Water Resources for use in Region C



vision of the planning group. The consulting team included Freese and Nichols, Inc., Alan Plummer Associates, Inc., Chiang, Patel, and Yerby, Inc., and Cooksey Communications, Inc.

Texas Water Development Board planning guidelines require the regional water plan to include the following ten sections:

1. Description of Region C
2. Population and Water Demand Projections
3. Analysis of Water Supply Currently Available to Region C
4. Identification, Evaluation, and Selection of Water Management Strategies
5. Impacts of Selected Water Management Strategies on Key Parameters of Water Quality and Impacts of Moving Water from Rural and Agricultural Areas
6. Water Conservation and Drought Management Recommendations
7. Description of How the Regional Water Plan Is Consistent with Long-Term Protection of the State's Water Resources, Agricultural Resources, and Natural Resources
8. Unique Stream Segments, Unique Reservoir Sites, Regulatory, Legislative, Administrative, and Other Recommendations
9. Water Infrastructure Funding Recommendations
10. Adoption of Plan and Public Participation

In addition to the ten required sections, this report also includes appendices providing more detailed information on the planning efforts.

Table I.1
Members of the Region C Water Planning Group

Member	Interest
James (Jim) Parks, Chairman	Water Districts
Robert (Bob) Johnson, Vice-Chairman	Municipalities
Paul Zweiacker, Secretary	Electric Generating Utilities
Brad Barnes	Agricultural Interests
Jerry W. Chapman	Water Districts
Roy F. Eaton	Small Businesses
Dale Fisseler	Municipalities
Russell Laughlin	Industries
G. K. Maenius	Counties
Howard Martin	Municipalities
Jim McCarter	Water Utilities
Paul Phillips	Municipalities
Elaine Petrus	Environmental Interests
Irvin M. Rice	Public
Robert O. Scott	Environmental Interests
George Shannon	Water Districts
Connie Standridge	Water Utilities
Danny Vance	River Authorities
Mary E. Vogelson	Public

1. Description of Region C

Table 1.1 shows historical populations for the counties in Region C [3, 4] from 1900 through 2000. Table 1.1 also shows the estimated total population for the region for the same period, including only the portion of Henderson County located in Region C. Figure 1.1 is a plot of the historical population for Region C. The population of the region has grown from 588,706 in 1900 to 5,254,722 in 2000. From 1940 through 2000, the region's population has increased at a compounded rate of 2.7 percent per year. The increase of 1,176,432 people (28.8 percent) from 1990 through 2000 indicates that the area is still growing rapidly.

As of 2000, Region C included 25.2 percent of Texas' total population. The two most populous counties in Region C, Dallas and Tarrant, have 69.7 percent of the region's population. Collin, Denton, Grayson, and Ellis Counties also have year 2000 populations exceeding 100,000 people. Table 1.2 lists the 40 cities in Region C with a year 2000 census population of more than 20,000. These cities include 81 percent of the year 2000 population of the region.

1.1 Economic Activity in Region C

Region C includes most of the Dallas and Fort Worth-Arlington metropolitan statistical areas (MSAs). The largest employment sector in the Dallas MSA is the service industry, followed by trade, manufacturing, and government. The Fort Worth-Arlington MSA's largest employment sectors are service, trade, and manufacturing. The Dallas and Fort Worth-Arlington MSAs experienced strong economic growth in the 1990s [3].

Table 1.3 lists year 2000 payrolls for Region C by county and economic sector [5]. (Year 2000 is the most recent year for which data were available when this report was written.) Payroll and employment in Region C are concentrated in the central urban counties of Dallas and Tarrant, which have 84.2 percent of the region's total payroll and 81.9 percent of the employment. (Economic activity is more concentrated than population because many workers commute from outlying counties to work in Dallas and Tarrant Counties.)

Table 1.1
Historical Population for Region C Counties

County	Historical Population [a]										
	1900	**1910**	**1920**	**1930**	**1940**	**1950**	**1960**	**1970**	**1980**	**1990**	**2000**
Collin	50,587	49,021	49,609	46,180	47,190	41,692	41,247	66,920	144,490	264,036	491,774
Cooke	27,494	26,603	25,667	24,136	24,909	22,146	22,560	23,471	27,656	30,777	36,363
Dallas	82,726	135,748	210,551	325,691	398,564	614,799	951,527	1,327,321	1,556,549	1,852,810	2,218,774
Denton	28,318	31,258	35,355	32,822	33,658	41,365	47,432	75,633	143,126	273,525	432,976
Ellis	50,059	53,629	55,700	53,936	47,733	45,645	43,395	46,638	59,743	85,167	111,360
Fannin	51,793	44,801	48,186	41,163	41,064	31,253	23,880	22,705	24,285	24,804	31,242
Freestone	18,910	20,557	23,264	22,589	21,138	15,696	12,525	11,116	14,830	15,818	17,867
Grayson	63,661	65,996	74,165	65,843	69,499	70,467	73,043	83,225	89,796	95,021	110,595
Henderson [b]	14,338	14,454	20,339	21,959	22,848	16,807	15,642	19,003	30,591	41,309	51,984
Jack	10,224	11,817	9,863	9,046	10,206	7,755	7,418	6,711	7,408	6,981	8,763
Kaufman	33,376	35,323	41,276	40,905	38,308	31,170	29,931	32,392	39,015	52,220	71,313
Navarro	43,374	47,070	50,624	60,507	51,308	39,916	34,423	31,150	35,323	39,926	45,124
Parker	25,823	26,331	23,382	18,759	20,482	24,528	22,880	33,888	44,609	64,785	88,495
Rockwall	8,531	8,072	8,591	7,658	7,051	6,156	5,878	7,046	14,528	25,604	43,080
Tarrant	52,376	108,572	152,800	197,553	225,521	361,253	538,495	716,317	860,880	1,170,103	1,446,219
Wise	27,116	26,450	23,363	19,178	19,074	16,141	17,021	19,687	26,575	34,679	48,793
Region C Total	**588,706**	**705,702**	**852,735**	**987,925**	**1,078,553**	**1,386,789**	**1,887,297**	**2,523,223**	**3,119,404**	**4,077,565**	**5,254,722**
% Increase		19.9%	20.8%	15.9%	9.2%	28.6%	36.1%	33.7%	23.6%	30.7%	28.8%

Notes: a. Population data through 1990 are from *The Texas Almanac* [3]. Data for year 2000 are from the U.S. Census [4].

b. The Henderson County population in Region C from 1900 through 1990 is assumed to be 71.8% of the total Henderson County population based on the ratio of TWDB's Region C Henderson County population to total Henderson County population in 1990. The 1990 value for Henderson County has been adjusted to reflect the removal of Berryville from Region C. As of 2000, the Henderson County population in Region C was 70.9% of the total Henderson County population.

Figure 1.1
Historical Population for Region C

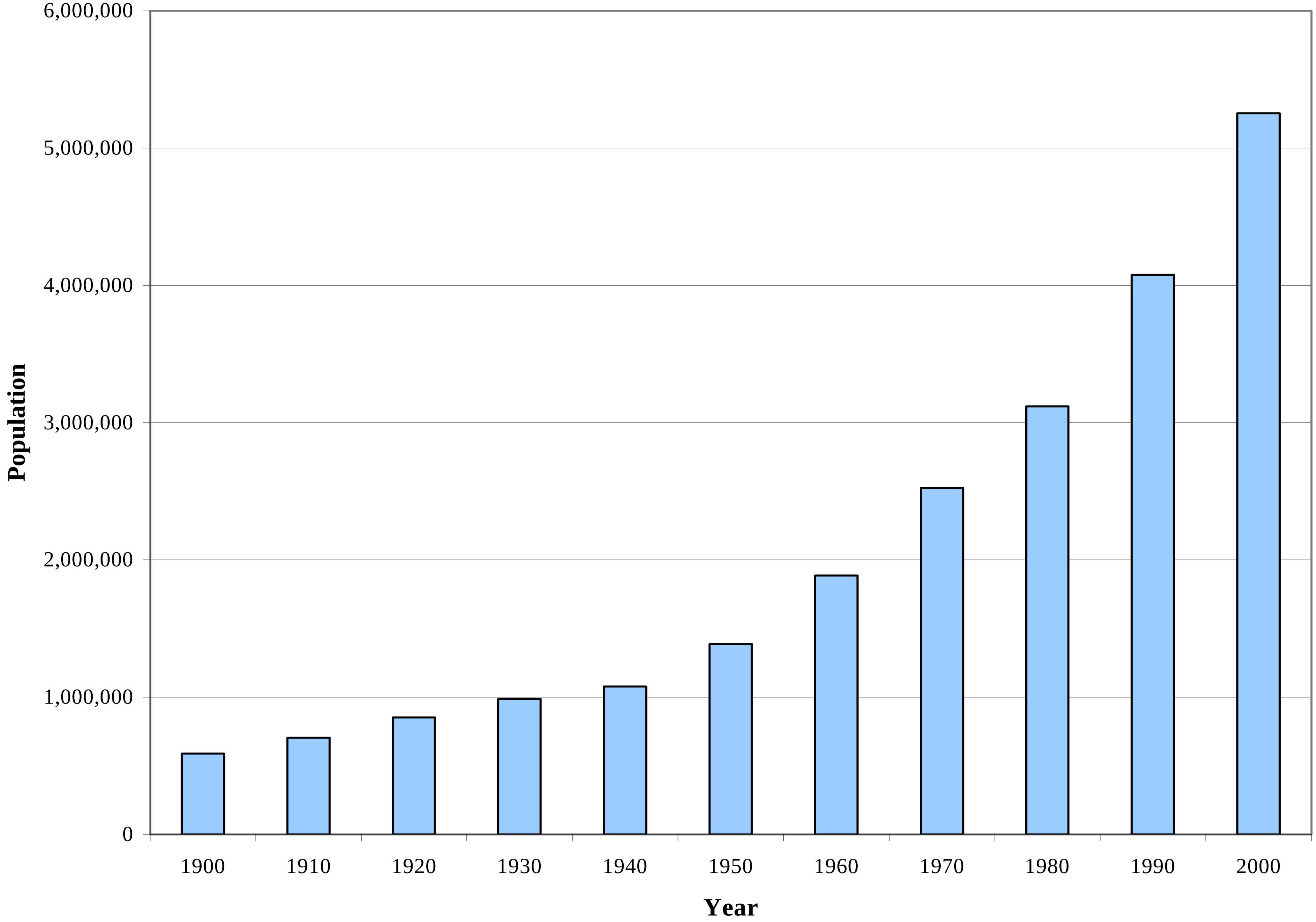


Table 1.2
Cities in Region C with Year 2000 Population Greater than 20,000

City	Year 2000 Population	County(ies)
Dallas	1,188,580	Dallas, Collin, Denton, Kaufman, Rockwall
Fort Worth	534,694	Tarrant, Denton, Parker, Wise
Arlington	332,969	Tarrant
Plano	222,030	Collin, Denton
Garland	215,768	Dallas, Collin
Irving	191,615	Dallas
Grand Prairie	127,427	Dallas, Tarrant, Ellis
Mesquite	124,522	Dallas
Carrollton	109,576	Dallas, Denton
Richardson	91,776	Dallas, Collin
Denton	80,537	Denton
Lewisville	77,737	Denton, Dallas
North Richland Hills	55,635	Tarrant
McKinney	54,369	Collin
Flower Mound	50,702	Denton
Bedford	47,152	Tarrant
Euless	46,005	Tarrant
Rowlett	44,503	Dallas, Rockwall
Allen	43,554	Collin
Grapevine	42,059	Tarrant, Dallas
Haltom City	39,018	Tarrant
DeSoto	37,646	Dallas
Hurst	36,273	Tarrant
Duncanville	36,081	Dallas
Coppell	35,734	Dallas
Sherman	35,082	Grayson
Frisco	33,714	Collin, Denton
Cedar Hill	32,093	Dallas, Ellis
Mansfield	28,031	Tarrant, Johnson, Ellis
Farmers Branch	27,508	Dallas
Keller	27,345	Tarrant
The Colony	26,531	Denton
Lancaster	25,894	Dallas
Corsicana	24,485	Navarro
University Park	23,324	Dallas
Denison	22,773	Grayson
Watauga	21,908	Tarrant
Southlake	21,519	Tarrant, Denton
Waxahachie	21,426	Ellis
Benbrook	20,208	Tarrant

Note: Data are from the U.S. Census [4].

Table 1.3
Year 2000 County Payroll by Category ($1,000)

Category	Collin	Cooke	Dallas	Denton	Ellis	Fannin	Freestone	Grayson
Forestry, Fishing, Hunting and Agriculture Support	$384	$109	$9,739	$1,540	$139	(a)	$0	(a)
Mining	$65,961	$6,892	$336,468	$5,121	$4,191	$0	$20,598	$3,728
Utilities	$13,568	$2,635	$415,904	$30,810	$3,607	$5,124	(a)	$8,925
Construction	$390,365	$7,920	$2,982,001	$310,981	$55,554	$5,878	$2,185	$67,812
Manufacturing	$1,487,197	$129,221	$6,809,188	$460,636	$348,353	$39,026	$1,986	$405,002
Wholesale Trade	$470,609	$9,582	$6,106,789	$323,346	$30,359	$11,849	$2,034	$33,812
Retail Trade	$655,861	$34,432	$3,194,674	$407,485	$69,855	$23,621	$9,885	$118,691
Transportation & Warehousing	$29,616	$15,947	$3,360,608	$76,479	$28,124	$1,385	$979	$16,090
Information	$1,140,443	$3,710	$5,225,634	$117,039	$15,936	$1,250	$1,415	$16,421
Finance & Insurance	$628,075	$8,068	$5,476,180	$161,960	$21,160	$12,897	$3,172	$68,793
Real Estate & Rental & Leasing	$75,366	$1,279	$1,332,100	$69,480	$6,808	$528	$994	$8,389
Professional, Scientific & Technical Services	$621,781	$5,217	$7,128,394	$166,032	$12,441	$3,190	$909	$28,170
Management of Companies & Enterprises	$701,411	(a)	$5,534,033	$289,746	$5,862	(a)	(a)	$4,333
Admin, Support, Waste Mgt, Remediation Services	$449,572	$2,103	$5,380,405	$145,889	$27,922	$698	(a)	$29,470
Education Services	$19,336	(a)	$541,219	$17,625	$5,560	(a)	$0	$13,527
Health Care & Social Assistance	$462,710	$24,152	$3,904,480	$346,131	$48,638	$33,449	$7,022	$214,774
Arts, Entertainment & Recreation	$36,232	$302	$451,781	$21,511	$3,043	$113	(a)	$5,009
Accommodation & Food Services	$299,963	$10,117	$1,561,905	$142,813	$21,424	$4,050	$5,159	$33,969
Other Services (except public admin)	$151,371	$7,336	$1,284,399	$120,237	$23,667	$2,374	$2,871	$19,975
Auxiliaries (except corporate, subsidiary & regional mgt)	$173,284	(a)	$955,789	$48,760	$4,961	$0	$0	(a)
Unclassified Establishments	$9,304	$220	$48,061	$4,289	$1,308	$168	$49	$758
Total Payroll	**$7,882,409**	**$277,538**	**$62,039,751**	**$3,267,910**	**$738,912**	**$148,248**	**$72,567**	**$1,098,466**
Total Employees	**183,324**	**11,890**	**1,478,116**	**110,615**	**28,482**	**5,764**	**3,165**	**39,519**

Table 1.3, Continued

Category	Henderson [b]	Jack	Kaufman	Navarro	Parker	Rockwall	Tarrant	Wise	Total
Forestry, Fishing, Hunting and Agriculture Support	(a)	$0	(a)	$2,460	$481	(a)	$7,190	(a)	$22,042
Mining	$3,259	$4,618	$2,955	$8,601	$3,454	$451	$77,763	$50,314	$594,374
Utilities	$7,314	(a)	$6,991	$4,443	$2,576	$886	$99,262	$4,110	$606,155
Construction	$20,384	$964	$45,035	$13,632	$42,467	$21,685	$1,429,246	$15,934	$5,412,043
Manufacturing	$51,273	(a)	$151,738	$79,703	$68,598	$56,076	$3,603,744	$40,875	$13,732,616
Wholesale Trade	$6,760	$3,530	$20,468	$16,336	$16,110	$8,715	$1,567,415	$9,965	$8,637,679
Retail Trade	$44,451	$2,321	$54,069	$35,902	$76,143	$47,417	$1,840,521	$38,471	$6,653,799
Transportation & Warehousing	$3,805	(a)	$7,902	$4,396	$5,659	$28,236	$747,889	$14,438	$4,341,553
Information	$9,833	$188	$4,020	$3,137	$5,856	$3,776	$712,812	$5,525	$7,266,995
Finance & Insurance	$12,198	$2,165	$23,431	$10,042	$12,277	$12,540	$1,241,625	$9,173	$7,703,756
Real Estate & Rental & Leasing	$3,329	$114	$1,585	$2,134	$3,911	$6,185	$308,222	(a)	$1,820,424
Professional, Scientific & Technical Services	$9,646	$566	$14,208	$5,217	$28,185	$17,970	$1,246,956	$5,269	$9,294,151
Management of Companies & Enterprises	(a)	$0	(a)	(a)	$3,657	(a)	$1,043,214	(a)	$7,582,256
Admin, Support, Waste Mgt, Remediation Services	$14,907	(a)	$48,111	$13,935	$15,517	$11,279	$1,987,723	$10,235	$8,137,766
Education Services	(a)	$0	$1,302	(a)	$1,365	$632	$202,052	(a)	$802,618
Health Care & Social Assistance	$55,388	$3,223	$62,695	$31,311	$35,027	$35,328	$2,082,079	$26,365	$7,372,772
Arts, Entertainment & Recreation	$1,634	(a)	(a)	$1,450	$2,267	$2,178	$248,197	(a)	$773,717
Accommodation & Food Services	$12,251	$1,053	$15,078	$8,536	$16,036	$14,499	$696,882	$8,593	$2,852,328
Other Services (except public admin)	$10,092	$632	$20,059	$7,525	$17,084	$9,368	$607,620	$27,424	$2,312,034
Auxiliaries (except corporate, subsidiary & regional mgt)	(a)	$0	(a)	(a)	$0	$0	$974,310	$0	$2,157,104
Unclassified Establishments	(a)	$57	(a)	$194	$565	$418	$15,401	(a)	$80,792
Total Payroll	**$269,835**	**$28,141**	**$487,322**	**$278,147**	**$357,235**	**$277,805**	**$20,740,123**	**$324,831**	**$98,289,240**
Total Employees	**13,030**	**1,348**	**20,314**	**13,521**	**15,658**	**10,934**	**640,927**	**10,923**	**$2,587,530**

Notes: a. Amount withheld to avoid disclosing data for individual companies. Data are included in county totals.
b. Data for Henderson County include the entire county.
Source: US Census Bureau- 2000 Economic Census [(5)]

1.2 Water-Related Physical Features in Region C

Most of Region C is located in the upper portion of the Trinity River Basin, with smaller parts in the Red, Brazos, Sulphur, and Sabine Basins. With the exception of the Red River Basin, the predominant flow of the streams is from northwest to southeast, as is true for most of Texas. The Red River itself flows west to east, forming the north border of Region C, and its major tributaries in Region C flow southwest to northeast. Figure I.1 shows the major streams in Region C, which include the Brazos River, Red River, Trinity River, Clear Fork Trinity River, West Fork Trinity River, Elm Fork Trinity River, East Fork Trinity River, and numerous other tributaries of the Trinity River. According to the Texas Parks and Wildlife Department, there are 324 streams of various sizes in Region C.

Figure 1.2 shows the average annual precipitation for Region C. Average annual precipitation increases west to east from slightly more than 30 inches per year in western Jack County to more than 44 inches per year in the northeast corner of Fannin County [(6)]. Figure 1.3 shows average annual runoff, which follows a similar pattern of increasing from west to east [(7)]. (It is interesting to note that the percentage of rainfall that becomes runoff increases dramatically from west to east across Region C. While the average rainfall is about 1.5 times as great in the east as in the west, the runoff is almost 5 times as great in the east as in the west.) Figure 1.4 shows gross reservoir evaporation in Region C, which is higher to the west [(6)]. (Gross reservoir evaporation indicates the amount lost to evaporation from the surface of a reservoir.) The rate of evaporation from a reservoir surface exceeds rainfall throughout Region C, but the margin is much greater in the western part of the region than in the east. The patterns of rainfall, runoff, and evaporation result in more abundant water supplies in the eastern part of Region C than in the west.

Figure 1.5 shows the variations in annual streamflow for five U.S. Geological Survey (USGS) streamflow gages in Region C [(8)]. The four gages on tributaries have watersheds with limited development and show the natural variation of streamflows in this region. The Trinity River near Rosser gage is on the main stem of the Trinity River downstream from the Dallas-Fort Worth area. At this location, natural flow patterns have been substantially altered by reservoir development and by return flows of treated wastewater. Figure 1.6 shows seasonal patterns of median streamflows for the same five gages [(8)]. Return flows from the Dallas-Fort Worth area

Figure 1.2
Average Annual Precipitation

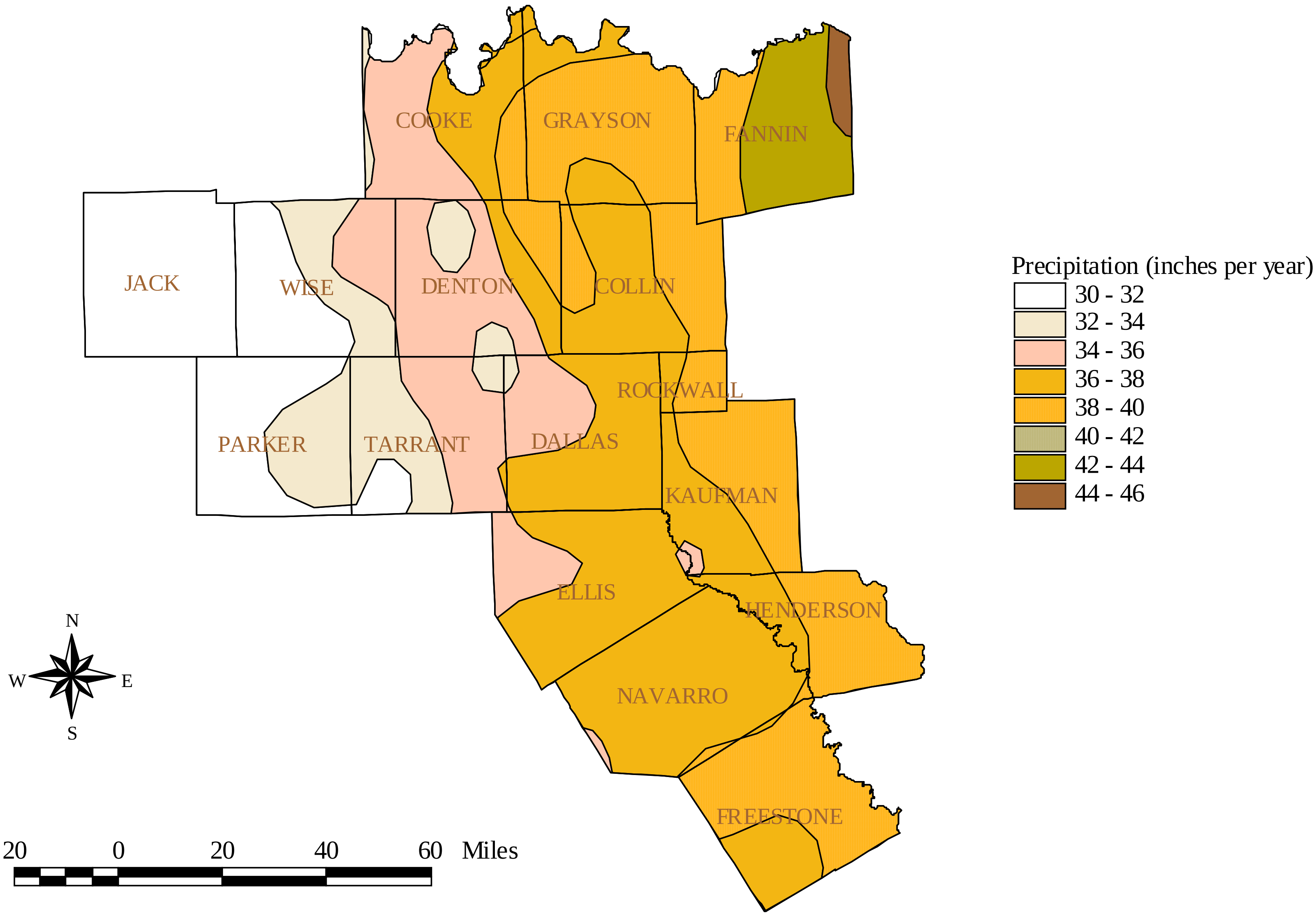


Figure 1.3
Average Annual Runoff

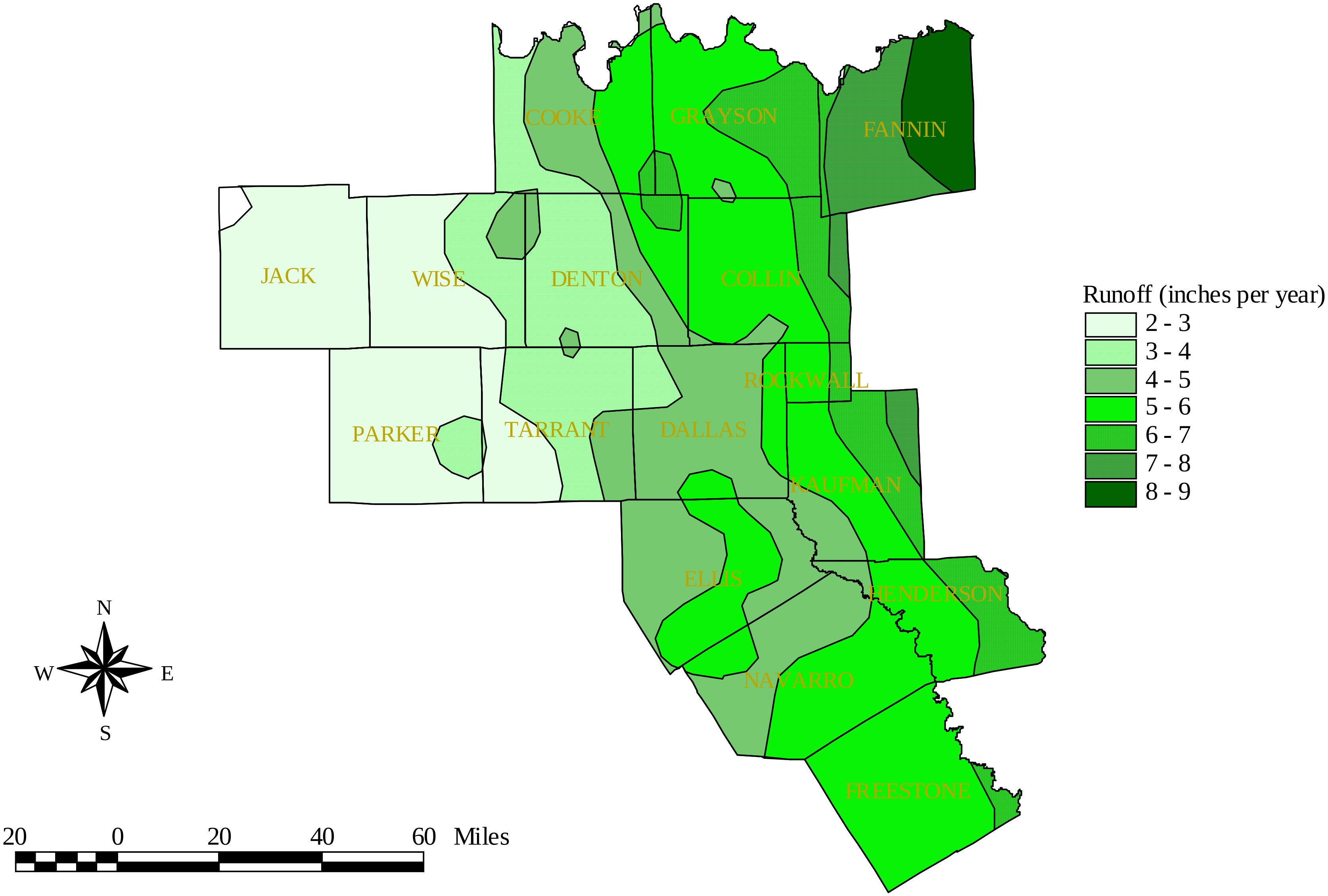
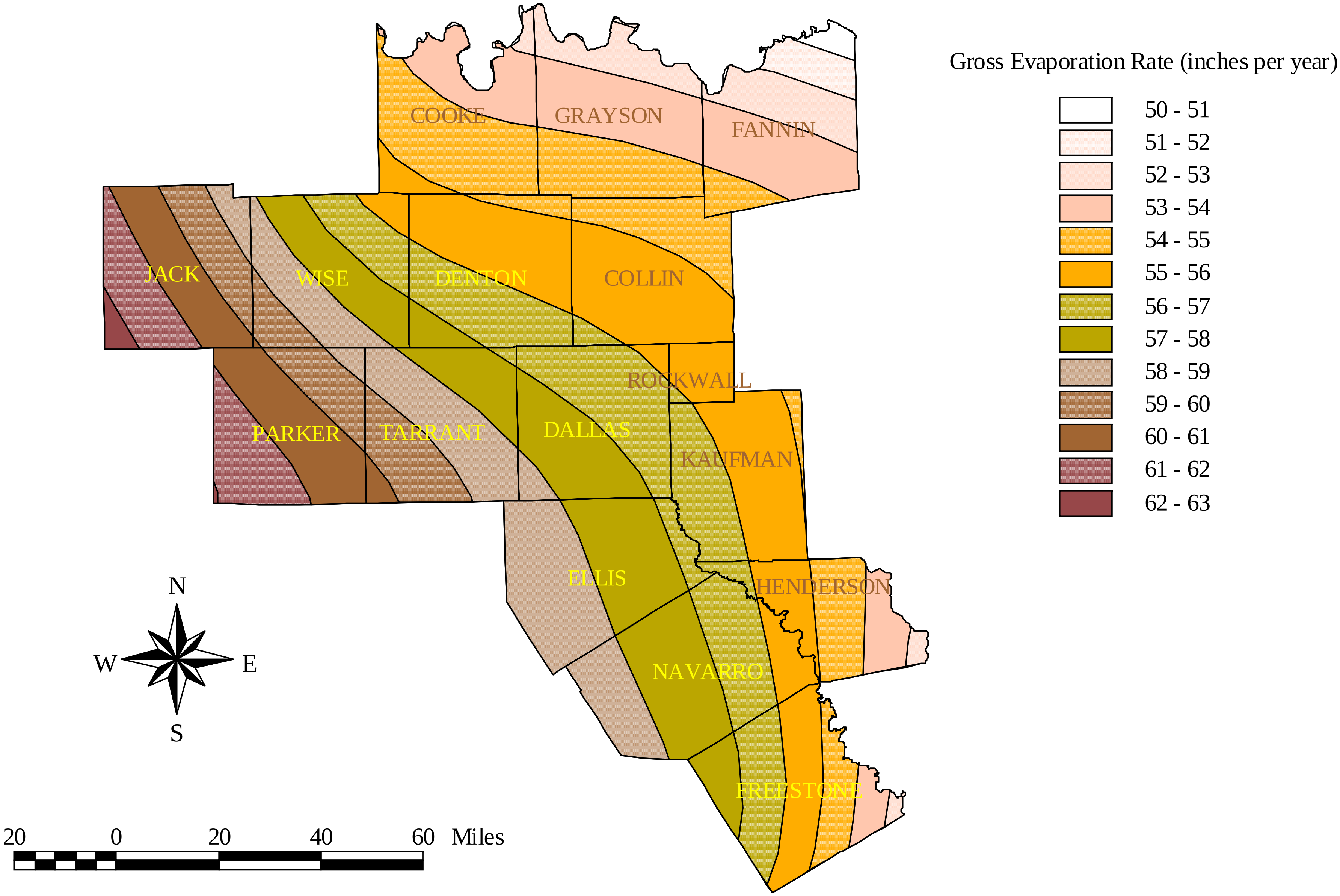


Figure 1.4
Average Annual Gross Evaporation



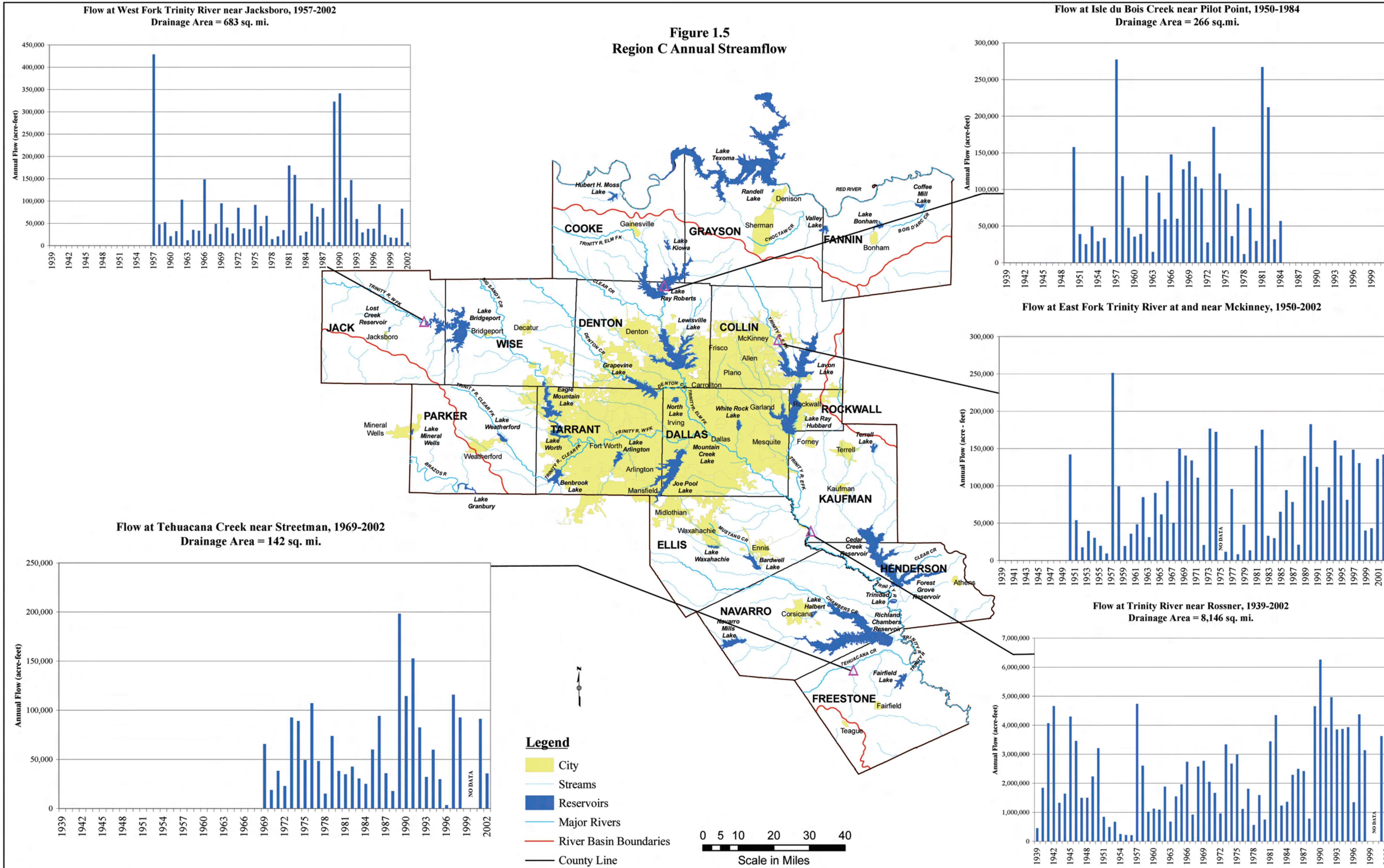
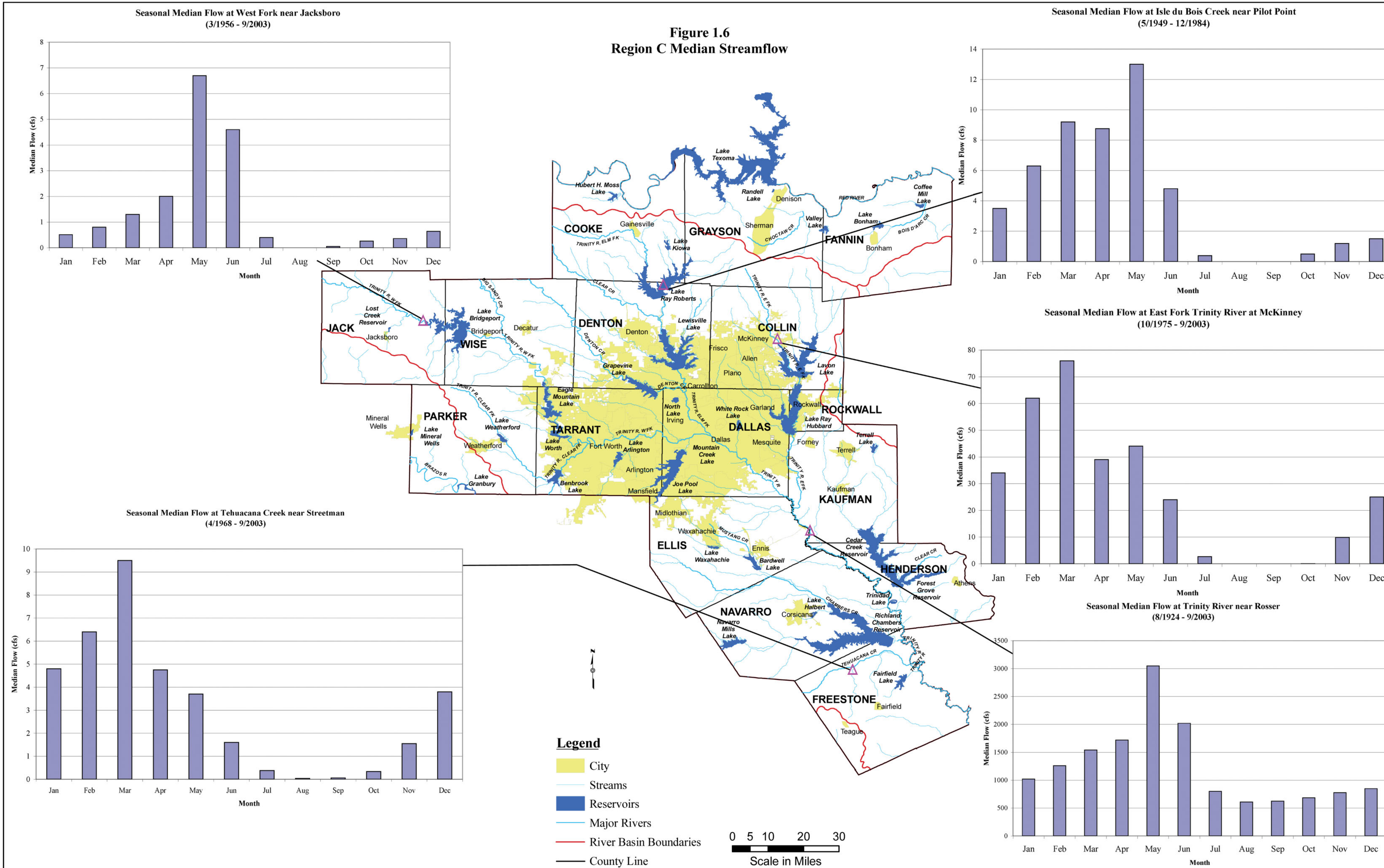


Figure 1.5
Region C Annual Streamflow

Figure 1.6
Region C Median Streamflow



reduce seasonal variations in flow at the Rosser gage by significantly increasing summer flows compared to natural conditions.

Table 1.4 lists the 34 reservoirs in Region C with conservation storage over 5,000 acre-feet, all of which are shown in Figure I.1. These reservoirs and others outside of Region C provide most of the region's water supply. Reservoirs are necessary to provide a reliable surface water supply in this part of the state because of the wide variations in natural streamflow. Reservoir storage serves to capture high flows when they are available and save them for use during times of normal or low flow.

Figure 1.7 shows major aquifers in Region C, and Figure 1.8 shows minor aquifers [9]. The most heavily used aquifer in Region C is the Trinity aquifer, which supplies most of the groundwater used in the region. The Carrizo-Wilcox aquifer also outcrops in Region C in Navarro, Freestone, and Henderson Counties. Minor aquifers in Region C include the Woodbine aquifer, the Nacatoch aquifer, and a small part of the Queen City aquifer.

1.3 Current Water Uses and Demand Centers in Region C

Table 1.5 shows the total water use by county in Region C from 1990 through 2000, the most recent year for which data are available [10]. Water use in Region C has increased significantly in recent years, primarily in response to increasing population and municipal use. The historical record shows years of high use, including 1996, 1998, 1999, and 2000. High use years are associated with dry weather, which causes higher municipal use due to increased outdoor water use (lawn watering). Table 1.6 shows water use since 1980 by Texas Water Development Board use category. Figure 1.9 is a graph of the historical water use for Region C by category. (The Texas Water Development Board categorizes water use as municipal, manufacturing, steam electric power generation, mining, irrigation, and livestock. Municipal use is by far the largest category in Region C, with significant manufacturing and steam electric use as well. There is limited mining, irrigation, and livestock use in Region C.) Table 1.6 also shows statewide water use by category for year 2000 and Region C use as a percent of statewide use. It is interesting to note that Region C, with 25.2 percent of Texas' population, had only 8.2 percent of the state's water use in 2000. This is primarily because Region C has very limited water use for irrigation, while irrigation use is more than 60 percent of the total use for the state as a whole.

Table 1.7 shows the water use in Region C by category by county in 2000, the base year for this round of regional water planning. About 85 percent of the current water use in Region C is for municipal supply, with manufacturing use as the second largest category, followed by steam electric power generation and irrigation. The irrigation water use in Region C is somewhat misleading in that this number primarily represents golf course irrigation, as opposed to crop irrigation. Mining and livestock are relatively minor uses of water in Region C. The year 2000 water use in Tarrant and Dallas Counties was 65.7 percent of the total Region C use, and these two counties had 69.8 percent of the region's population in 2000.

Figure 1.10 is a comparison of year 2000 per capita municipal water use for the sixteen Senate Bill 1 planning regions. (Per capita water use, usually expressed as gallons per capita per day, or gpcd, is an estimate of the water use per person.) Region C had the third highest per capita municipal water use in the year 2000, about 15 percent higher than the statewide average. Figure 1.11 shows a comparison of year 2000 per capita non-agricultural water use by region. This includes municipal, manufacturing, steam electric power generation, and mining use. Region C had the 6th lowest per capita non-agricultural water use, about 15 percent below the statewide average. Figure 1.12 shows the year 2000 total per capita water use by region. Region C had by far the lowest per capita total water use of any of the planning regions in the year 2000.

In addition to the consumptive water uses discussed above, water is used for recreation and other purposes in Region C. Reservoirs for which records of visitors are maintained (primarily Corps of Engineers lakes with recreational facilities) draw millions of visitors each year in Region C. In addition, smaller lakes and streams in the region draw many visitors for fishing, boating, swimming, and other water-related recreational activities. Water in streams and lakes is also important to fish and wildlife in the region.

1.4 Current Sources of Water Supply

Table 1.8 summarizes the total surface water and groundwater use in Region C from 1980 through 2000 [(10)], and Figure 1.13 shows the division of total water use between surface water and groundwater. Total water use has increased significantly since 1980. Since 1990, over 90 percent of the water use in Region C has been supplied by surface water. Table 1.9 shows the groundwater and surface water use by county and category for year 2000 [(10)]. Table 1.9 demonstrates some interesting points about water use in Region C in the year 2000:

- Although groundwater provided only 7.4 percent of the overall water use in Region C, it provided 21 percent of the irrigation use and 26 percent of the livestock use.
- Groundwater provided the majority of the total water use in Cooke and Parker Counties and over 25 percent in Ellis, Fannin, Grayson, and Henderson Counties.
- Groundwater provided all municipal water use in Cooke County and the majority of the municipal use in Fannin, Freestone, Parker, and Wise Counties.
- Dallas and Tarrant Counties had 73 percent of the municipal water use in the region.
- Dallas and Tarrant Counties had 71 percent of the manufacturing water use in the region.
- Dallas and Freestone Counties had 62 percent of the steam electric power water use in the region.
- Dallas and Tarrant Counties had 54 percent of the irrigation use in the region.
- Wise County had 74 percent of the mining use in the region.
- Livestock use is widely spread throughout the region.

Surface Water Sources

Most of the surface water supply in Region C comes from major reservoirs. Table 1.10 lists the permitted conservation storage, permitted diversion, year 2000 yield and the actual 2000 diversion for major reservoirs (over 5,000 acre-feet of conservation storage) in the region.

Another major source of supply in Region C is surface water imported from other regions. Table 1.11 lists currently permitted imports of water to Region C from other regions. (No special permit is required if importation from another region does not involve interbasin transfers, but all significant imports to Region C, except TRA's upstream sale from Lake Livingston, currently involve interbasin transfers and thus require interbasin transfer permits.) Figure I.1 shows the surface water reservoirs that provide these imports. There is also small-scale importation of treated water in parts of the region, where small suppliers purchase water that originates in other regions.

Groundwater Sources

Table 1.12 lists historical groundwater pumping by aquifer for Region C [10]. Table 1.13 shows the year 2000 pumping by county and aquifer [10]. (Note that the pumping totals do not match use totals given in Tables 1.8 and 1.9. The Texas Water Development Board supplied both of these sets of data. The discrepancy may be due to water that is pumped in one county and used in another.) The Trinity aquifer is by far the largest source of groundwater in Region

Table 1.4
Major Reservoirs in Region C (Over 5,000 Acre-Feet of Conservation Storage)

Reservoir	Basin	Stream	County(ies)	Permitted Conservation Storage (Acre-Feet)	Owner	Water Right Holder(s)
Moss	Red	Fish Creek	Cooke	23,210	Gainesville	Gainesville
Texoma	Red	Red River	Grayson, Cooke	2,722,000	Corps of Engineers	Red River Authority, Greater Texoma UA, Denison, North Texas MWD, TXU Electric
Randell	Red	Unnamed Trib. Shawnee Creek	Grayson	5,400	Denison	Denison
Valley	Red	Sand Creek	Fannin, Grayson	15,000	TXU Electric	TXU Electric
Bonham	Red	Timber Creek	Fannin	13,000	Bonham MWA	Bonham
Coffee Mill	Red	Coffee Mill Creek	Fannin	8,000	USDA	U.S. Department of Agriculture
Kiowa	Trinity	Indian Creek	Cooke	7,000	Lake Kiowa POA Inc.	Lake Kiowa Property Owners Association, Inc.
Ray Roberts	Trinity	Elm Fork Trinity River	Denton, Cooke, Grayson	799,600	Corps of Engineers	Dallas and Denton
Lost Creek	Trinity	Lost Creek	Jack	11,961	Jacksboro	Jacksboro
Bridgeport	Trinity	West Fork Trinity River	Wise, Jack	387,000	TRWD	Tarrant Regional Water District
Lewisville	Trinity	Elm Fork Trinity River	Denton	618,400	Corps of Engineers	Dallas and Denton
Lavon	Trinity	East Fork Trinity River	Collin	380,000	Corps of Engineers	North Texas MWD
Weatherford	Trinity	Clear Fork Trinity River	Parker	19,470	Weatherford	Weatherford
Grapevine	Trinity	Denton Creek	Tarrant, Denton	161,250	Corps of Engineers	Park Cities MUD, Dallas, Grapevine
Eagle Mountain	Trinity	West Fork Trinity River	Tarrant, Wise	210,000	TRWD	Tarrant Regional Water District
Worth	Trinity	West Fork Trinity River	Tarrant	38,124	Fort Worth	Fort Worth
Benbrook	Trinity	Clear Fork Trinity River	Tarrant	72,500	Corps of Engineers	Tarrant Regional Water District, Benbrook WSA
Arlington	Trinity	Village Creek	Tarrant	45,710	Arlington	Arlington and TXU Electric
Joe Pool	Trinity	Mountain Creek	Dallas, Tarrant	176,900	Corps of Engineers	Trinity River Authority
Mountain Creek	Trinity	Mountain Creek	Dallas	22,840	TXU Electric	TXU Electric
North	Trinity	South Fork Grapevine Creek	Dallas	17,100	TXU Electric	TXU Electric
White Rock	Trinity	White Rock Creek	Dallas	21,345	Dallas	Dallas

Table 1.4, Continued

Reservoir	Basin	Stream	County(ies)	Permitted Conservation Storage (Acre-Feet)	Owner	Water Right Holder(s)
Ray Hubbard	Trinity	Elm Fork Trinity River	Dallas, Kaufman, Rockwall	490,000	Dallas	Dallas
Terrell	Trinity	Muddy Cedar Creek	Kaufman	8,712	Terrell	Terrell
Bardwell	Trinity	Waxahachie Creek	Ellis	54,900	Corps of Engineers	Trinity River Authority
Waxahachie	Trinity	Waxahachie Creek	Ellis	13,500	Ellis Co. WCID#1	Ellis Co. WCID#1
Cedar Creek	Trinity	Cedar Creek	Henderson, Kaufman	678,900	TRWD	Tarrant Regional Water District
Forest Grove	Trinity	Caney Creek	Henderson	20,038	TXU Electric	TXU Electric
Trinidad	Trinity	Off-channel	Henderson	6,200	TXU Electric	TXU Electric
Navarro Mills	Trinity	Richland Creek	Navarro	63,300	Corps of Engineers	Trinity River Authority
Halbert	Trinity	Elm Creek	Navarro	7,357	Corsicana	Corsicana
Richland-Chambers	Trinity	Richland Creek	Freestone, Navarro	1,135,000	TRWD	Tarrant Regional Water District, Corsicana
Fairfield	Trinity	Big Brown Creek	Freestone	50,600	TXU Electric	TXU Electric
Mineral Wells	Brazos	Rock Creek	Parker	7,065	Mineral Wells	Mineral Wells

Note: Data are from TCEQ water rights list [(11)] and other sources.

Figure 1.7
Major Aquifers in Region C Counties

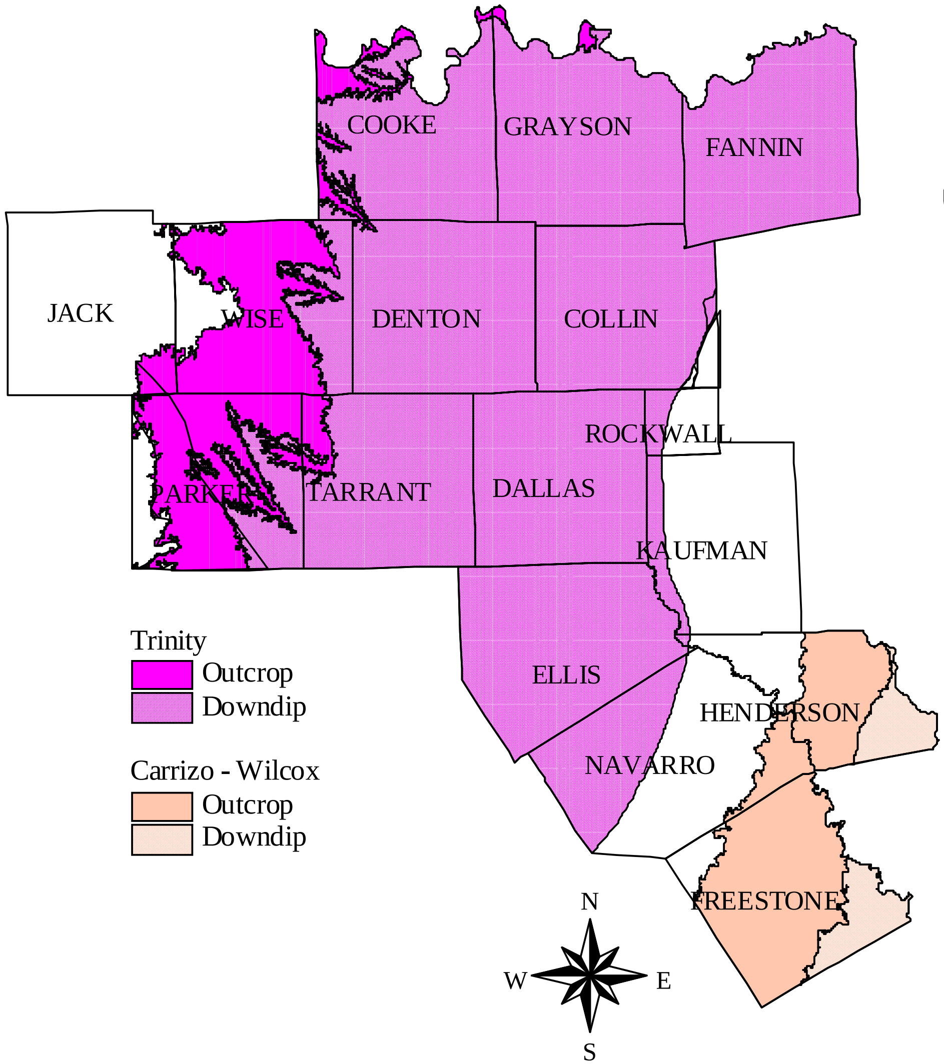
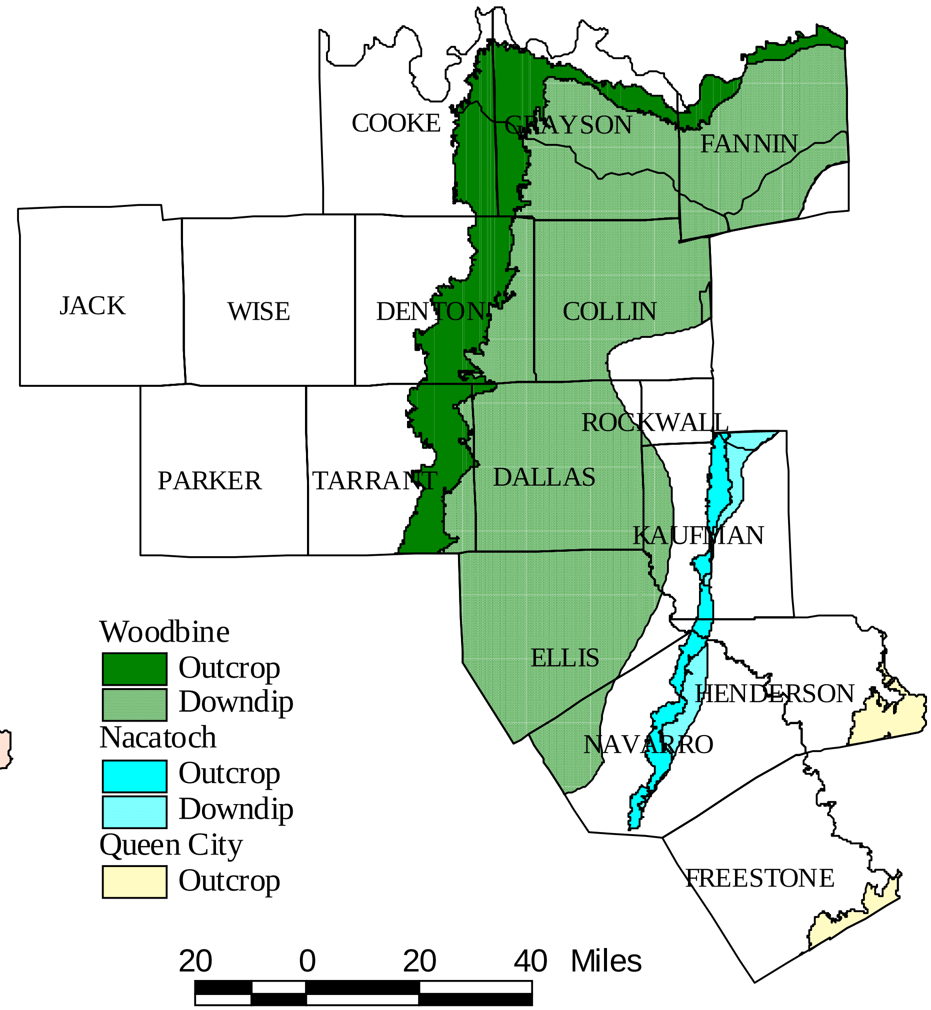


Figure 1.8
Minor Aquifers in Region C Counties



Note:
Outcrop is the area of the formation at the surface.
Downdip is the area of the formation below the surface.

Table 1.5
Historical Total Water Use by County in Region C
- Values in Acre-Feet -

County	Year										
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Collin	62,349	60,461	62,689	72,759	71,803	82,827	89,230	94,231	105,027	117,119	138,306
Cooke	7,406	7,781	8,047	8,643	9,044	8,330	8,429	8,534	8,236	7,555	7,270
Dallas	483,283	450,134	463,009	492,243	449,483	492,531	505,423	495,381	535,553	589,264	623,535
Denton	49,876	48,647	49,303	54,527	52,063	58,738	65,075	66,880	74,902	80,643	93,982
Ellis	18,967	17,218	16,726	18,567	17,650	17,799	19,721	20,368	22,353	23,490	25,469
Fannin	13,133	9,175	9,339	13,353	12,664	14,965	17,515	13,760	13,714	14,230	16,935
Freestone	17,155	18,278	16,569	17,659	18,477	17,262	20,608	15,446	14,722	14,568	17,107
Grayson	23,150	22,379	21,274	23,892	23,943	26,958	29,152	27,810	44,689	42,375	32,478
Henderson [b]	9,615	7,920	7,583	8,875	7,915	9,217	10,653	9,791	10,651	10,886	11,244
Jack	2,071	2,407	2,380	2,434	2,624	2,319	3,337	2,399	2,228	2,232	2,600
Kaufman	10,008	9,741	9,530	11,657	10,819	10,770	10,653	10,245	15,322	15,722	15,523
Navarro	9,234	8,714	8,372	9,107	8,838	8,598	10,558	10,540	14,618	14,316	11,007
Parker	11,236	11,839	10,231	11,268	11,505	11,231	12,372	12,600	12,090	12,163	15,617
Rockwall	5,273	5,076	4,718	5,462	5,495	6,212	6,566	6,437	8,298	8,514	10,350
Tarrant	285,033	264,569	248,053	274,763	264,769	273,657	291,406	283,626	304,518	324,790	331,066
Wise	15,219	15,094	14,605	20,869	23,594	24,396	25,688	30,608	25,322	24,363	28,067
Total	**1,023,008**	**959,433**	**952,428**	**1,046,078**	**990,686**	**1,065,810**	**1,126,518**	**1,108,656**	**1,212,243**	**1,302,230**	**1,380,556**

Notes: a. Data are from the Texas Water Development Board [10].
b. Data for Henderson County include only the part of the county in Region C for 1990 through 1997. Data for Henderson County include the entire county from 1998 through 2000.

Table 1.6
Historical Water Use by Category in Region C
- Values in Acre-Feet -

Year	Municipal	Manu-facturing	Steam Electric	Irrigation	Mining	Livestock	Total
1980	666,010	100,657	53,009	23,993	10,114	18,381	872,164
1984	747,532	83,337	53,403	7,716	4,149	20,004	916,141
1985	789,077	81,998	51,661	12,404	6,386	19,159	960,685
1986	777,798	84,946	45,210	7,918	10,508	17,354	943,734
1987	801,530	79,017	48,503	7,817	13,437	17,224	967,528
1988	856,896	89,916	57,809	7,841	13,107	18,248	1,043,817
1989	801,595	97,859	47,433	6,640	7,153	17,464	978,144
1990	844,430	100,062	46,959	5,434	7,153	18,970	1,023,008
1991	798,811	89,141	36,951	4,441	10,948	19,141	959,433
1992	804,145	81,776	33,393	5,117	9,522	18,475	952,428
1993	879,038	81,043	39,175	10,749	17,478	18,595	1,046,078
1994	825,076	78,619	36,252	9,514	20,449	20,776	990,686
1995	897,591	76,036	40,321	11,693	20,324	19,845	1,065,810
1996	946,454	71,366	52,103	9,689	22,576	24,330	1,126,518
1997	942,004	79,048	35,673	10,451	23,283	18,197	1,108,656
1998	1,044,678	83,818	33,300	10,605	22,082	17,760	1,212,243
1999	1,154,658	62,639	32,601	10,895	22,082	19,355	1,302,230
2000	1,196,452	58,289	43,071	40,153	23,479	19,112	1,380,556
State Total in 2000	**4,047,322**	**1,449,508**	**561,394**	**10,116,043**	**271,215**	**300,441**	**16,745,923**
% in Region C	**29.6%**	**4.0%**	**7.7%**	**0.4%**	**8.7%**	**6.4%**	**8.2%**

Note: Data are from the Texas Water Development Board [(10)]

C, providing 66 percent of the total groundwater pumped in 2000. (The Trinity aquifer is sometimes called the Trinity Sands and includes the Antlers, Twin Mountain, Glen Rose, and Paluxy formations [(12)].) The Woodbine and Carrizo-Wilcox aquifers provided 19 and 8 percent of the year 2000 totals, respectively. The Nacatoch and Queen City aquifers provide slightly over 1 percent combined, and another 3 percent is from other and undifferentiated aquifers. Groundwater pumping is highest in Denton, Grayson, and Tarrant Counties. These three counties have 47 percent of the region's total groundwater pumping.

Figure 1.9
Historical Water Use by Category in Region C

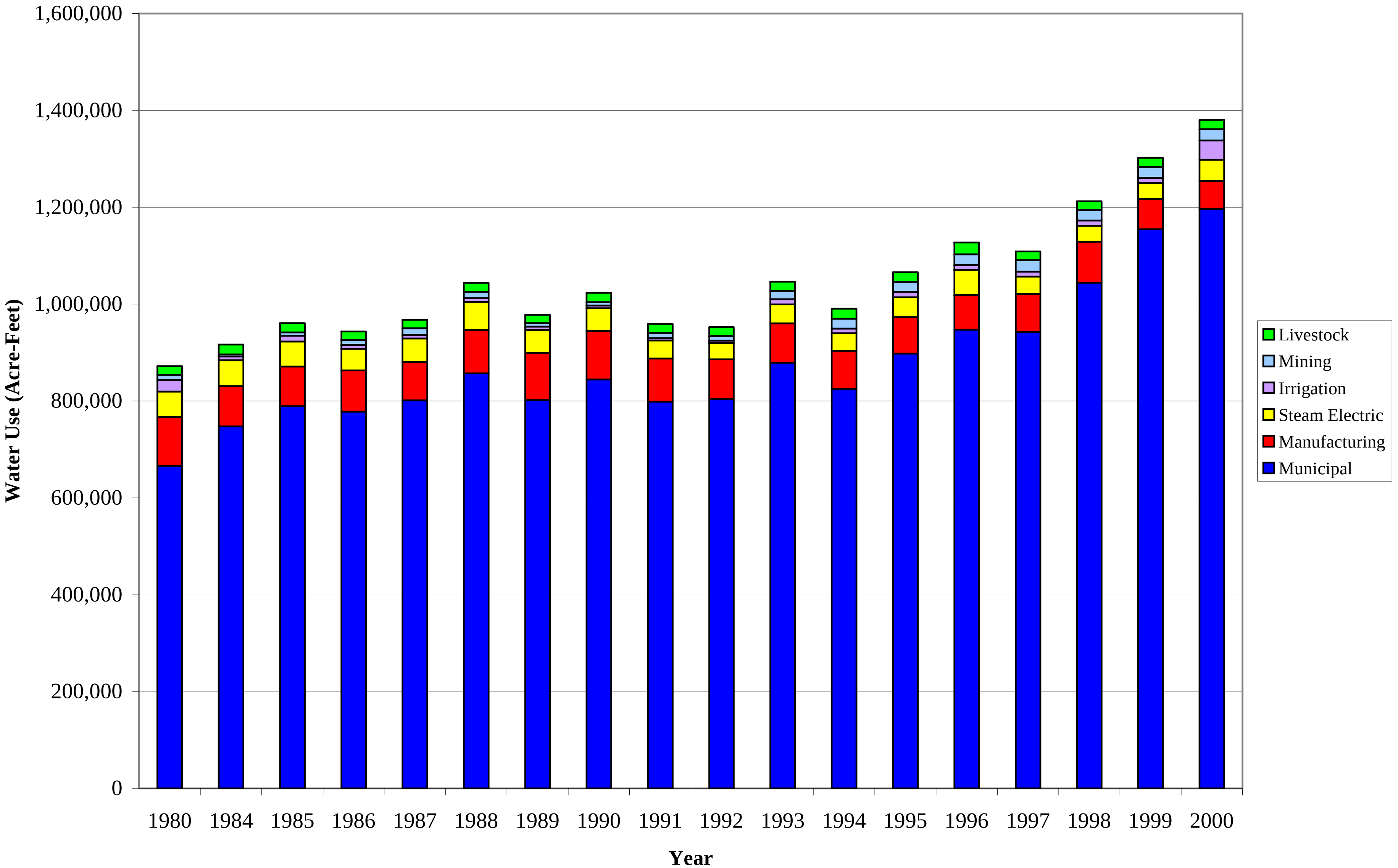


Table 1.7
Year 2000 Water Use by Category by County
- Values in Acre-Feet -

County	Municipal	Manu-facturing	Steam Electric	Irrigation	Mining	Livestock	Total
Collin	129,603	2,728	1,901	2,995	195	884	138,306
Cooke	4,998	221	0	0	289	1,762	7,270
Dallas	565,148	28,159	13,749	13,087	2,910	482	623,535
Denton	89,062	807	631	2,108	139	1,235	93,982
Ellis	19,820	3,049	744	583	90	1,183	25,469
Fannin	5,349	58	5,638	4,608	12	1,270	16,935
Freestone	2,471	0	13,004	8	96	1,528	17,107
Grayson	21,056	5,685	0	3,382	1,058	1,297	32,478
Henderson [b]	7,625	98	2,465	0	202	854	11,244
Jack	1,140	2	0	0	433	1,025	2,600
Kaufman	10,276	711	0	2,916	75	1,545	15,523
Navarro	8,426	949	0	0	89	1,543	11,007
Parker	12,621	607	36	422	75	1,856	15,617
Rockwall	9,046	15	0	1,125	33	131	10,350
Tarrant	303,194	13,407	4,903	8,417	342	803	331,066
Wise	6,617	1,793	0	502	17,441	1,714	28,067
Total	**1,196,452**	**58,289**	**43,071**	**40,153**	**23,479**	**19,112**	**1,380,556**

Notes: a. Data are from the Texas Water Development Board [10].
b. Data for Henderson County include all of Henderson County.

Water Reclamation

Over half of the water used for municipal supply in Region C is discharged as treated effluent from wastewater treatment plants after use, making wastewater reclamation and reuse a potentially significant source of additional water supply. At present, only a fraction of the region's treated wastewater is reclaimed and reused in the region. There are currently a number of water reclamation projects in Region C that reuse treated wastewater for non-potable uses such as the irrigation of golf courses. In addition, there are sizable return flows of treated wastewater upstream from many Region C reservoirs. If the reservoir's water rights exceed its firm yield without return flows, as is the case for many Region C reservoirs, return flows will increase the reliable supply from the reservoir. If the reservoir's water rights do not exceed its firm yield, a water right must be obtained to allow

Figure 1.10
Comparison of Year 2000 Municipal Per Capita Water Use by Region

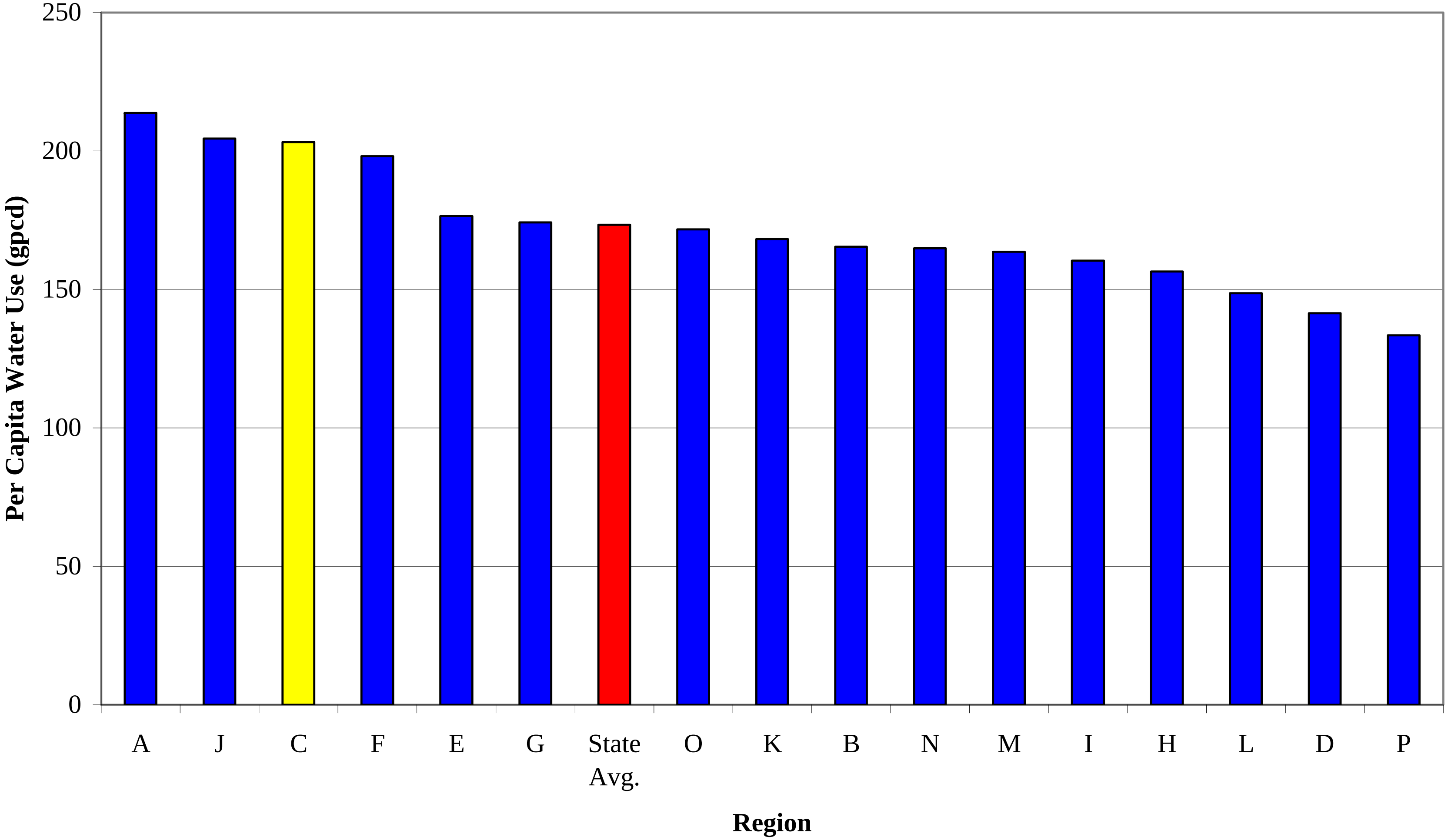


Figure 1.11
Comparison of Year 2000 Non-Agricultural Per Capita Water Use by Region

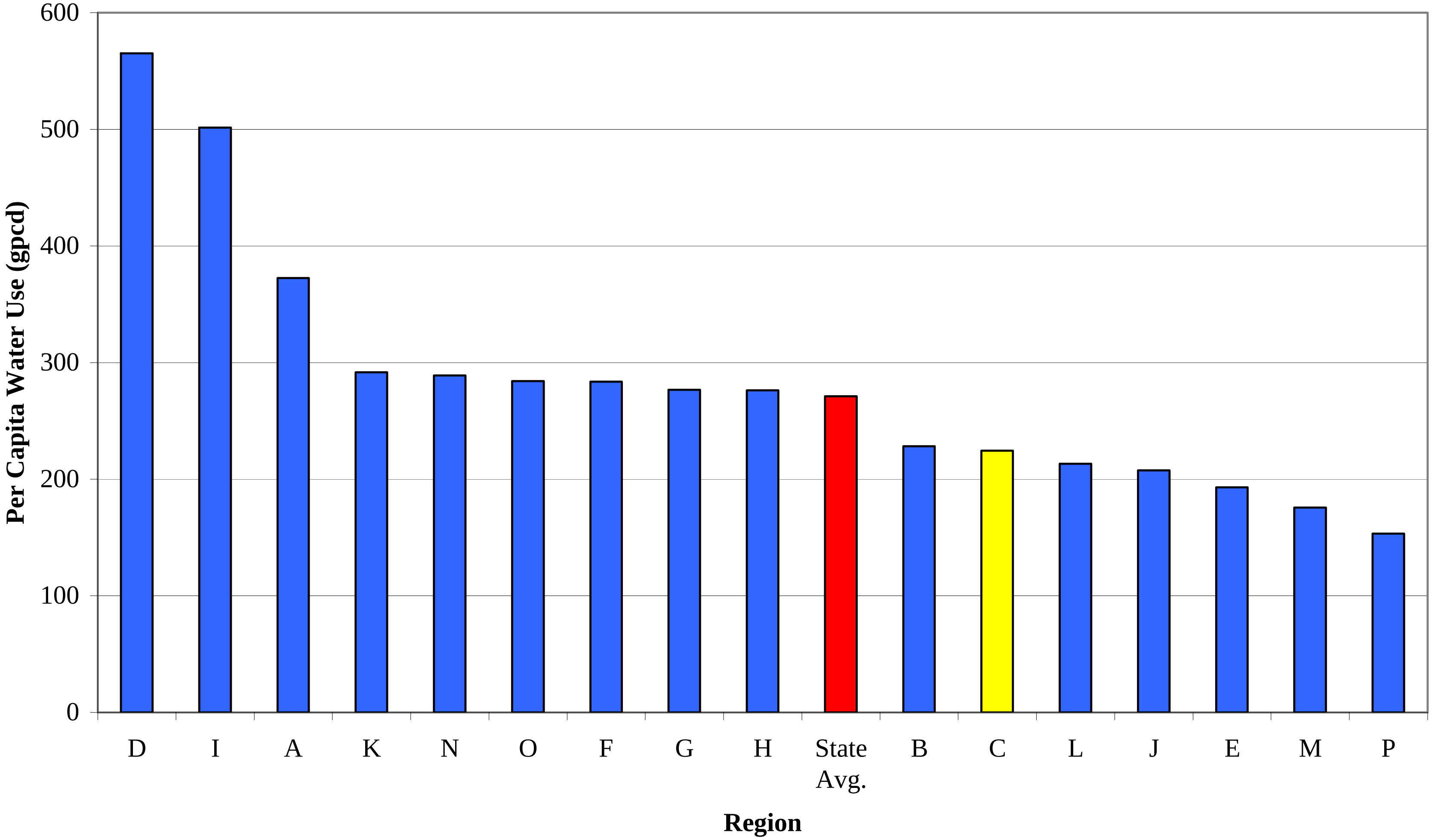


Figure 1.12
Comparison of Year 2000 Total Per Capita Water Use by Region

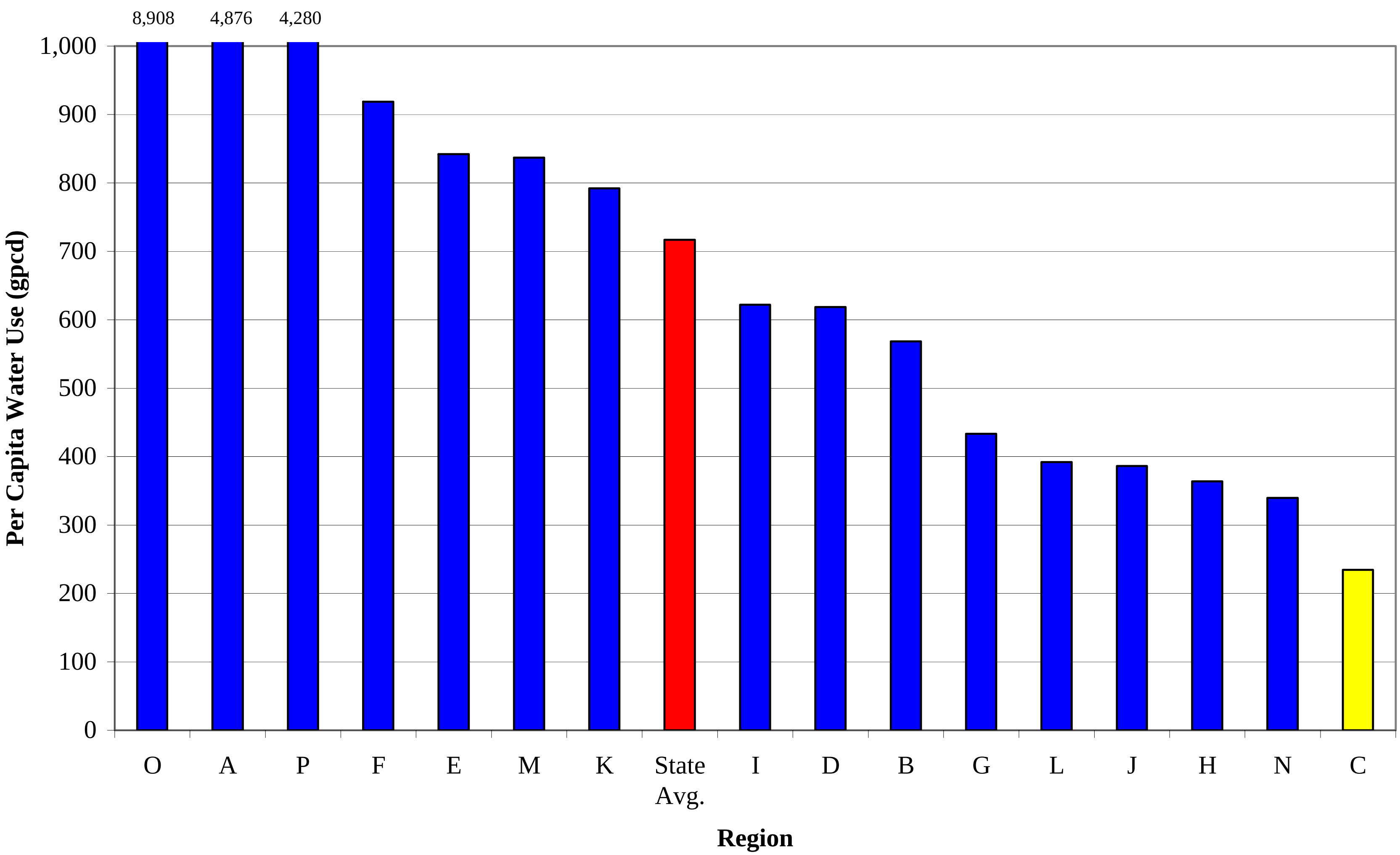


Table 1.8
Historical Sources of Water Supply in Region C

Year	Supply in Acre-Feet		
	Surface Water	Ground-water	Total
1980	779,799	92,365	872,164
1984	818,762	97,379	916,141
1985	858,607	102,078	960,685
1986	848,838	94,896	943,734
1987	871,038	96,490	967,528
1988	942,863	100,954	1,043,817
1989	884,663	93,481	978,144
1990	932,298	90,710	1,023,008
1991	874,846	84,587	959,433
1992	869,064	83,364	952,428
1993	959,840	86,238	1,046,078
1994	908,770	81,916	990,686
1995	981,168	84,642	1,065,810
1996	1,038,508	88,010	1,126,518
1997	1,020,639	88,017	1,108,656
1998	1,109,954	102,289	1,212,243
1999	1,205,237	96,993	1,302,230
2000	1,276,561	103,995	1,380,556

Notes: Data are from Texas Water Development Board [(10)].
1998-2000 includes all of Henderson County.

Table 1.9
Sources of Water Supply by County by Category in 2000 for Region C
- Values in Acre-Feet -

County	Water Type	Munic-ipal	Manu-facturing	Steam Electric	Irriga-tion	Mining	Live-stock	Total
Collin	Ground	4,149	139	570	1,718	0	88	6,664
	Surface	125,454	2,589	1,331	1,277	195	796	131,642
	Total	129,603	2,728	1,901	2,995	195	884	138,306
Cooke	Ground	4,998	221	0	0	52	881	6,152
	Surface	0	0	0	0	237	881	1,118
	Total	4,998	221	0	0	289	1,762	7,270
Dallas	Ground	4,998	706	0	330	1,385	48	7,467
	Surface	560,150	27,453	13,749	12,757	1,525	434	616,068
	Total	565,148	28,159	13,749	13,087	2,910	482	623,535
Denton	Ground	12,845	38	0	2,108	69	617	15,677
	Surface	76,217	769	631	0	70	618	78,305
	Total	89,062	807	631	2,108	139	1,235	93,982

Table 1.9, Continued

County	Water Type	Munic-ipal	Manu-facturing	Steam Electric	Irriga-tion	Mining	Live-stock	Total
Ellis	Ground	4,909	1,536	0	58	90	118	6,711
	Surface	14,911	1,513	744	525	0	1,065	18,758
	Total	19,820	3,049	744	583	90	1,183	25,469
Fannin	Ground	2,941	0	333	1,158	0	126	4,558
	Surface	2,408	58	5,305	3,450	12	1,144	12,377
	Total	5,349	58	5,638	4,608	12	1,270	16,935
Freestone	Ground	2,314	0	59	0	30	611	3,014
	Surface	157	0	12,945	8	66	917	14,093
	Total	2,471	0	13,004	8	96	1,528	17,107
Grayson	Ground	10,471	571	0	2,972	815	130	14,959
	Surface	10,585	5,114	0	410	243	1,167	17,519
	Total	21,056	5,685	0	3,382	1,058	1,297	32,478
Henderson [b]	Ground	3,151	16	0	0	143	513	3,823
	Surface	4,474	82	2,465	0	59	341	7,421
	Total	7,625	98	2,465	0	202	854	11,244
Jack	Ground	419	0	0	0	63	103	585
	Surface	721	2	0	0	370	922	2,015
	Total	1,140	2	0	0	433	1,025	2,600
Kaufman	Ground	218	0	0	0	0	155	373
	Surface	10,058	711	0	2,916	75	1,390	15,150
	Total	10,276	711	0	2,916	75	1,545	15,523
Navarro	Ground	187	0	0	0	89	154	430
	Surface	8,239	949	0	0	0	1,389	10,577
	Total	8,426	949	0	0	89	1,543	11,007
Parker	Ground	9,358	17	0	74	55	185	9,689
	Surface	3,263	590	36	348	20	1,671	5,928
	Total	12,621	607	36	422	75	1,856	15,617
Rockwall	Ground	122	0	0	0	0	13	135
	Surface	8,924	15	0	1,125	33	118	10,215
	Total	9,046	15	0	1,125	33	131	10,350
Tarrant	Ground	15,179	1,123	1	0	0	401	16,704
	Surface	288,015	12,284	4,902	8,417	342	402	314,362
	Total	303,194	13,407	4,903	8,417	342	803	331,066
Wise	Ground	3,774	39	0	147	265	857	5,082
	Surface	2,843	1,754	0	355	17,176	857	22,985
	Total	6,617	1,793	0	502	17,441	1,714	28,067
Region C	Ground	80,033	4,406	963	8,565	3,056	5,000	102,023
	Surface	1,116,419	53,883	42,108	31,588	20,423	14,112	1,278,533
	Total	1,196,452	58,289	43,071	40,153	23,479	19,112	1,380,556

Notes: a. Data are from the Texas Water Development Board [10].
b. Data for Henderson County include all of Henderson County.

Figure 1.13
Historical Source of Supply in Region C

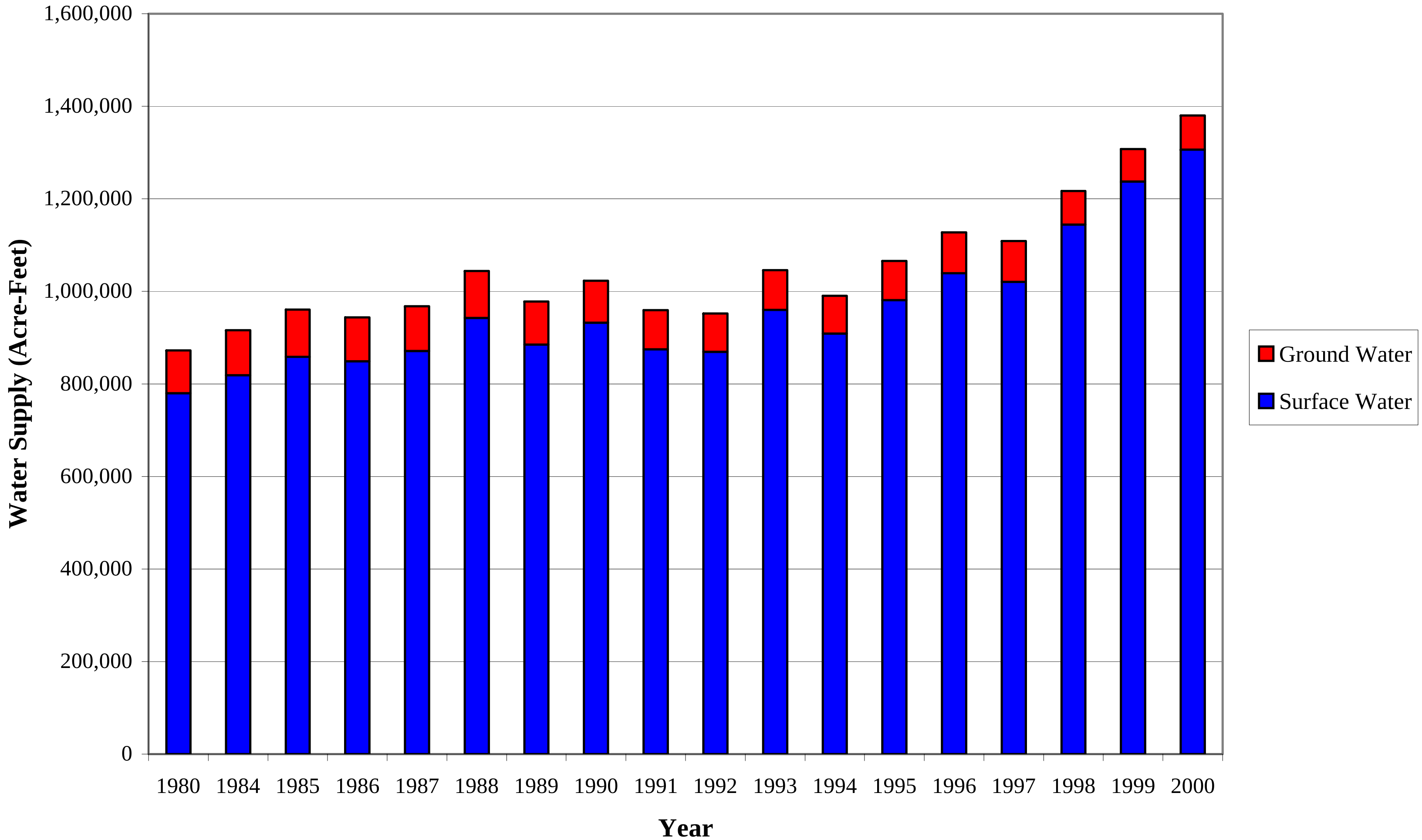


Table 1.10
Water Rights, Storage, Diversion, and Yield for Major Reservoirs in Region C

Reservoir	County(ies)	Water Right Number(s) [a]	Permitted Conservation Storage [b] (Acre-Feet)	Permitted Diversion [b] (Acre-Feet/Year)	2000 Diversion [c] (Acre-Feet)	Year 2000 Yield [l] (Acre-Feet/Year)
Moss	Cooke	4881	23,210	4,500	0	4,500[m]
Texoma	Grayson, Cooke	4898, 2006, 4899, 4901, 4900, 5003	2,733,000	145,650	20,098	138,700[m]
Randell	Grayson	4901	5,400	5,280	4,847	5,280[m]
Valley	Fannin, Grayson	4900	15,000	10,000	8,549	0[m]
Bonham	Fannin	4925	13,000	5,340	No Data	5,340[m]
Coffee Mill	Fannin	4915	8,000	0	0	0(Recreation)
Kiowa	Cooke	2334A	7,000	0	0	0(Recreation)
Ray Roberts	Denton, Cooke, Grayson	2335A, 2455A	799,600	799,600	128,513	System
Lewisville	Denton	2348,2456	618,400	598,900	98,119	System
Elm Fork/ Lewisville/Ray Roberts System						222,657
Lost Creek	Jack	3313A	11,961	1,440	0	1,440
Bridgeport	Wise, Jack	3808A	387,000	15,000[d]	44,379	System
Eagle Mountain	Tarrant, Wise	3809	210,000	159,600[g]	86,630	System
Bridgeport/Eagle Mountain/Worth System						110,000
Lavon	Collin	2410C	380,000	139,941[e]	216,150	104,000
Weatherford	Parker	3356	19,470	5,220[f]	3,629	2,900
Grapevine	Tarrant, Denton	2362, 2363, 2458B	161,250	161,250	27,230	16,800
Benbrook	Tarrant	5157A	72,500	6,834	52,921[k]	6,834
Arlington	Tarrant	3391	45,710	23,120	16,890	8,400
Joe Pool	Dallas, Tarrant	3404B	176,900	17,000	4,734	16,400
Mountain Creek	Dallas	3408	22,840	6,400	4,732	6,400
North	Dallas	2365	17,100	1,000[h]	1,801	0
White Rock	Dallas	2461	21,345	8,703	773	5,900
Ray Hubbard	Dallas, Kaufman, Rockwall	2462C 2462D 2462E	490,000	89,700	84,394	60,700
Terrell	Kaufman	4,972	8,712	6,000	4,333	2,300

Table 1.10, Continued

Reservoir	County(ies)	Water Right Number(s) [a]	Permitted Conservation Storage [b] (Acre-Feet)	Permitted Diversion [b] (Acre-Feet/Year)	2000 Diversion [c] (Acre-Feet)	Year 2000 Yield [l] (Acre-Feet/Year)
Bardwell	Ellis	5021A	54,900	14,729[i]	6,373	8,980
Waxahachie	Ellis	5018	13,500	3,570	No Data	2,760
Cedar Creek	Henderson, Kaufman	4976A	678,900	175,000	94,203	175,000
Teague City Lake	Freestone	5291	1,160	605	0	189
Clark	Ellis	5019	1,549	450	0	139
Forest Grove	Henderson	4983	20,038	9,500[j]	0	8,600
Trinidad	Henderson	4970	6,200	4,000	4,557	3,100
Navarro Mills	Navarro	4992	63,300	19,400	7,898	19,400
Halbert	Navarro	5030	7,357	4,003	1,760	0
Richland-Chambers	Freestone, Navarro	5030, 5035A	1,135,000	223,650	111,661	222,750
Fairfield	Freestone	5040	50,600	14,150	4,692	1,700
Mineral Wells	Parker	4039	7,065	2,520	61	2,520

Notes:
a. Water right numbers are Certificate of Adjudication numbers. For permits issued since adjudication, they are the application number.
b. Permitted conservation storage and permitted diversions are from TCEQ permits [(13)].
c. Year 2000 diversion amount is from TCEQ water use records [(14)].
d. Release of 78,000 acre-feet per year for diversion and use from Eagle Mountain Lake is also authorized.
e. Permitted diversion includes reuse of up to 35,941 acre-feet per year of return flows.
f. Diversion does not include 59,400 acre-feet per year of non-consumptive industrial use.
g. Permitted diversion includes water released from Lake Bridgeport.
h. Additional use (beyond the water right) is based on purchased water.
i. Permitted diversion includes reuse of up to 5,129 acre-feet per year of return flows.
j. Permitted diversion does not include non-consumptive use.
k. Year 2000 use includes water originally diverted from Cedar Creek and Richland-Chambers Reservoir and stored in Benbrook Lake.
l. Year 2000 yield is from Water Availability Models where possible.
m. Yields for Red River Reservoirs are based on previous yield analyses [(1)] rather than the Red River Water Availability Model.

indirect reuse of return flows. Current permits for indirect reuse in Region C include the following:

- Trinity River Authority sells treated wastewater from its Central Wastewater Treatment Plant in Dallas County to the Dallas County Utility and Reclamation District.
- North Texas Municipal Water District has a permit to reuse treated wastewater from its Wilson Creek Wastewater Treatment Plant through rediversion from Lake Lavon.

Table 1.11
Permitted Importation of Water to Region C

Destination	Source	Source Region	Source Basin	Destination Basin	Permitted Amount (Acre-Feet/Year)	Raw or Treated	Status
North Texas MWD	Chapman Lake [a]	D	Sulphur	Trinity	57,214	Raw	Operating
Irving	Chapman Lake [a]	D	Sulphur	Trinity	54,000	Raw	Operating
Upper Trinity RWD	Chapman Lake [a]	D	Sulphur	Trinity	16,106	Raw	Operating
Dallas	Lake Tawakoni	D	Sabine	Trinity	184,600	Raw	Operating
Dallas	Lake Fork Reservoir	D	Sabine	Trinity	120,000	Raw	Under Construction
Dallas	Lake Palestine	I	Neches	Trinity	114,337	Raw	Not Yet Developed
Athens [b]	Lake Athens	I	Neches	Trinity	5,477	Treated	Operating
Terrell	Lake Tawakoni	D	Sabine	Trinity	10,090	Raw	Operating
TXU Big Brown Plant	Lake Livingston [c]	H	Trinity	Trinity	20,000	Raw	Operating

Notes: a. Chapman Lake was formerly Cooper Lake.
b. Most of Athens is in the Trinity Basin.
c. Use is an upstream diversion based on Lake Livingston water right. Contract allows 20,000 acre per year, with a maximum of 48,000 acre-feet over 3 years.

- The Trinity River Authority has permits for future reuse of wastewater returned to the Bardwell Lake watershed from the City of Ennis and the City of Waxahachie.
- The Tarrant Regional Water District has water rights allowing the diversion of return flows from the Trinity River through artificial wetlands into Richland-Chambers and Cedar Creek Reservoirs to increase the yield of the lakes.
- The City of Athens has a water right allowing the reuse of its return flows through Lake Athens.
- The City of Denton has a reuse permit to use the effluent from the Pecan Creek Water Reclamation Plant. A portion is expected to be returned to Lewisville Lake for subsequent use.

The largest wastewater treatment plants in Region C discharge into the Trinity River and its tributaries downstream from all Region C reservoirs. At this time, several major applications for water rights for indirect reuse of treated wastewater effluent in Region C are pending before the Texas Commission on Environmental Quality. These include applications by:

- Trinity River Authority
- Dallas

Table 1.12
Historical Groundwater Pumping by Aquifer in Region C

Year	Pumping by Aquifer (Acre-Feet)						
	Trinity	Woodbine	Carrizo-Wilcox	Nacatoch	Queen City	Undifferent-iated/Other	Total
1980	65,200	12,898	4,745	424	56	1,734	85,057
1984	74,768	13,210	6,470	283	66	1,686	96,483
1985	77,760	16,324	6,579	325	59	1,501	102,548
1986	73,464	13,654	6,317	269	66	1,485	95,255
1987	74,728	14,861	5,716	253	49	1,444	97,051
1988	78,344	13,979	6,697	277	65	1,434	100,796
1989	71,443	14,332	5,328	278	63	1,211	92,655
1990	69,295	13,486	5,305	256	63	1,212	89,617
1991	63,484	13,256	4,998	311	64	1,447	83,560
1992	61,322	14,009	5,266	238	62	1,391	82,288
1993	61,089	16,330	5,526	241	58	1,881	85,125
1994	57,110	13,408	5,808	244	60	4,134	80,764
1995	57,241	15,349	6,117	285	62	4,677	83,731
1996	60,589	14,849	6,464	316	76	4,452	86,746
1997	60,032	15,423	5,873	285	58	3,938	85,609
1998	66,564	15,494	7,851	309	1,008	3,971	95,197
1999	62,331	17,562	7,989	292	952	4,064	93,190
2000	63,856	18,255	7,849	306	958	3,030	94,254

Note: Data are from the Texas Water Development Board (10). From 1980 through 1997, Henderson County data include only the portion of the county in Region C. For 1998-2000, data for Henderson County include the entire county. That is the reason for the increase in use from the Queen City aquifer.

- Upper Trinity Regional Water District
- City of Irving
- North Texas Municipal Water District (Wilson Creek Wastewater Treatment Plant)
- North Texas Municipal Water District (East Fork reuse project)

Springs in Region C

There are no springs in Region C that are currently used as a significant source of water supply. Springs are further discussed in Section 1.7 of this report (Agricultural and Natural Resources in Region C).

Table 1.13
Year 2000 Groundwater Pumping by County and Aquifer

County	Year 2000 Pumping by Aquifer (Acre-Feet) [a]						
	Trinity	Woodbine	Carrizo-Wilcox	Nacatoch	Queen City	Undifferent-iated/Other	Total
Collin	2,058	1,618				298	3,974
Cooke	6,372						6,372
Dallas	5,158	529				422	6,109
Denton	10,370	3,117					13,487
Ellis	4,707	2,160					6,867
Fannin	649	2,591				1,158	4,398
Freestone			3,280		32	40	3,352
Grayson	9,397	8,014				28	17,439
Henderson [b]			4,498		926	149	5,573
Jack	5					596	601
Kaufman		97		268			365
Navarro		129	71	38		134	372
Parker	6,951					25	6,976
Rockwall						168	168
Tarrant	13,823						13,823
Wise	4,366					12	4,378
Total	**63,856**	**18,255**	**7,849**	**306**	**958**	**3,030**	**94,254**

Notes: a. Data are from the Texas Water Development Board [(10)]
b. Data for Henderson County include all of Henderson County.

1.5 Water Providers in Region C

Water providers in Region C include regional wholesale water providers such as river authorities, larger water districts, and cities with large wholesale customer bases; local wholesale water providers such as smaller water districts and some cities, and retail suppliers (cities and towns, water supply corporations, special utility districts, and private water companies). Cities and towns provide most of the retail water service in Region C, with significant contributions from water districts and water supply corporations. Table 1.14 lists water providers that supplied more than 5,000 acre-feet of water in Region C in the year 2000. The list includes 44 entities - 37 cities, 5 water districts, and 2 river authorities.

Table 1.14
Entities Supplying more than 5,000 Acre-Feet in Region C in the Year 2000

Supplier	Year 2000 Region C Supplies (Acre-Feet) [a]					Comments
	Municipal Wholesale	Manufac-turing	Municipal Retail	Other	Total	
Dallas Water Utilities [b]	182,032	16,543	342,731	7,644	548,950	Other includes steam electric power sales.
Tarrant Regional Water District	315,701	784	0	6,977	323,462	Other includes irrigation and steam electric power sales.
North Texas Municipal Water District	251,457	0	38	0	251,495	Includes Sales into Region D (Cash SUD, Caddo Basin SUD, and Josephine).
Fort Worth	52,772	8,559	119,357	1,735	182,423	Includes sales into Region G (Burleson and Bethesda WSC).
Sabine River Authority	115,264	0	0	0	115,264	Includes sales to Dallas, Cash WSC, MacBee WSC, and Terrell.
Plano	23	564	66,287	0	66,874	
Trinity River Authority	54,793	0	0	9,820	64,613	Other is steam electric power sales.
Arlington	0	1,849	62,446	0	64,295	
Irving	0	2,077	47,173	0	49,250	
Garland	0	2,667	38,571	33	41,271	Other is steam electric power sales.
Richardson	0	829	28,978	0	29,807	
Carrollton	0	2,271	23,315	0	25,586	
Denton	1	363	23,428	19	23,811	

Table 1.14, Continued

Supplier	Year 2000 Region C Supplies (Acre-Feet)					Comments
	Municipal Wholesale	Manufac-turing	Municipal Retail	Other	Total	
Mesquite	0	990	22,307	0	23,297	
Lewisville	2	319	14,567	0	14,888	
Grand Prairie	282	941	13,056	0	14,279	
Sherman	258	5,203	8,756	0	14,217	
McKinney	2,150	448	11,549	0	14,147	
North Richland Hills	2,920	256	10,650	0	13,826	
Farmers Branch	0	1,140	10,273	0	11,413	
Frisco	0	148	11,128	0	11,276	
Allen	0	72	10,918	0	10,990	
Dallas County Park Cities MUD	10,831	0	0	0	10,831	Sales to Highland Park and University Park.
Grapevine	11	9	10,492	0	10,512	
Upper Trinity Regional Water District	10,162	0	0	0	10,162	Most sales in Denton County.
Bedford	0	16	9,799	0	9,815	
Coppell	0	0	9,301	0	9,301	
Corsicana	3,398	484	5,034	0	8,916	Wholesale sales based on data provided by Corsicana.
Rowlett	0	10	8,266	0	8,276	
Euless	0	32	8,188	0	8,220	
De Soto	0	18	8,018	0	8,036	
Greater Texoma Utility Authority	7,658	0	0	0	7,658	Sales to Sherman.
Hurst	0	26	7,218	0	7,244	

Table 1.14, Continued

Supplier	Year 2000 Region C Supplies (Acre-Feet)					Comments
	Municipal Wholesale	Manufac-turing	Municipal Retail	Other	Total	
Addison	99	12	6,994	0	7,105	
Mansfield	0	174	6,888	0	7,062	
Duncanville	0	50	6,934	0	6,984	
Cedar Hill	589	71	6,185	0	6,845	
Southlake	22	13	6,726	0	6,761	
University Park	0	0	6,707	0	6,707	
Keller	24	32	6,395	0	6,451	
Haltom City	0	31	6,389	0	6,420	
Waxahachie	1,625	862	3,880	0	6,367	Provided by Ellis County WCID #1.
Rockwall	1,154	9	4,897	0	6,060	
Colleyville	0	0	5,875	0	5,875	

Notes: a. Information based on TWDB data in the WUGSUMM file, unless specific sales data were provided by the entity.
b. Wholesale sales provided by City of Dallas.

Wholesale Water Providers (WWPs)

In the first round of Senate Bill One planning, the regulations required additional data development for "major providers of water for municipal and manufacturing purposes." For the second round of Senate Bill One planning, the Texas Water Development Board (TWDB) has replaced the term "major water providers" with the term "wholesale water providers". There are no implications of designation as a "wholesale water provider" except for the additional data required by TWDB. The wholesale water provider data is a different way of grouping water supply information.

The Texas Water Development Board defined the term wholesale water provider (WWP) as follows: "[A WWP is] any person or entity, including river authorities and irrigation districts, that has contracts to sell more than 1,000 acre-feet of water wholesale in any one year during the five years immediately preceding the adoption of the last Regional Water Plan. The Planning Groups shall [also] include as wholesale water providers other persons and entities that enter or that the Planning Group expects to enter contracts to sell more than 1,000 acre-feet of water wholesale during the period covered by the plan."

Table 1.15 lists the 35 entities in Region C that qualify as wholesale water providers (17 cities, 2 river authorities, and 16 water districts). Twelve of the wholesale water providers provide a large amount of wholesale supplies to several customers and are discussed below as regional wholesale water providers. The remaining 23 have fewer customers and are discussed as local wholesale water providers.

Table 1.15
Wholesale Water Providers in Region C

Wholesale Water Provider	Year 2000 Wholesale Sales (Acre-Feet)	Year 2000 Total Sales (Acre-Feet)	Number of Wholesale Customers	
			Year 2000	Additional Future
City of Cedar Hill	589	6,845	1	0
City of Corsicana	3,398	8,916	17	3
City of Dallas (Dallas Water Utilities)	183,747	458,950	29	8
City of Denton	1	23,811	1	0
City of Ennis	354	3,502	3	0

Table 1.15, Continued

Wholesale Water Provider	Year 2000 Wholesale Sales (Acre-Feet)	Year 2000 Total Sales (Acre-Feet)	Number of Wholesale Customers	
			Year 2000	Additional Future
City of Forney	733	2,137	4	1
City of Fort Worth	54,507	182,423	28	4
City of Gainesville	42	2,701	1	6
City of Garland	0	41,271	0	1
City of Mansfield	0	7,062	0	1
City of Midlothian	1,984	4,679	3	1
City of North Richland Hills	2,920	13,826	1	0
City of Rockwall	1,154	6,060	4	0
City of Seagoville	292	2,100	1	0
City of Terrell	993	4,542	8	0
City of Waxahachie	1,625	6,367	2	0
City of Weatherford	0	4,048	0	2
Athens Municipal Water Auth.	1,958	4,289	2	0
Dallas County Park Cities MUD	13,379	13,379	2	0
East Cedar Creek FWSD	0	2,457	2	0
Greater Texoma Utility Authority	7,658	7,658	1	20
Lake Cities MUA	805	815	3	0
Mustang SUD	0	728	0	3
North Texas Municipal Water District	251,457	251,495	40	17
Parker County Utility District #1	0	0	0	3
Rockett SUD	110	3,699	2	0
Sabine River Authority	115,584	115,584	22	0
Sulphur River Water District (all in Region D) [a]	0	0	4	0
Tarrant Regional Water District	315,701	323,462	37	3
Trinity River Authority	64,613	64,613	10	4
Upper Neches River Municipal Water Authority (all in Region I)	3,733	4,111	4	2
Upper Trinity Regional Water District	10,162	10,162	9	7
Walnut Creek SUD	101	1,278	7	0
West Cedar Creek MUD	331	1,382	2	0
Wise County WSD	7	457	1	0

Note: a Based on TCEQ water use reports.

Regional Wholesale Water Providers

There are twelve wholesale water providers in Region C that serve a large number of customers and/or provide large wholesale supplies and are called regional wholesale water providers: the City of Dallas (Dallas Water Utilities), Tarrant Regional Water District, North Texas Municipal Water District, the City of Fort Worth, Sabine River Authority, Trinity River Authority, Upper Neches River Municipal Water Authority, Upper Trinity Regional Water District, Sulphur River Water District, Dallas County Park Cities Municipal Utility District, Greater Texoma Utility Authority, and the City of Corsicana.

City of Dallas (Dallas Water Utilities, or DWU). Table 1.16 lists the year 2000 wholesale water sales by Dallas Water Utilities, which totaled 183,747 acre-feet. (As shown in Table 1.14, Dallas Water Utilities also provided retail supplies of 342,731 acre-feet in the year 2000.) Dallas Water Utilities currently obtains its water supplies from Lake Ray Hubbard, Lake Tawakoni, Grapevine Lake, and the Lake Ray Roberts/Lewisville/Elm Fork system. Dallas Water Utilities has contracted with the Sabine River Authority to secure water from Lake Fork Reservoir and with the Upper Neches River Municipal Water Authority to secure water from Lake Palestine. However, neither of these two lakes is currently connected to DWU's system. Currently, DWU has the capacity to treat up to 875 million gallons of water per day. DWU supplies treated and raw water to wholesale customers in Dallas, Collin, Denton, Ellis, and Kaufman Counties.

Tarrant Regional Water District (TRWD). Table 1.17 is a list of year 2000 sales by the Tarrant Regional Water District, which totaled 323,462 acre-feet. TRWD supplies raw water to customers in Tarrant County, eight other counties in Region C, and Johnson County in the Brazos G Region. TRWD owns and operates Lake Bridgeport, Eagle Mountain Lake, Cedar Creek Reservoir, and Richland-Chambers Reservoir. The district's water supply system also includes Lake Arlington (owned by Arlington), Lake Worth (owned by Fort Worth), and Benbrook Lake (owned by the Corps of Engineers, with TRWD holding water rights), as well as a substantial water transmission system. In addition to the customers shown in Table 1.17, the district has commitments to supply water to Weatherford and to users in Ellis County through the Trinity River Authority.

North Texas Municipal Water District (NTMWD). Table 1.18 is a list of year 2000 sales by the North Texas Municipal Water District, which totaled 251,495 acre-feet. NTMWD supplies treated water to customers in suburban communities north and east of Dallas. The district obtains raw water from water rights in Lake Lavon, Lake Texoma, and Chapman Lake, all of which are owned and operated by the Corps of Engineers. NTMWD also has a permit to reuse treated wastewater effluent from its Wilson Creek Wastewater Treatment Plant. This supply is blended with other freshwater supplies in Lake Lavon. In addition to providing treated water, the NTMWD also owns and/or operates a number of wastewater treatment plants in Region C.

City of Fort Worth. Table 1.19 lists wholesale water sales by the City of Fort Worth for fiscal year 2000, which totaled 54,507 acre-feet. (As shown in Table 1.14, Fort Worth also had 119,357 acre-feet of retail sales in 2000.) The City of Fort Worth purchases all of its water from Tarrant Regional Water District and has water treatment plants with combined current capacity to treat 370 million gallons of water per day. The City of Fort Worth sells wholesale treated water to other water suppliers, mostly located in Tarrant County.

Sabine River Authority (SRA). The Sabine River Authority is primarily located in Region D (the North East Texas Region) and Region I (the East Texas Region). However, SRA has contracts to supply water to several entities in Region C, the largest contracts being with Dallas Water Utilities. SRA has water supplies in Lake Fork Reservoir, Lake Tawakoni, Toledo Bend Reservoir, and the Sabine River Basin canal system. Table 1.20 shows the 2000 raw water sales by SRA to its Region C customers, which totaled 115,584 acre-feet. In addition to the sales shown in Table 1.20, SRA has a contract to sell water from Lake Fork Reservoir to Dallas Water Utilities, which is currently constructing facilities to deliver those supplies.

Trinity River Authority (TRA). The Trinity River Authority serves as a regional wholesale water supplier through a number of projects in Region C:

- TRA holds water rights in Joe Pool Lake, Navarro Mills Lake, and Bardwell Lake, all owned and operated by the Corps of Engineers. TRA sells raw water from these lakes for use in Region C. (TRA has contracts to sell Joe Pool Lake water to Midlothian, Duncanville, Cedar Hill, and Grand Prairie. TRA sells water from Navarro Mills Lake to the City of Corsicana and from Bardwell Lake to Ennis and Waxahachie.)
- TRA sells raw water to TXU Electric for use in the Big Brown Steam Electric Station on Lake Fairfield. This water is diverted from the Trinity River under water rights held by TRA in Lake Livingston downstream, in Region H.

Table 1.16
Year 2000 Wholesale Sales by Dallas Water Utilities

Customer	2000 Treated Water Sales (Acre-Feet)	2000 Raw Water Sales (Acre-Feet)	2000 Total Sales (Acre-Feet)
Addison	7,005		7,005
Carrollton	25,280		25,280
Cedar Hill	6,845		6,845
Cockrell Hill	497		497
The Colony	3,246		3,246
Coppell	9,116		9,116
DCWCID #6	2,373		2,373
D/FW Airport	2,508		2,508
DeSoto	8,013		8,013
Duncanville	6,866		6,866
Farmers Branch	11,267		11,267
Flower Mound	5,925		5,925
Glenn Heights	802		802
Grand Prairie	20,146		20,146
Hutchins	678		678
Irving	48,668		48,668
Lancaster	3,747		3,747
Lewisville	6,752		6,752
Seagoville	1,909		1,909
Denton [a, c]		0	0
Grapevine [a]		768	768
Lewisville [a]		7,752	7,752
Upper Trinity Regional Water District [a]		1,863	1,863
Carrollton/Farmers Branch ISD [b]		17	17
Carrollton Indian Creek Golf Course [b]		297	297
Dallas County Utility & Reclamation District [b, d]		0	0
EDS [b]		707	707
Garland Firewheel Golf Course [b]		677	677
USACE [b]		23	23
TOTAL	**171,643**	**12,104**	**183,747**

Notes: Data provided by the City of Dallas.

a. Purchases untreated water for municipal use.
b. Purchases untreated water for irrigation use.
c. At present time, Denton purchases no DWU untreated water but pays a monthly readiness to serve fee.
d. Annual payment over 20 years is for conveyance of 432 acre feet of water rights.

Table 1.17
Year 2000 Sales by Tarrant Regional Water District

Customer	2000 Raw Water Sales (Acre-Feet)
Fort Worth (from East Texas)	100,248
Fort Worth (from the West Fork)	82,175
Arlington	71,224
Trinity River Authority (Tarrant Co.)	37,393
Mansfield	7,062
TXU Electric	5,546
Benbrook Water & Sewer Authority	3,437
Bridgeport	1,703
Azle	1,554
West Cedar Creek MUD	1,382
Wise County WSD	1,290
Walnut Creek SUD	1,278
East Cedar Creek FWSD	1,273
Mabank Gifford-Hill	1,145
River Oaks	1,035
Southwest Water Co.	561
Ridglea County Club	480
Mira Vista County Club	431
Texas Industries	407
West Wise SUD	404
Community WSC	323
Kemp	300
Whitestone Golf	298
Runaway Bay	260
Trinity Materials	259
Shady Oaks Country Club	190
Springtown	169
Warren Petroleum	118
Cedar Creek Country Club	113
Fort Worth Country Day School	91
Pinnacle Club	83
Star Harbor	76
Winkler Water Supply	54
Bay Golf Holdings	32
Long Cove	26
Bill Sisul	8
TOTAL	**323,462**

Note: Data were provided by the Tarrant Regional Water District.

Table 1.18
Year 2000 Sales by North Texas Municipal Water District

Customer	Total Treated Water Sales (Acre-Feet)
Plano	78,853
Garland	41,271
Richardson	32,871
Mesquite	23,672
McKinney	15,963
Frisco	11,302
Allen	10,988
Rowlett	8,378
Rockwall	6,060
Wylie	2,530
Forney	2,137
Sachse	2,023
Kaufman	1,185
Sunnyvale	1,114
Kaufman 4-1	1,049
Fairview	988
Princeton	963
Farmersville	870
Lucas	865
North Collin County WSC	857
Murphy	847
Royse City	808
Cash WSC	719
Parker	635
Caddo Basin SUD	598
East Fork SUD	550
Forney Lake WSC	440
Wylie Northeast WSC	372
Mt Zion WSC	358
Lavon WSC	357
Milligan WSC	356
Seis Lagos MUD	245
Gastonia-Scurry WSC	231
Nevada WSC	205
Copeville WSC	196
College Mound WSC	168
Fate	156
Little Elm	104
Josephine	90
Rose Hill WSC	89
Individual Meters	38
TOTAL	**251,495**

Notes: a. Data were provided by the North Texas Municipal Water District.
b. All sales are from the NTMWD system, which draws water from Lake Lavon, Lake Texoma, and Chapman Lake.

- TRA has a regional treated water system in northeast Tarrant County, which treats raw water delivered by the Tarrant Regional Water District system through Lake Arlington and sells treated water to cities.
- TRA has a commitment to sell raw water from the Tarrant Regional Water District to water suppliers in Ellis County in the future and is now selling water to some Ellis County entities.

Table 1.21 lists the 2000 sales by Trinity River Authority in Region C, which totaled 36,023 acre-feet of treated water from the Tarrant County Water Supply System and 28,590 acre-feet of raw water. In addition to its raw and treated water sales, TRA operates a number of regional wastewater treatment projects in Region C.

Upper Neches River Municipal Water Authority (UNRMWA). The Upper Neches River Municipal Water Authority is located in Region I (the East Texas Region), where it owns and operates Lake Palestine. UNRMWA has contracted to supply up to 114,937 acre-feet per year to Dallas Water Utilities in Region C, and the facilities to connect the supplies have not yet been constructed.

Upper Trinity Regional Water District (UTRWD). Table 1.22 lists the year 2000 water sales by the Upper Trinity Regional Water District, which totaled 10,162 acre-feet. UTRWD operates a regional water supply system in Denton County, which is a rapidly growing area. Water sales have increased dramatically in recent years, with UTRWD's sales reaching 15,836 acre-feet in 2003. The current capacity of the UTRWD water treatment plant is 70 million gallons per day.

UTRWD has a contract with the City of Commerce to divert up to 16,106 acre-feet per year of raw water from Chapman Lake in the Sulphur River Basin. UTRWD cooperates with the City of Irving to bring that water to Lewisville Lake. UTRWD also has contracts to buy raw water from Dallas and Denton and has applied for an indirect reuse permit. In addition to its water supply activities, UTRWD provides regional wastewater treatment services in Denton County.

Sulphur River Water District (SRWD). The Sulphur River Water District is located in Region D (the North East Texas Region) and has water rights in Chapman Lake on the South Fork of the Sulphur River. The SRWD sells raw water to the Upper Trinity Regional Water District in Region C.

Table 1.19
Year 2000 Wholesale Sales by the City of Fort Worth

Customer	2000 Treated Water Sales (Acre-Feet)
Southlake	12,015
North Richland Hills	7,150
Haltom City	6,473
Hurst	5,977
Keller	4,009
Burleson	3,479
Saginaw	2,220
D/FW Airport	1,735
Trophy Club MUD #1	1,701
Forest Hill	1,402
White Settlement	1,252
Crowley	1,073
Richland Hills	939
Grand Prairie	874
Westover Hills	854
Bethesda Water Supply	563
Roanoke	545
Edgecliff Village	509
Dalworthington Gardens	405
Lake Worth	403
Westworth Village	258
Tarrant County MUD No 1	216
Haslet	151
Everman	106
TRA (Mosier Valley)	76
Westlake	60
Northlake	56
River Oaks	5
TOTAL	**54,507**

Note: Data are from City of Fort Worth

Table 1.20
Year 2000 Sales by the Sabine River Authority to Region C Customers

Customer	2000 Raw Water Sales (Acre-Feet)
Dallas [a]	113,486
Cash WSC [b]	1,194
MacBee WSC [b]	577
Able Springs WSC [b]	320
Terrell	7
TOTAL	**115,584**

Notes: Data are from the Sabine River Authority.
a. Year 2000 sales were reduced due to a gasoline pipeline spill into Lake Tawakoni in March 2000. Year 2001 sales were 145,649 acre-feet.
b. Cash WSC, MacBee WSC, and Able Springs WSC are located in both Regions C and D. Data listed are for all water sold, not just the portion used in Region C.

Table 1.21
Year 2000 Sales by Trinity River Authority

Customer	2000 Water Sales (Acre-Feet)			Source
	Treated	Raw	Total	
Bedford	9,857		9,857	Tarrant County System (TRWD)
Colleyville	6,199		6,199	Tarrant County System (TRWD)
Euless	6,834		6,834	Tarrant County System (TRWD)
Grapevine	6,457		6,457	Tarrant County System (TRWD)
North Richland Hills	6,676		6,676	Tarrant County System (TRWD)
Midlothian		4,679	4,679	Joe Pool
Ellis County WCID		2,865	2,865	Bardwell
Ennis		3,502	3,502	Bardwell
TXU Electric [b]		9,820	9,820	Livingston (Trinity River)
Corsicana		7,723	7,723	Navarro Mills
TOTAL	**36,023**	**28,590**	**64,613**	

Notes: a. Data are from the Trinity River Authority.
b. Water use is highly variable depending on annual rainfall. For example, 1996 water use was 12,682 acre-feet, whereas 2001 water use was only 2,890 acre-feet.

Dallas County Park Cities Municipal Utility District (PCMUD). The Dallas County Park Cities Municipal Utility District has a water right to divert 50,000 acre-feet per year from Grapevine Lake, but its share of the firm yield from the lake is considerably less than the water right. According to TCEQ use records, the PCMUD diverted 13,379 acre-feet from Grapevine Lake in year 2000 [(14)]. The district operates its own water treatment plant and provides treated water to Highland Park and University Park.

Greater Texoma Utility Authority (GTUA). The Greater Texoma Utility Authority has water rights for 25,000 acre-feet per year from Lake Texoma and sells raw water to Sherman, which operates a desalination and treatment plant. In 2000, the GTUA diverted 7,658 acre-feet of raw water from Lake Texoma [(14)]. The authority also operates wastewater treatment plants for several communities in the Red River Basin.

City of Corsicana. Table 1.23 lists the year 2000 wholesale water sales by the City of Corsicana, which totaled 3,398 acre-feet. (As shown in Table 1.14, Corsicana also supplied 5,034 acre-feet of retail water in 2000.) The City of Corsicana supplies treated surface water to a significant portion of Navarro County. Corsicana has water rights in Lake Halbert and Richland-Chambers Reservoir and has a contract to purchase water from Navarro Mills Lake from the Trinity River Authority. Corsicana currently uses water from Lake Halbert and Navarro Mills Lake. The City does not have the infrastructure in place to divert water from the Richland-Chambers Reservoir. Corsicana has the capacity to treat up to 3 million gallons per day at their Lake Halbert water treatment plant and up to 17 million gallons per day at their Navarro Mills treatment plant.

Table 1.22
Year 2000 Sales by the Upper Trinity Regional Water District

Customer	2000 Treated Water Sales (Acre-Feet)
Flower Mound	4,895
Corinth	2,043
Highland Village	1,125
Lake Cities MUA	815
Bartonville WSC	550
Denton County FWSD #1A	302
Sanger	214

Table 1.22, Continued

Customer	2000 Treated Water Sales (Acre-Feet)
Argyle WSC	194
Denton County FWSD #7	23
Denton County FWSD #8A [a]	0
Denton County FWSD #9 [a]	0
Denton County FWSD #10 [a]	0
Denton County FWSD #11 [a]	0
Aubrey [a]	0
Justin [b]	0
Lincoln Park [b]	0
Celina [b]	0
TOTAL	**10,162**

Notes: Data are from Upper Trinity Regional Water District
a. UTRWD sold water to these entities in 2003 and 2004.
b. UTRWD sold water to these entities in 2004.

Table 1.23
Year 2000 Sales by the City of Corsicana

Customer	2000 Treated Water Sales (Acre-Feet)
Rice WSC	609
Post Oak WSC	564
Chatfield WSC	339
B&B WSC	281
M.E.N. WSC	277
Navarro Mills WSC	259
Corbet WSC	257
City of Kerens	187
City of Blooming Grove	154
Community WC	110
Angus WSC	110
City of Frost	73
Northtown Acres	61
City of Emhouse	59
City of Richland	45
Lakeside	8
Dawson	5
TOTAL	**3,398**

Local Wholesale Water Providers

Twenty three other entities qualify as local wholesale water providers in Region C. These entities provide or are expected to provide over 1,000 acre-feet of wholesale water per year. These entities have been noted as “local” because they supply only a few customers in their immediate area. Table 1.24 lists the local wholesale water providers and their customers.

Retail Water Suppliers

Cities, towns, water supply corporations, and special utility districts provide most of the retail water service in Region C. The Texas Water Development Board developed the term “water user group” (WUG) to identify entities that regional water planning groups must include in their plans. The TWDB definition for a water user group states that a WUG is defined as one of the following:

- Cities and towns with a population of 500 or more
- Non-city utilities providing more than 280 acre-feet per year of water for municipal use
- Collective reporting units (CRUs) consisting of grouped utilities having a common association
- County-Wide WUGs:
    - Rural/unincorporated areas of municipal water use (referred to as County-Other)
    - Manufacturing
    - Steam electric power generation
    - Mining
    - Irrigation
    - Livestock.

Table 1.25 shows the number of WUGs for each county in Region C.

1.6 Pre-Existing Plans for Water Supply Development

Previous Water Supply Planning in Region C

Appendix B is a list of water-related plans and reports for Region C. The region has a long history of successful local water supply planning and development. Significant plans for developing additional water supplies in Region C in the near future include the following:

- Dallas Water Utilities plans to connect its currently unused supplies in Lake Fork Reservoir and Lake Palestine to its system.

Table 1.24
Local Wholesale Water Providers and Associated Customers

Name of Local Wholesale Water Provider	2000 Wholesale Sales (Acre-Feet)	Customer of Local Wholesale Water Provider
City of Cedar Hill	589	Ovilla
City of Denton	1	Denton County Steam Electric
		Upper Trinity Regional Water District
City of Ennis	354	Community Water Co.
		Rice WSC
		East Garrett WSC
City of Forney	733	High Point WSC
		Talty WSC
		Kaufman County Steam Electric (reuse)
City of Gainesville	42	Woodbine WSC
		Valley View
		Lindsey
		Kiowa Homeowners WSC
		Bolivar WSC
City of Garland	0	Collin County Steam Electric
		Dallas County Steam Electric
		Forney for Kaufman County Steam Electric (reuse)
City of Mansfield	0	Johnson County SUD
City of Midlothian	1,984	Rockett SUD
		Ellis County Steam Electric
		Mountain Peak WSC
		Venus
City of North Richland Hills	2,920	Watauga
City of Rockwall	1,154	Mt. Zion WSC
		McLendon-Chisolm
		Blackland WSC
		RCH WSC
City of Seagoville	292	Combine WSC

Table 1.24, Continued

Name of Local Wholesale Water Provider	2000 Wholesale Sales (Acre-Feet)	Customer of Local Wholesale Water Provider
City of Terrell	993	College Mound WSC
		High Point WSC
City of Waxahachie	1625	Rockett SUD
City of Weatherford	0	Brazos Electric Co-op
		Parker Co.Utility District
Athens MWA	1,958	Texas Parks and Wildlife Department Fish Hatchery
		City of Athens
		Local lake irrigation
East Cedar Creek FWSD	0	Payne Springs
		Gun Barrel City
Lake Cities Municipal Utility Authority	805	Lake Dallas
		Hickory Creek
		Shady Shores
Mustang SUD	0	Cross Roads
		Oak Point
		Krugerville
Parker County Utility District #1	0	Hudson Oaks
Rockett SUD	110	Pecan Hill
		Red Oak
		Ferris
Walnut Creek SUD	101	Boyd
		Rhome
		West Wise SUD
		Reno
West Cedar Creek MUD	331	Seven Points
		Tool
Wise County Water Supply District	7	Decatur

Note: Data are from the Texas Water Development Board [10].

Table 1.25
Region C Number of Water User Groups by County and Category

County	Cities	Utilities	County-Other	Non- Municipal	Total
Collin	27	10	1	5	43
Cooke	4	4	1	5	14
Dallas	30	5	1	5	41
Denton	37	5	1	5	48
Ellis	17	9	1	5	32
Fannin	8	3	1	5	17
Freestone	3	2	1	5	11
Grayson	13	6	1	5	25
Henderson	10	4	1	5	20
Jack	2	0	1	5	8
Kaufman	13	7	1	5	26
Navarro	6	6	1	5	18
Parker	11	1	1	5	18
Rockwall	7	8	1	5	21
Tarrant	36	3	1	5	45
Wise	11	4	1	5	21
TOTAL	**201**	**54**	**16**	**80**	**351**

Note that the columns do not sum to the total because some WUGs are located in more than one county.

- Tarrant Regional Water District plans to complete the facilities needed to divert return flows of treated wastewater from the Trinity River into Cedar Creek and Richland-Chambers Reservoirs to increase the yield of its system. TRWD also plans to complete pump station improvements on its water transmission line from Richland-Chambers Reservoir and develop the proposed Eagle Mountain Connection.
- The North Texas Municipal Water District plans to increase the reuse from its Wilson Creek Wastewater Treatment Plant, develop an East Fork reuse project, and obtain a permit for additional water supplies from Lake Texoma.
- Several Region C water suppliers have applied for permits to reuse return flows of treated wastewater in Region C.
- The Upper Trinity Regional Water District has applied for a water right permit for the proposed Lake Ralph Hall on the North Sulphur River in Fannin County.
- Region C water suppliers are considering the development of water supplies in the Sulphur Basin to the east. Alternatives included George Parkhouse Reservoirs (North and South), Marvin Nichols Reservoir, and Marvin Nichols Reservoir (South).
- Region C water suppliers are exploring obtaining water from existing sources in Oklahoma and from Toledo Bend Reservoir in East Texas.
- Other Region C suppliers are planning and developing smaller water supply projects to meet local needs.

As discussed in Section 1.4, there has been an increasing interest in the reuse of treated wastewater in Region C in recent years. There are several permits for significant indirect reuse projects in the region. In addition to these permitted indirect reuse projects, many of the reservoirs in Region C make indirect reuse of treated wastewater return flows in their watersheds, which increase reservoir yields. Several applications for indirect reuse are pending with the Texas Commission on Environmental Quality (TCEQ). TCEQ policy on future indirect reuse projects is not yet firmly established. If TCEQ does not allow the development of additional indirect reuse in Region C, current local water supply planning will be disrupted and other sources must be sought. Direct reuse, often for irrigation of golf courses, is also increasing in the region. It is clear that reuse of treated wastewater will remain a significant part of future water planning for Region C.

Recommendations in the 2001 *Region C Water Plan* and the *2002 State Water Plan*

The most significant recommendations for Region C in the 2001 *Region C Water Plan* [1] and the 2002 State Water Plan [15] are summarized below. (A more detailed discussion of the recommendations is available in the original documents.)

A large part of the water supplied in Region C is provided by five major water providers: Dallas Water Utilities, Tarrant Regional Water District, North Texas Municipal Water District, Fort Worth, and the Trinity River Authority. In the 2001 *Region C Water Plan* and the 2002 State Water Plan, these five entities are expected to provide the majority of the water supply for Region C through 2050. Recommended water management strategies to meet the needs of these major water providers include the following:

- **Marvin Nichols I Lake**
  - Called Marvin Nichols Reservoir in this plan
  - Located in the Sulphur River Basin in the North East Texas Region (Region D)
  - Yield of 495,300 acre-feet per year for Region C
    - 112,000 acre-feet per year to Dallas Water Utilities
    - 156,000 acre-feet per year to Tarrant Regional Water District
    - 163,300 acre-feet per year to North Texas Municipal Water District
    - 25,000 acre-feet per year to Irving
    - 39,000 acre-feet per year to meet other Region C needs.

- **Dallas Water Utilities**
    - Continue to use return flows above its lakes
    - Extend the Elm Fork permit for wet weather diversions (done)
    - Connect Lake Fork Reservoir to its system (underway)
    - Connect Lake Palestine to its system
    - Participate in the Marvin Nichols I (North) project (called Marvin Nichols Reservoir in this plan)
    - Develop a reuse project
    - Develop additional water treatment capacity as needed
    - Other alternatives for Dallas Water Utilities include additional reuse and development of yield from return flows in the watersheds of water supply reservoirs.
- **Tarrant Regional Water District**
    - Develop additional capacity in the pipeline from Richland-Chambers Reservoir to Tarrant County (underway)
    - Develop the Eagle Mountain Connection to allow water to be transferred among the parts of the water supply system (under design)
    - Develop the proposed reuse project to pump water from the Trinity River into Cedar Creek Reservoir and Richland-Chambers Reservoir to supplement yields (underway)
    - Develop a water supply from existing water sources in Oklahoma
    - Develop a third pipeline from Cedar Creek Reservoir and Richland-Chambers Reservoir to Tarrant County
    - Participate in the Marvin Nichols I (North) project (called Marvin Nichols Reservoir in this plan)
    - Other alternatives for Tarrant Regional Water District include the development of Lake Tehuacana and obtaining water from Lake Texoma.
- **North Texas Municipal Water District**
    - Develop additional water supplies in Lake Lavon from reuse
    - Develop the East Fork reuse project (added by amendment in 2005)
    - Develop additional water supplies from Lake Texoma
    - Develop a water supply from existing water sources in Oklahoma
    - Develop Lower Bois d'Arc Creek Reservoir on Bois d'Arc Creek in Fannin Co.
    - Participate in the Marvin Nichols I (North) project (called Marvin Nichols Reservoir in this plan)
    - Develop additional water treatment capacity and treated water transmission system improvements as needed

- Other alternatives for North Texas Municipal Water District include obtaining a substantial additional supply from Lake Texoma and extending the existing Lake Texoma pipeline to minimize channel losses.

- **City of Fort Worth**
  - Continue to obtain raw water from Tarrant Regional Water District
  - Renew contracts with its existing customers as they expire
  - Develop additional water treatment capacity as needed
- **Trinity River Authority**
  - Continue to obtain raw water from Tarrant Regional Water District for its Tarrant County water supply project
  - Expand Tarrant County water supply project facilities as needed
  - Obtain raw water from Tarrant Regional Water District and implement the Ellis County water supply project
  - Develop reuse projects:
    - Additional golf course and landscape irrigation in the Las Colinas area
    - Golf course and landscape irrigation in Denton and Tarrant Counties
    - Steam electric power supply in Dallas and Ellis Counties
    - Reuse for municipal supply through Joe Pool Lake and Grapevine Lake

In addition to the strategies recommended for the five major water providers above, the Region C plan included strategies for individual water user groups. Major types of strategies included the following:

- Development of new regional surface water supply systems in Cooke, Ellis, Fannin, Grayson, Parker, and Wise Counties to supplement local groundwater supplies
- Continued development and expansion of existing regional water supply systems
- Connection of water user groups to larger regional systems
- Construction of additional water treatment capacity as needed
- Temporary overdrafting of groundwater where needed
- Development of reuse projects to meet growing steam electric and other demands
- Development of transmission facilities to deliver water from Chapman Lake for Irving and Upper Trinity Regional Water District (done)

The estimated capital costs for all recommended water management strategies in the 2001 *Region C Water Plan* total $6.16 billion in 1999 dollars.

Conservation Planning in Region C

Significant new information regarding water conservation in Region C has been developed since completion of the 2001 *Region C Water Plan* [1]. Sources of new information include water conservation plans, the Water Conservation Implementation Task Force, a TWDB-sponsored study of the effectiveness of water conservation techniques, and conservation implementation by Region C entities.

Water Conservation Plans. For the last several years, the Texas Water Development Board and the Texas Commission on Environmental Quality have required the development of conservation plans as a condition for TWDB financing of projects and for TCEQ permitting. Primarily as a result of these requirements, many entities in Region C and around the state have developed conservation and drought contingency plans. These plans have significantly improved the awareness of water conservation in Texas.

Under Senate Bill One, all holders of existing water rights for 10,000 acre-feet per year or more for irrigation or for 1,000 acre-feet per year or more for any other purpose were required to develop and implement a water conservation plan by September 1, 1999 [16]. In addition, all applicants for a new or amended water right must also submit a water conservation plan to the TCEQ [16]. Beginning May 1, 2005, all water conservation plans must include specific, quantified 5-year and 10-year targets for water savings [17, 50]. According to the new rules, water conservation plans have to be updated again by May 1, 2009 and every five years thereafter.

Water Conservation Implementation Task Force. The 78th Texas Legislature, in Senate Bill 1094, created the Water Conservation Implementation Task Force. Among other tasks, the Task Force was to identify, evaluate, and select best management practices for municipal, industrial, and agricultural water uses; evaluate the costs and benefits for the selected best management practices; evaluate the implementation of water conservation strategies recommended in regional and state water plans; and advise the TWDB and the TCEQ on establishing per capita water use targets and goals, accounting for such local effects as climate and demographics.

In 2004, the Task Force published the *Water Conservation Best Management Practices Guide* [18], published the *Report to the 79th Legislature* [19], and made a number of recommendations regarding water conservation and regional water planning. These recommendations include the following:

- The Best Management Practices (BMPs) should be voluntary and state policies should recognize the fundamental decision-making primacy and prerogative of planning groups, municipalities, industrial and agricultural water users, and water providers.
- Municipal water user groups that are developing water conservation plans should consider a target that implements a minimum one percent per year reduction in total per capita water use, based on a rolling five-year average, until the total per capita water use is 140 gallons per capita per day (gpcd) or less. [Note that the Task Force also recommended that water supplied by indirect reuse should not be included when computing per capita use.]
- The TWDB should work with manufacturers of water-using equipment, water utilities, water users, and others to reduce overall statewide indoor water use to 50 gpcd through education, research, and funding programs.
- Municipal water user groups with projected water needs should first meet or reduce the need using advanced water conservation strategies (beyond implementation of state plumbing fixture requirements and adoption and implementation of water conservation education programs).

TWDB-Sponsored Effectiveness Study. In May 2002, a TWDB-sponsored study [20] entitled *Quantifying the Effectiveness of Various Water Conservation Techniques in Texas* was completed. This report provided estimates of potential water savings in each planning region from several municipal and commercial water conservation strategies. This report has been reviewed by consultants to the Region C Water Planning Group, and the conclusions have been used in evaluation of potentially feasible water conservation strategies (discussed in Section 6.3).

Conservation Implementation by Region C Entities. In addition to the water conservation plans discussed above, Region C entities have implemented water conservation strategies since completion of the 2001 *Region C Water Plan* [1]. Several cities, including Dallas and Arlington, have implemented an increasing block water pricing structure.

In particular, Dallas has completed a Five-Year Strategic Plan on Water Conservation that includes water conservation measures such as upgrading plumbing fixtures at city facilities, adopting new water conservation ordinances, water price increases, a multimedia public awareness program, customer water audits, and several rebate and incentive programs. Dallas is currently implementing the first year of its five-year strategic plan.

Finally, as mentioned in previous sections, several Region C entities have continued to develop and implement direct and indirect reuse projects.

Preliminary Assessment of Current Preparations for Drought in Region C

The recent dry summers in 1996, 1998, 1999, and 2000 placed considerable stress on water suppliers throughout Texas, including Region C. The larger systems in Region C did not have a shortage of supply, but several had problems with delivery of raw water to points of need and with treated water distribution. Many Region C water suppliers have already made or are currently making improvements to increase delivery of raw and treated water under drought conditions. Some smaller suppliers in Region C faced a shortage of supplies in the recent drought. Most of those entities have moved to address this problem by connecting to a larger supplier or by developing additional supplies on their own.

Most of the water conservation plans developed in response to TCEQ and TWDB requirements include a drought contingency plan. In addition to its regional planning provisions, Senate Bill One included a requirement that all public water suppliers and irrigation districts develop and implement a drought contingency plan.

Other Water-Related Programs

In addition to the Senate Bill One regional planning efforts, there are a number of other significant water-related programs that will affect water supply efforts in Region C. Perhaps the most important are Texas Commission on Environmental Quality water rights permitting, the Clean Rivers Program, the Clean Water Act, and the Safe Drinking Water Act.

Texas Commission on Environmental Quality (TCEQ) Water Rights Permitting. Surface water in Texas is a public resource, and the TCEQ is empowered to grant water rights that allow beneficial use of that resource. The development of any new surface water supply requires a water right permit. In recent years, TCEQ has increased its scrutiny of the environmental impacts of water supply projects, and permitting has become more difficult and complex. Among its many other provisions, Senate Bill One set out formal criteria for the permitting of interbasin transfers for water supply. Since many of the major sources of supply that have been considered for Region C involve interbasin transfers, these criteria will be important in Region C planning.

Clean Rivers Program. The Clean Rivers Program is a Texas program overseen by TCEQ and funded by fees assessed on water use and wastewater discharge permit holders. The program is designed to provide information on water quality issues and to develop plans to resolve water quality problems. The Clean Rivers Program is carried out by local entities. In Region C, the program is carried out by river authorities: the Trinity River Authority in the Trinity Basin, the Red River Authority in the Red Basin, the Brazos River Authority in the Brazos Basin, the Sulphur River Basin Authority in the Sulphur Basin, and the Sabine River Authority in the Sabine Basin.

Clean Water Act. The Clean Water Act is a federal law designed to protect water quality. The parts of the act which have the greatest impact on water supplies are the National Pollutant Discharge Elimination System (NPDES) permitting process, which covers wastewater treatment plant and storm water discharges, and the Section 404 permitting program for the discharge of dredged and fill material into the waters of the United States, which affects construction for development of water resources. In Texas, the state has recently taken over the NPDES permitting system, renaming it the Texas PDES (TPDES). The TPDES Program sets the discharge requirements for wastewater treatment plants and for storm water discharges associated with construction and industrial activities. The Section 404 permit program is handled by the U.S. Army Corps of Engineers. Section 404 permitting is a required step in the development of a new reservoir and is also required for pipelines, pump stations, and other facilities constructed in or through waters of the United States.

Safe Drinking Water Act (SDWA). The Safe Drinking Water Act is a federal program that regulates drinking water supplies. In recent years, new requirements introduced under the SDWA have required significant changes to water treatment. On-going SDWA initiatives will continue to impact water treatment requirements. Some of the initiatives that may have significant impacts in Region C are the reduction in allowable levels of trihalomethanes in treated water, the requirement for reduction of total organic carbon levels in raw water, and the reduction of the allowable level of arsenic in drinking water.

1.7 Agricultural and Natural Resources in Region C

Springs in Region C

No springs in Region C are currently used as a significant source of water supply. Springs were important sources of water supply to Native Americans and in the initial settlement of the area and had great influence on the initial patterns of settlement. Groundwater development and the resulting water level declines have caused many springs to disappear and greatly diminished the flow from those that remain [21].

The TPWD has identified a number of small to medium-sized springs in Region C [22]. Table 1.26 shows the distribution and number of these springs as of 1980. Former springs are springs that have run dry due to groundwater pumping, sedimentation caused by surface erosion, or other causes [23].

Table 1.26
Distribution and Estimated Size of Springs and Seeps

County	Medium (2.8 – 28 cfs)	Small (0.28 – 2.8 cfs)	Very Small (0.028 – 0.28 cfs)	Seep (Less than 0.028 cfs)	Former
Collin	0	3	10	1	4
Cooke	0	3	9	3	1
Dallas	2	6	2	0	4
Denton	0	3	8	1	1
Ellis	0	0	0	0	1
Fannin	0	3	6	3	1
Grayson	0	2	12	1	1
Parker	0	8	3	2	6
Rockwall	0	0	1	0	2
Tarrant	3	6	1	3	5
Wise	0	7	4	3	2

Note: Data are from Texas Parks and Wildlife Department [22].

Wetlands

According to the regulatory definition of the U.S. Army Corps of Engineers [24], wetlands are "areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." Areas classified as wetlands are often dependent on water from streams and reservoirs. Some of the important functions of wetlands include providing food and habitat for fish and wildlife, water quality improvement, flood protection, shoreline erosion control, and groundwater exchange, in addition to opportunities for human recreation, education, and research.

The Natural Resources Conservation Service (NRCS) has mapped and quantified areas of hydric soils for all but five of the counties in Region C. The agency makes these data available through its local county offices and, in some cases, publishes the acreages of soil series in the soil survey report for the county. Hydric soil is defined as "soil that in its undrained condition is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation" [(25)]. Thus, the area of hydric soils mapped in a county provides an indication of the potential extent of wetlands in that county. However, as implied in the definition, some areas mapped as hydric soils may not occur as wetlands because the hydrology has been changed to preclude saturation or inundation.

Table 1.27 is a list of acreages of hydric soils for the counties in Region C for which the data are available. The hydric soil areas range from just over one percent of the county area in Collin, Cooke, and Tarrant counties to approximately 24 percent in Henderson County. The acreages of hydric soils listed in Table 1.27 should be considered as an indicator of the relative abundance of wetlands in the counties and not as an absolute quantity. It should also be noted that wetlands are likely to occur in other areas throughout the region as "atypical" or "problem area" wetlands, as defined in the Corps of Engineers' Wetland Delineation Manual [(24)].

Table 1.27
Hydric Soils Mapped by the Natural Resources Conservation Service for the Counties in Region C

County	Total County Acreage (Acres)	Hydric Soil Acreage within County (Acres)	Percent of County (%)
Collin	565,760	8,620	1.52
Cooke	568,320	7,100	1.25
Dallas	577,920	53,570	9.27
Denton	611,200	10,460	1.71
Ellis	608,000	Not Available	
Fannin	574,080	Not Available	
Freestone	574,720	85,855	14.94
Grayson	627,840	29,240	4.66
Henderson [a]	604,800	142,540	23.57
Jack	588,800	Not Available	
Kaufman	517,760	Not Available	
Navarro	695,680	86,100	12.38
Parker	581,760	35,350	6.08
Rockwall	94,080	Not Available	
Tarrant	574,080	9,410	1.64
Wise	592,000	13,100	2.21

Note: a. The values for Henderson County include all of Henderson County, not just the Region C portion.

Endangered or Threatened Species

Table 1.28 lists "species of special concern" identified in Region C counties by the Texas Parks and Wildlife Department (TPWD) [26] and U.S. Fish and Wildlife Service [27]. Species of special concern include species listed as threatened or endangered at the state level and species that have limited range within the state. The TPWD maintains a list of species of special concern in the Texas Biological and Conservation Data System.

Stream Segments with Significant Natural Resources

In each river basin in Texas, the TPWD has identified stream segments classified as having significant natural resources in their report *A Natural Resource Survey for Proposed Reservoir Sites and Selected Stream Segments in Texas* [28]. Stream segments have been placed on this list because they have been identified by TPWD as having one or more of the following: high water quality, exceptional aquatic life, high aesthetic value, fisheries, spawning areas, unique state holdings, endangered or threatened species, priority bottomland hardwood habitat, wetlands, springs, and pristine areas.

Stream segments that have been classified by TPWD as having significant natural resources in the Trinity River Basin in Region C include the following [28]:

- <u>High water quality, exceptional aquatic life, and high aesthetic value</u> - Elm Fork of the Trinity River (headwaters to Ray Roberts Lake), West Fork of the Trinity River (downstream of Lake Bridgeport to Eagle Mountain Lake), Big Sandy Creek (downstream of Lake Amon G. Carter to West Fork of the Trinity River), Spring Creek (Dallas County near Garland), and Tenmile Creek (Dallas County).
- <u>Diverse fishery</u> - Tenmile Creek (Dallas County)
- <u>Unique state holdings</u> - Segment 0804 of the Trinity River (below Cedar Creek Reservoir spillway; significant holding in Region C is Richland Creek Wildlife Management Area).
- <u>Paddlefish stocking area</u> - Trinity River (Lake Ray Hubbard to Lake Livingston).
- <u>Priority bottomland hardwood habitat</u> - Confluence of Buffalo and Linn Creeks in Freestone County.

Stream segments in the Red River Basin in Region C classified by TPWD as having significant natural resources include the following [28]:

- <u>Pristine area, spring fed, intermittent pools and riffles</u> - North Fish Creek and South Fish Creek in Cooke County.

- Striped bass spawning and migration and unique saltwater springs - Segment 0204 of the Red River (above Lake Texoma).
- Unique community, wetlands - Rock Creek in Cooke County.
- Unique state holdings - Bois d'Arc Creek in Fannin County (Caddo Wildlife Management Area).
- Paddlefish - Segment 0202 of the Red River (below Lake Texoma) and Shawnee Creek in Grayson County.
- Blue Sucker - Segment 0202 of the Red River (below Lake Texoma).

Stream segments in the Brazos River Basin in Region C classified as having significant natural resources include the following [(28)]:

- Recreation - Brazos River, Possum Kingdom Dam to Lake Granbury, including the reach in Parker County that is in Region C.
- Striped bass spawning migration and smallmouth bass fishery - Brazos River, Possum Kingdom Dam to Granbury, including the reach in Parker County that is in Region C.
- Pristine and historic area - Sanchez Creek in Parker County.

Navigation

There is very little navigation in Region C. However, the Corps of Engineers has defined two stretches of river in Region C that qualify as "navigable". In the Red River Basin, the segment of the Red River from Denison Dam forming Lake Texoma upstream to Warrens Bend in Cooke County is defined as navigable. In the Trinity River Basin, the Trinity River has a reach that is considered to be "navigable" from the southeastern border of Freestone County up to Riverside Drive in Fort Worth. While these rivers meet the definition of navigable waters, they are not currently used for this purpose.

Agriculture and Prime Farmland

Table 1.29 gives some basic data on agricultural production in Region C, based on the 2002 Agricultural Census from the U.S. Department of Agriculture (USDA) [(29)]. Region C includes over 6,100,000 acres in farms and over 2,600,000 acres of cropland. Irrigated agriculture does not play a significant role in Region C, with less than 2 percent of the harvested cropland being irrigated. The market value of agricultural products is significant in all Region C counties, with a total value for 2002 of over $582,000,000. (Separate data are not available for the portion of Henderson County in Region C, so the USDA data include the entire county.)

Table 1.28
State and Federal Species of Special Concern in Region C [a]

Species [e]	Federal Status [b]	State Status [c]	Riparian or Wetland Dependent	County															
				Collin	Cooke	Dallas	Denton	Ellis	Fannin	Freestone	Grayson	Henderson	Jack	Kaufman	Navarro	Parker	Rockwall	Tarrant	Wise
Bachman's sparrow		T								x		x							
Piping plover	LT	T	X								x								
Cerulean warbler																			
Golden-cheeked warbler	LE	E														x			
White-faced ibis		T	X	x			x	x						x	x		x		
Whooping crane	LE	E	X	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
Bald eagle	LT PDL	T	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Wood stork		T	X	x	x	x	x	x	x	x	x	x		x	x		x		
Eskimo curlew	LE	E			x				x		x		x						x
Interior least tern	LE	E	X		x	x		x	x	x	x	x		x	x	x		x	x
Black-capped vireo	LE	E				x													
Blue sucker		T	X						x		x								
Creek Chubsucker		T	X						x		x								
Blackside darter		T	X						x										
Paddlefish		T	X						x	x	x	x			x				
Shovelnose sturgeon		T	X						x		x								
Red wolf	LE	E			x				x		x		x			x			x
Gray wolf	LE	E											x			x			x
Black-footed ferret	LE				x														
Black bear	T/SA	T							x										
Rafinesque's big-eared bat		T								x									
Timber/canebrake rattlesnake		T		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Brazos water snake		T	X													x			
Texas horned lizard		T		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Houston toad	LE	E	X							x									

Table 1.28, Continued

Species	Federal Status [b]	State Status [c]	Riparian or Wetland Depen-dent	County															
				Collin	Cooke	Dallas	Denton	Ellis	Fannin	Freestone	Grayson	Henderson	Jack	Kaufman	Navarro	Parker	Rockwall	Tarrant	Wise
Northern scarlet snake		T										x							
Alligator snapping turtle		T	X		x				x		x	x							
Large-fruited sand verbena	LE	E								x									
Navasota ladies' -tresses	LE	E	X							x									
Texas Kangaroo rat		T			x								x						x

Notes:
a. Information obtained from the Texas Parks and Wildlife Department [26] and from the U.S. Fish and Wildlife Service [27].
b. LE is federally listed endangered, LT is federally listed threatened, and T/SA is federally threatened by similarity of appearance.
c. E is state listed endangered, T is state listed threatened.
d. PDL stands for potential delisting.
e. The following species were listed as threatened in the 2001 Plan and have since been de-listed: American peregrine falcon and arctic peregrine falcon.

The Natural Resources Conservation Service (NRCS) defines prime farmland as “land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these uses [30].” As part of the National Resources Inventory, the NRCS has identified prime farmland throughout the country. Figure 1.14 shows the distribution of prime farmland in Region C. Each color in Figure 1.14 represents the percentage of the total acreage that is prime farmland of any kind. (There are four categories of prime farmland in the NRCS STATSGO database for Texas: prime farmland, prime farmland if drained, prime farmland if protected from flooding or not frequently flooded during the growing season, and prime farmland if irrigated.) There are large areas of prime farmland in Cooke, Denton, Collin, Tarrant, Dallas, and Ellis Counties.

There are localized areas of irrigated agriculture in Region C. Table 1.9 shows that 21 percent of the year 2000 water use for irrigation in Region C came from groundwater (compared

Table 1.29
2002 U.S. Department of Agriculture County Data

	Collin	Cooke	Dallas	Denton	Ellis	Fannin	Freestone	Grayson
Farms	2,135	1,765	730	2,358	2,089	1,976	1,468	2,597
Land in Farms (acres)	309,630	458,775	89,112	349,093	464,039	483,446	429,339	441,246
Crop Land (acres)	194,240	182,494	47,881	160,292	264,247	273,137	127,418	232,120
Harvested Crop Land (acres)	130,915	101,470	28,952	92,283	172,088	160,625	35,193	145,332
Irrigated Crop Land (acres)	970	829	696	1,171	921	7,379	980	2,461
Market Value ($1,000)								
Crops	25,629	7,388	16,780	11,764	26,952	19,682	2,081	41,865
Livestock	12,493	38,881	2,207	37,338	16,484	37,683	30,473	16,121
Total	38,122	46,269	18,987	49,102	43,436	57,365	32,554	57,986

	Henderson[b]	Jack	Kaufman	Navarro	Parker	Rockwall	Tarrant	Wise	Total
Farms	1,798	884	2,438	1,864	3,215	385	1,227	2,696	29,625
Land in Farms (acres)	340,869	596,172	419,553	537,104	486,658	46,419	173,493	493,044	6,117,992
Crop Land (acres)	155,850	113,636	202,047	222,944	166,642	25,314	56,618	214,449	2,639,329
Harvested Crop Land (acres)	57,415	18,178	79,920	97,398	60,099	14,158	24,129	84,846	1,303,001
Irrigated Crop Land (acres)	1,028	0	841	172	1,280	103	1,302	1,469	21,602
Market Value ($1,000)									
Crops	13,605	791	6,515	11,826	12,782	1,054	21,729	7,561	228,004
Livestock	29,614	14,761	23,523	24,704	34,818	1,945	7,352	25,739	354,136
Total	43,219	15,552	30,038	36,530	47,600	2,999	29,081	33,300	582,140

Notes: a. Data are from the U.S. Department of Agriculture [29].
b. Data for Henderson County are for the entire county.

to only 7 percent of total water use from groundwater.) Texas Water Development Board Report 269 [(12)] studied groundwater in most of Region C (except for Jack and Henderson Counties and part of Navarro County). Most irrigation wells in the study area were scattered over the outcrop areas of the Trinity and the Woodbine aquifers with only a few areas of concentrated activity. The largest concentration of irrigation wells is located on the Woodbine outcrop in an area bounded by western Grayson County, the eastern edge of Cooke County, and the northeastern corner of Denton County. Approximately 80 irrigation wells operated in this region (as of 1982), and several produced as much as 900 gpm. Several smaller irrigation well developments were located in Parker County and Wise County in the Trinity aquifer. There were also irrigation wells in Fannin County producing from the alluvium along the Red River [(12)].

State and Federal Natural Resource Holdings

The TPWD operates several state parks in Region C: Bonham State Park in Fannin County, Cedar Hill State Park in Dallas County, Eisenhower State Park in Grayson County, Fairfield Lake State Park in Freestone County, Lake Lewisville State Park in Denton County, Lake Mineral Wells State Park in Parker County, Lake Ray Roberts State Park in Denton and Cooke Counties, and Purtis Creek State Park partially located in Henderson County. TPWD also operates Caddo Wildlife Management Area in Fannin County, Ray Roberts Wildlife Management Area in Cooke, Denton, and Grayson Counties, Richland Creek Wildlife Management Area in Freestone and Navarro Counties, and Eisenhower State Historic Park in Grayson County.

Federal government natural resource holdings in Region C include the following:

- Parks and other land around all of the Corps of Engineers lakes in the region (Texoma, Ray Roberts, Lewisville, Lavon, Grapevine, Benbrook, Joe Pool, Bardwell, and Navarro Mills)
- Hagerman National Wildlife Refuge on the shore of Lake Texoma in Grayson County
- Caddo National Grasslands in Fannin County
- Lyndon B. Johnson National Grasslands in Wise County.

Area reservoirs provide a variety of recreational benefits, as well as water supply. Table 1.30 lists the reservoirs located in Region C that have national or state lands associated with them and the recreational opportunities available at these sites [(47, 48, 49)]. Recreational activities typically found at these sites include camping, fishing, boating, hiking, swimming, and picnicking.

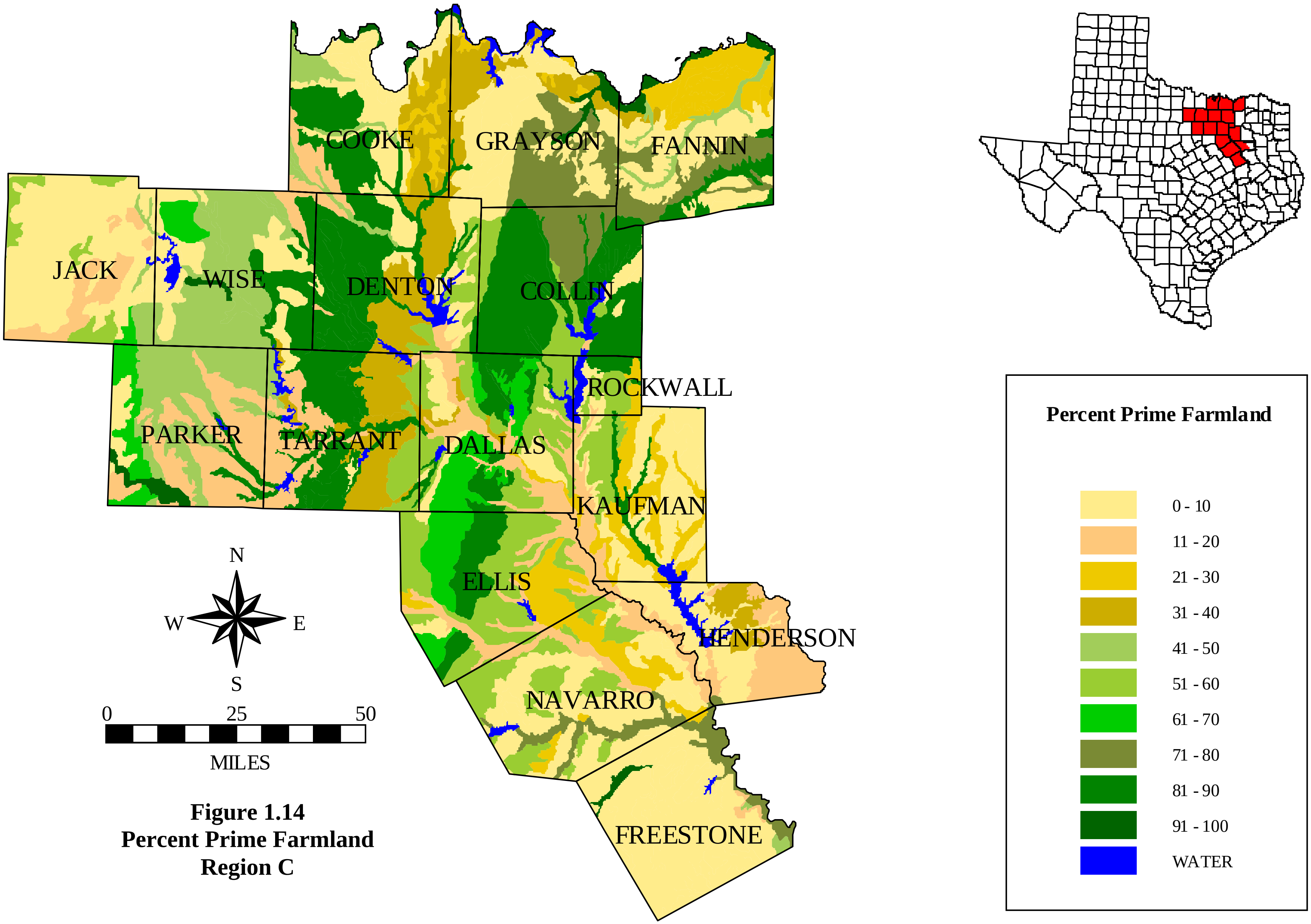


Figure 1.14
Percent Prime Farmland
Region C

Area reservoirs provide a variety of recreational benefits, as well as water supply. Table 1.30 lists the reservoirs located in Region C that have national or state lands associated with them and the recreational opportunities available at these sites [47, 48, 49]. Recreational activities typically found at these sites include camping, fishing, boating, hiking, swimming, and picnicking,

Table 1.30
Recreational Activities at Region C Reservoirs

Reservoir	National Lands	State Lands	Camping	Fishing	Boating	Hiking/Nature Trails	Hunting	Swimming	Picnic Sites	Bicycling Trails	Equestrian Trails	Playgrounds
Lavon	x		x	x	x	x	x	x	x	x	x	
Texoma	x	x	x	x	x	x	x	x	x	x		x
Bonham		x	x	x	x	x		x	x	x		x
Ray Roberts	x	x	x	x	x	x	x	x	x	x	x	x
Lewisville	x		x	x	x	x	x	x	x	x	x	
Benbrook	x		x	x	x	x	x	x	x	x		
Grapevine	x		x	x	x	x	x	x	x	x	x	
Joe Pool	x	x	x	x	x	x		x	x	x	x	x
Bardwell	x		x	x	x	x	x	x	x	x	x	
Navarro Mills	x		x	x	x	x	x	x	x			
Fairfield		x	x	x	x	x		x	x	x		x
Mineral Wells		x	x	x	x	x		x	x	x	x	x

Oil and Gas Resources

Oil and natural gas fields are significant natural resources in portions of Region C. There are a significant number of oil wells in Jack, Wise, Cooke, Navarro, and Grayson Counties, with a lesser number in Denton, Parker, Freestone, Henderson, and Kaufman Counties [31]. There are a significant number of wells producing natural gas in Freestone, Parker, Denton, Jack, and Wise Counties, with a lesser number in Navarro, Henderson, Tarrant, Cooke, and Grayson Counties [32]. None of the 25 top-producing oil fields in Texas (based on 1999 production) is located in Region C, but two of the 25 top-producing gas fields are in the region [33]. The East Newark field ranked 9th in Texas natural gas production, while the Boonesville field ranked 12th. Both gas fields are centered in Wise County. There has recently been a great deal of development to produce natural gas from the Barnett Shale in parts of Region C.

Lignite Coal Fields

There are some lignite coal resources in Region C [34]. Paleozoic rocks with bituminous coal deposits underlie most of Jack County and small portions of Wise and Parker Counties. Near surface (to 200 feet in depth) lignite deposits in the Wilcox Group underlie significant portions of Freestone, Navarro, and Henderson Counties. Deposits of deep basin lignite (200 - 2,000 feet in depth) in rocks of the Wilcox Group underlie a significant portion of Freestone County. The most significant current lignite production in Region C is from the near surface Wilcox Group deposits in Freestone County to supply TXU Electric's Big Brown Steam Electric Station on Lake Fairfield [35].

1.8 Summary of Threats and Constraints to Water Supply in Region C

The most significant potential threats to existing water supplies in Region C are surface water quality concerns, groundwater drawdown, and groundwater quality. Constraints on the development of new supplies include the availability of sites and unappropriated water for new water supply reservoirs and the challenges imposed by environmental concerns and permitting.

Need to Develop Additional Supplies

Most of the water suppliers in Region C will have to develop additional supplies before 2060. The major water suppliers have supplies in excess of current needs, but they will require additional supplies to meet projected growth. Some smaller water suppliers face a more urgent need for water. Their needs can be addressed by local water supply projects or by purchasing water from a major water supplier.

Surface Water Quality Concerns

The Texas Commission on Environmental Quality (TCEQ) publishes *The State of Texas Water Quality Inventory* every two years in accordance with the schedule mandated under section 305(b) of the Clean Water Act. The latest EPA-approved edition of the Water Quality Inventory was published in April 2002 [36]. The Water Quality inventories indicate that public water supply use is supported in the stream segments designated for public water supply in

Region C. The TCEQ has also established a list of stream segments for which it intends to develop total maximum daily load (TMDL) evaluations to address water quality concerns [37]. Table 1.31 lists the stream segments in Region C for which TMDL evaluations are proposed and summarizes the water quality concerns to be addressed.

Only a few of the proposed TMDL studies in Region C are due to concerns related to public water supply. Most are due to concerns over aquatic life, contact recreation, and fish consumption. One public water supply concern is the detection of atrazine in treated drinking water originating from several reservoirs in Region C, including Bardwell Lake, Lake Waxahachie, Lake Lavon, Navarro Mills Lake, Richland-Chambers Reservoir, and Joe Pool Lake. Atrazine was also found in treated drinking water originating from Lake Tawakoni, which is not in Region C but does provide water for Region C. In each case, the level of atrazine detected was much less than the maximum contaminant level for drinking water. In its Clean Water Act Section 303(d) list, the TCEQ stated as follows for each of these reservoirs: "All water quality measurements currently support use as a public drinking water supply; however, atrazine concentrations in finished drinking water indicate contamination of source water and represent a threat to future use." [37] To address this concern, TCEQ has assigned a high priority to development of total maximum daily load (TMDL) evaluations for these watersheds.

Other potential water quality concerns that might affect public water supplies in Region C include nutrient levels in water supply reservoirs, excessive total organic carbon (TOC) levels in source waters, dissolved solids in some reaches, and arsenic. Most of the water supply reservoirs in Region C are experiencing increasing discharges of treated wastewater in their watersheds. To date, this has not presented a problem for public water supplies, but increased amounts of wastewater and greater nutrient loads may lead to concerns about eutrophication in some lakes. Figure 1.15 shows municipal wastewater treatment plants in Region C with over 1 mgd of permitted discharge. Most of the largest plants are on the Trinity River in the Dallas-Fort Worth Metroplex and do not discharge into the watershed of any Region C reservoir. However, there are significant permitted discharges upstream from many reservoirs in the region, and return flows are tending to increase with time.

In December 1998, the U.S. EPA published the *Stage 1 Disinfectants and Disinfection Byproducts (D/DBP) Rule* [38], which applies to water systems that treat surface water with a chemical disinfectant. This rule sets forth Maximum Contaminant Levels for a number of different contaminants including: total organic carbon, trihalomethane, haloacetic acid, dissolved solids, and arsenic. Under certain circumstances, the rule mandates the use of enhanced coagulation to remove total organic carbon (TOC), an indicator of potential disinfection byproduct formation. A 1995 study commissioned by the Trinity River Authority determined the impact of this new rule on Trinity Basin water supplies [39]. Based on TCEQ's 1982-1992 water quality data, 20 Trinity Basin segments in Region C exhibited an average TOC over 6 mg/l. Based on source water TOC and surface water alkalinity, this rule will require TOC reductions of 25 to 40 percent by enhanced coagulation for most Region C water supplies in the Trinity Basin [39]. This rule also establishes maximum contaminant levels (MCLs) for two groups of disinfection by-products (DBPs): total trihalomethanes (TTHM) and haloacetic acids (group of five) (HAA5) [40]. Effective January 1, 2004, all community and nontransient, noncommunity systems must be in compliance with the MCLs for TTHM of 0.080 milligrams per liter and HAA5s of 0.060 milligrams per liter running annual average of the entire distribution system.

Stage 2 Disinfectants and Disinfection Byproducts Rule (Stage 2 DBPR) is currently anticipated to become final in January 2006 [41]. This rule will require systems to evaluate their distribution system to identify the locations with high disinfection by-product concentrations. These locations will then be used by the systems as the sampling sites for DBP compliance monitoring [42]. This rule will also require compliance with the MCLs for TTHM of 0.080 milligrams per liter and HAA5s of 0.060 milligrams per liter at each monitoring location as soon as six years of promulgation. This differs from the current MCLs for TTHM of 0.120 milligrams per liter and HAA5s of 0.100 milligrams per liter at each monitoring location [41].

The proposed Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) is a companion rule to Stage 2 DBPR. This rule would require additional Cryptosporidium treatment techniques for higher risk systems. Systems will initially conduct source water monitoring to determine their treatment requirements. EPA predicts that the majority of systems will be classified in the lowest risk bin, which carries no additional treatment requirements [43]. The effect of this rule on Region C source waters has not been evaluated.

Dissolved solids in the Red River and Lake Texoma along the northern boundary of Region C are generally high. The use of Lake Texoma water for public supply requires desalination (Sherman, Red River Authority Preston Shores) or blending with higher quality water (North Texas MWD, Denison). This has limited the use of water from the Red River and Lake Texoma for public water supply. The Red River Authority is serving as a local sponsor for the proposed Red River Chloride Control Project, which may serve to improve the quality of Lake Texoma water for public water supply by diverting saline water before it reaches the lake.

Two reaches in the Trinity River Basin within Region C - the West Fork of the Trinity River above Lake Bridgeport (Segment 0812) and Joe Pool Lake (Segment 0838) - show average concentrations of total dissolved solids and other salts greater than the current stream standards. In both cases, the levels are less than the TCEQ secondary standards for drinking water and should not present a problem for public water supply. It is important to note that the Draft 2004 Water Quality Inventory states that Joe Pool Lake fully supports all uses, and Joe Pool Lake has been taken off the 2004 Draft 303(d) list.

Arsenic is a naturally occurring metal that is found in groundwater in various parts of the state. The highest levels of arsenic in Texas occur in the Ogallala and Gulf Coast aquifers. Currently the maximum contaminant level (MCL) for arsenic is 0.05 mg/L or 50 ppb. Beginning January 23, 2006, the MCL for arsenic will change to 0.010 mg/L or 10 ppb.

Currently only one public water system in the state is in violation for exceeding the MCL for arsenic. When the new MCL comes into effect in 2006, as many as 300 systems will likely exceed the MCL. Systems that exceed the MCL will be required to treat their water to bring arsenic levels down below the MCL.

There are many methods available to remove arsenic from drinking water. Treatment processes include precipitation, adsorption, ion exchange, membrane filtration, and several other alternative methods.

The Texas Commission on Environmental Quality (TCEQ) has the primary responsibility for enforcing state laws regarding water pollution. Chapter 7 of the Texas Water Code also establishes laws to allow local governments to combat environmental crime, including water pollution. Local enforcement of these laws can supplement the enforcement activities of TCEQ and help protect Texas' water resources.

Table 1.31
Total Maximum Daily Load (TMDL) Studies Proposed for Region C [a]

Segment #	Segment Name	Basin	Priority	Concern is for: Public Supply	General	Aquatic Life	Contact Recreation	Fish Consumption	Description
507	Lake Tawakoni [b]	Sabine	Low	x	x	x			All water quality measurements support use as public water supply, but atrazine has been detected at low levels in treated water; depressed DO near dam; high pH in Kitsee inlet and Cowleech Fork.
804	Trinity River-Cedar Creek Spillway to Lake Livingston	Trinity	Low/ Under-way				x		Bacteria sometimes exceed contact recreation level in upper 25 miles.
805	Trinity River- Elm Fork to Cedar Creek Spillway	Trinity	Medium/ Under-way				x	x	Bacteria sometimes exceed contact recreation level. Fish consumption not supported in upper 19 miles due to chlordane in fish tissue.
806	West Fork Trinity River-Lake Worth Dam to Village Creek	Trinity	Medium/ Under-way				x	x	Bacteria sometimes exceed contact recreation level in a 17 mile stretch. Fish consumption not supported in lower 22 miles due to chlordane in fish tissue.
806A	Fosdic Lake	Trinity	Medium					x	Fish consumption not supported due to chlordane, dieldrin, DDE, and PCBs in fish tissue.
806B	Echo Lake	Trinity	Medium					x	Fish consumption not supported due to PCBs in fish tissue.
810	West Fork Trinity River-Lake Bridgeport to Eagle Mountain Lake	Trinity	Low				x		Bacteria sometimes exceed contact recreation level in lower 25 miles.

Table 1.31, Continued

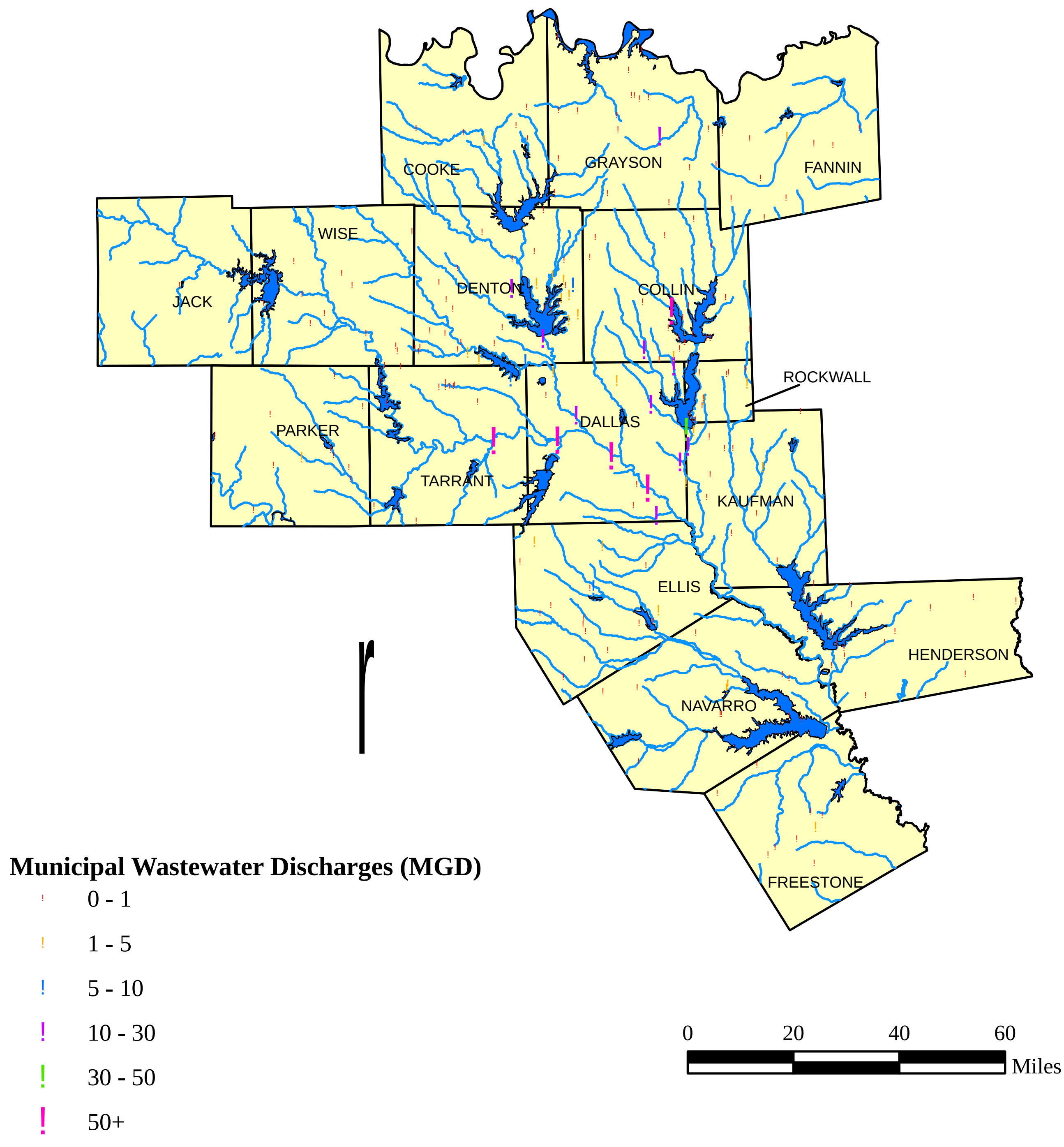
Segment #	Segment Name	Basin	Priority	Concern is for: Public Supply	General	Aquatic Life	Contact Recreation	Fish Consump-tion	Description
812	West Fork Trinity River above Lake Bridgeport	Trinity	Medium		x	x			In lower 25 miles, dissolved oxygen is sometimes lower than the standard to protect aquatic life. In lower 25 miles, average chlorides and total dissolved solids exceed general standard for segment (but not secondary drinking water standards).
814	Chambers Creek	Trinity	Low			X			In portion of segment upstream of confluence with Cummins Creek, dissolved oxygen concentrations are occasionally lower than the standard for aquatic life.
815	Bardwell Lake	Trinity	Threat-ened/ High	x					All water quality measurements support use as public water supply, but atrazine has been detected at low levels in treated water.
816	Lake Waxahachie	Trinity	Threat-ened/ High	x					All water quality measurements support use as public water supply, but atrazine has been detected at low levels in treated water.
817	Navarro Mills Lake	Trinity	Threat-ened/ Medium	x					All water quality measurements support use as public water supply, but atrazine has been detected at low levels in treated water.
819	East Fork Trinity River below Lake Ray Hubbard	Trinity	Low				x		Bacteria sometimes exceed contact recreation levels in lower 14 miles.
821	Lake Lavon	Trinity	Threat-ened/ Medium	x					All water quality measurements support use as public water supply, but atrazine has been detected at low levels in treated water.
829	Clear Fork Trinity River- Lake Benbrook to West Fork Trinity River	Trinity	Medium					x	Fish consumption not supported in the lower mile due to chlordane in fish tissue.

Table 1.31, Continued

Segment #	Segment Name	Basin	Priority	Concern is for: Public Supply	General	Aquatic Life	Contact Recreation	Fish Consump-tion	Description
829A	Lake Como	Trinity	Medium					x	Fish consumption not supported due to chlordane, dieldrin, DDE, and PCBs in fish tissue.
831	Clear Fork Trinity River- Lake Weatherford to Benbrook Lake	Trinity	Medium			x			Dissolved oxygen concentrations are occasionally lower than aquatic life standard in lower 15.7 miles.
833	Clear Fork Trinity River above Lake Weatherford	Trinity	Low			x			Dissolved oxygen standards are occasionally lower than aquatic life standard.
836	Richland-Chambers Reservoir	Trinity	Threat-ened/ Medium	x					All water quality measurements support use as public water supply, but atrazine has been detected at low levels in treated water.
838	Joe Pool Lake [c]	Trinity	Low	x	x				Average sulfates and total dissolved solids exceed general standards for segment (but not secondary drinking water standards). All water quality measurements support use as public water supply, but atrazine has been detected at low levels in treated water.
841	West Fork Trinity River-Village Creek to Elm Fork	Trinity	Low/ Under-way				x	x	Bacteria sometimes exceed contact recreation levels in lower 21 miles. Fish consumption not supported due to chlordane in fish tissue.
841A	Mountain Creek Lake	Trinity	Medium					x	Fish consumption not supported due to PCBs, chlordane, heptachlor epoxide, dieldrin, DDE, DDD, and DDT in fish tissues.

Notes: a. All information is from Texas 2000 Clean Water Act Section 303(d) List [37].
b. Lake Tawakoni is outside of Region C, but provides water to Region C.
c. Joe Pool Lake is not listed in the 2004 Draft 303(d) list.

Figure 1.15
Wastewater Discharge Points



Groundwater Drawdown

Overdevelopment of aquifers and the resulting decline in water levels poses a threat to small water suppliers and to household water use in rural areas. As water levels decline, the cost of pumping water grows and water quality generally suffers. Wells that go dry must be redrilled to reach deeper portions of the aquifer. Water level declines have been reported in localized areas in each of the major and minor aquifers in Region C. In particular, the annual pumpage from the Trinity aquifer in some counties is estimated to be greater than the annual recharge [12]. Concern about groundwater drawdown is likely to prevent any substantial increase in groundwater use in Region C and may require conversion to surface water in some areas.

Groundwater Quality

Figure 1.7 shows the major aquifers in Region C, the Trinity aquifer and the Carrizo-Wilcox aquifer. Figure 1.8 shows the minor aquifers in Region C, which are the Woodbine aquifer, the Nacatoch aquifer, and the Queen City aquifer. Water quality in the Trinity aquifer is acceptable for most municipal and industrial purposes [12, 37]. However, in some areas, natural concentrations of arsenic, fluoride, nitrate, chloride, iron, manganese, sulfate, and total dissolved solids in excess of either primary or secondary drinking water standards can be found. Water on the outcrop tends to be harder with relatively high iron concentration. Downdip, water tends to be softer, with concentrations of TDS, chlorides, and sulfates higher than on the outcrop. Groundwater contamination from man-made sources is found in localized areas. Texas Water Development Board Report 269 reported contaminated water in wells located between Springtown in Parker County and Decatur in Wise County [12]. The apparent source of the contamination was improperly completed oil and gas wells. Other potential contaminant sources (agricultural practices, abandoned wells, septic systems, etc.) are known to exist on the Trinity outcrop, but existing data are insufficient to quantify their impact on the aquifer [44].

Water from the Carrizo-Wilcox aquifer is fresh to slightly saline. In the outcrop, the water is hard and low in TDS [45]. In the downdip, the water is softer, with a higher temperature and higher TDS concentrations [45]. Hydrogen sulfide and methane may be found in localized areas [45]. In much of the northeastern part of the aquifer, water is excessively corrosive and has high iron content [45]. In this area, the groundwater may also have high concentrations of TDS, sulfate, and chloride. Some of these sites may be mineralized due to waters passing through lignite deposits, especially in the case of high sulfate [45]. Another cause may be the historic practice of storing oil field brines in unlined surface storage pits [45]. In Freestone County, excessive iron concentration may be a problem; a well recently completed by the City of Fairfield contained water with a high iron concentration [46]. Excessive iron concentrations can be removed by treatment.

Water quality in the layers of the Woodbine aquifer used for public water supply is good along the outcrop. Water quality decreases downdip (southeast), with increasing concentrations of sodium, chloride, TDS, and bicarbonate. High sulfate and boron concentrations may be found in Tarrant, Dallas, Ellis, and Navarro Counties. Excessive iron concentrations also occur in parts of the Woodbine formation.

The Nacatoch and Queen City aquifers provide very little water in Region C. Available data indicate that the quality of the Nacatoch in this area is acceptable for most uses. Water quality data on the Queen City aquifer in Region C are very limited.

1.9 Water-Related Threats to Agricultural and Natural Resources in Region C

Water-related threats to agricultural and natural resources in Region C include changes to natural flow conditions, water quality concerns, and inundation of land due to reservoir development. In general, there are few significant water-related threats to agricultural resources in Region C due to the limited use of water for agricultural purposes. Water-related threats to natural resources are more significant.

Changes to Natural Flow Conditions

Reservoir development, groundwater drawdown, and return flows of treated wastewater have greatly altered natural flow patterns in Region C. Spring flows in Region C have diminished, and many springs have dried up because of groundwater development and the resulting drawdown. This has reduced reliable flows for many tributary streams. Reservoir development also changes natural hydrology, diminishing flood flows and capturing low flows. (Some reservoirs provide steady flows in downstream reaches due to releases to empty flood control storage or meet permit requirements.) Downstream from the Dallas-Fort Worth Metroplex, base flows on the Trinity River have been greatly increased due to return flows of treated wastewater.

It is unlikely that future changes to flow conditions in Region C will be as dramatic as those that have already occurred. If additional reservoirs are developed, they will likely be required to release some inflow to maintain downstream stream conditions, which was often not required in the past. It is likely that return flows from the Dallas-Fort Worth area will continue to increase, thus increasing flows in the Trinity River. On balance, this will probably enhance habitat in this reach.

Figure 1.16 shows the historical and projected return flows for the Trinity River Basin in Region C after implementation of planned reuse projects. The model indicates that the return flows are expected to remain near current levels from 2010 through 2030. Return flows are projected to increase significantly over historical levels from 2040 through 2060. Chapters 4E and 6 include more detailed information on this return flow analysis.

Water Quality Concerns

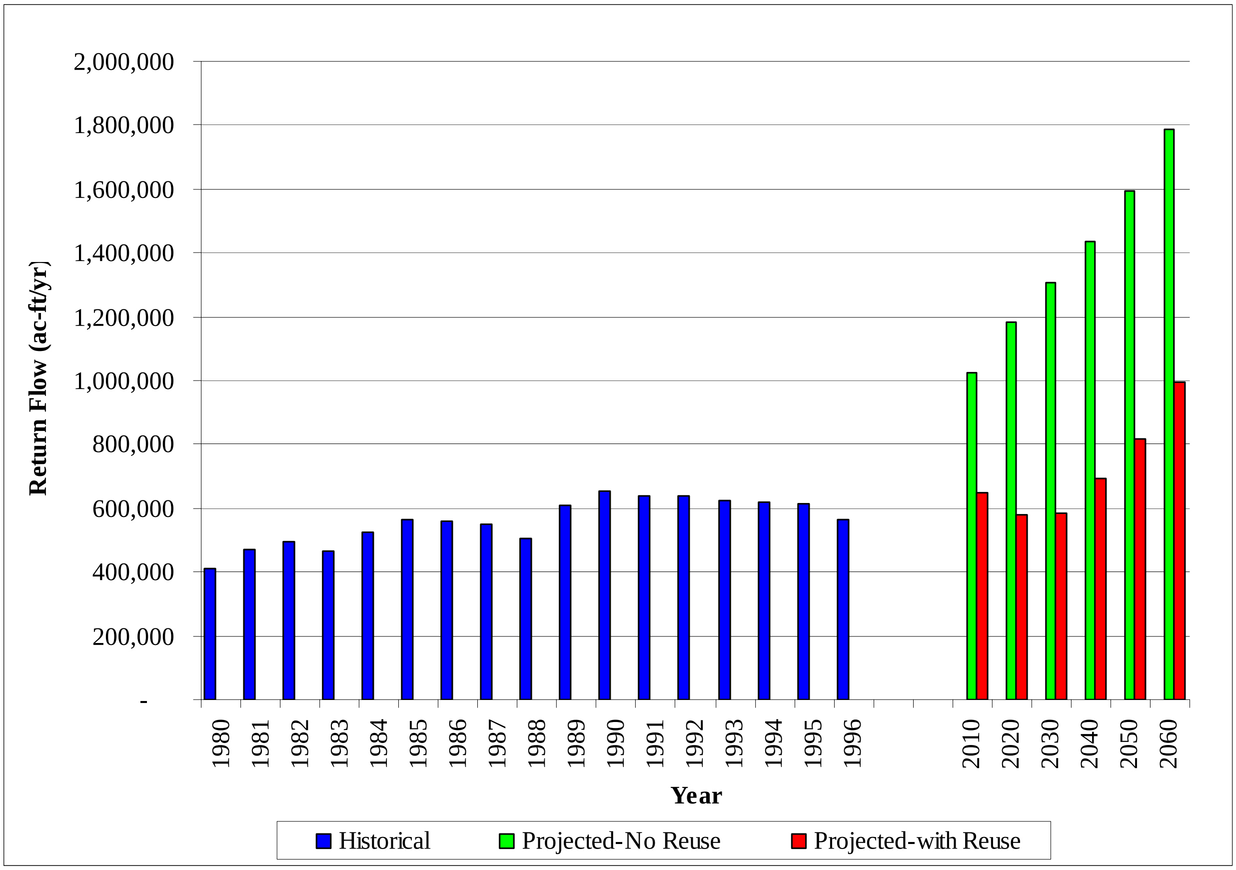
Table 1.31 lists a number of reaches in which the TCEQ has documented concerns over water quality impacts to aquatic life or fish consumption. In general, these concerns are due to low dissolved oxygen levels or to levels of lead, pesticides, or other pollutants that can harm aquatic life or present a threat to humans eating fish in which these compounds tend to accumulate. Several total maximum daily load (TMDL) studies on areas of concerns have been conducted and others will follow over the next few years.

Inundation Due to Reservoir Development

At various times, a number of new reservoirs have been considered for development in Region C, including:

- Tehuacana Reservoir on Tehuacana Creek in Freestone County.
- Tennessee Colony Reservoir on the main stem of the Trinity River in Freestone, Navarro, Henderson, and Anderson Counties.
- Roanoke Reservoir on Denton Creek in Denton County.
- Italy Reservoir on Chambers Creek in Ellis and Navarro Counties.
- Emhouse Reservoir at the confluence of Chambers and Waxahachie Creeks in Ellis and Navarro Counties.
- Upper Red Oak Reservoir and Lower Red Oak Reservoir on Red Oak Creek in Ellis County.
- Bear Creek Reservoir on Bear Creek in Ellis County.

Figure 1.16
Summary of the Historical and Projected Return Flows in the Trinity River Basin in Region C



- Lower Bois d'Arc Reservoir on Bois d'Arc Creek in Fannin County.
- Ralph Hall Reservoir on North Fork Sulphur River in Fannin County.
- Muenster Lake in Cooke County.

At this time, Lower Bois d'Arc Reservoir, Lake Ralph Hall, Tehuacana Reservoir, and Muenster Lake seem to be the most likely to be developed of these projects. The impacts of a new reservoir on natural resources include the inundation of habitat, often including wetlands and bottomland hardwoods, and changes to downstream flow patterns. Depending on the location, a reservoir may also inundate prime farmland. The impacts of specific projects depend on the location, the mitigation required, and the operation of the projects. Muenster Lake is under construction and is scheduled to be completed in the spring of 2006.

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(49) U.S. Army Corps of Engineers, Fort Worth District: Information on Federal Parks and Reservoirs, Fort Worth, [Online], Available URL: http://www.swf-wc.usace.army.mil/index.htm, November 2005.

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2. Population and Water Demand Projections

2.1 Historical Perspective

This section presents the population and water demand projections for Region C as approved by the Texas Water Development Board (TWDB). The section includes a discussion on historic growth trends in Region C, the basis and methodology of projections, and the final population and water demand projections for Region C.

The sixteen counties that comprise Region C have been among the fastest growing areas in Texas and the nation since the 1950s. The region's highest population density is centered in and near Dallas and Tarrant Counties. For many years, the population growth in the region was concentrated in the cities of Dallas and Fort Worth. In the 1960s and 1970s, growth spilled over into the near suburbs of Dallas and Tarrant Counties. Then in the 1980s and more so in the 1990s, the growth spilled into Collin, Denton and Rockwall Counties, and to some extent into Ellis County.

According to the U.S. Census Bureau, the year 2000 population of Region C was 5,254,722 (1). This value excludes the portion of Henderson County that is located in the Neches Basin, which is included in Region I. The total Region C water demand in the year 2000 was 1,380,556 acre-feet (2). Figure 2.1 is a chart of the historical population for Region C from 1900 to 2000 (1, 3). The historical water use for Region C by type of use in 1980, 1990 and 2000 is presented in Figure 2.2 (2).

2.2 Population Projections

Basis for Population Projections

The population projections presented in this section are based on census data (1), TWDB draft projections (4, 5), North Central Texas Council of Governments (NCTCOG) data (6), and input from cities, counties and water user groups. In addition to projections for cities and counties, TWDB projections for this round of regional water planning include retail water suppliers such as water supply corporations and utility districts. The entities for which projections of population and water use were developed are referred to collectively as water user groups

Figure 2.1
Historical Population in Region C

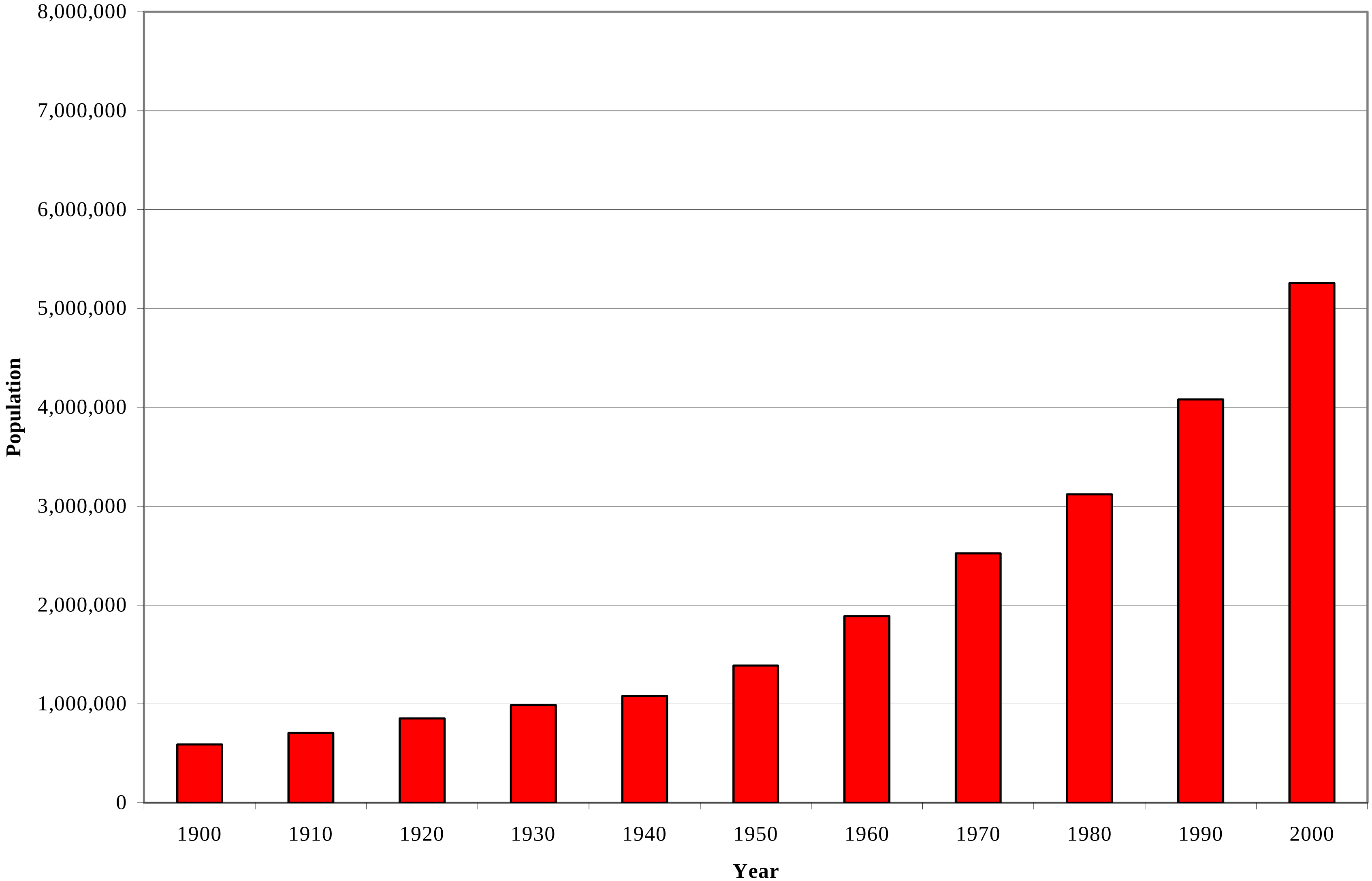
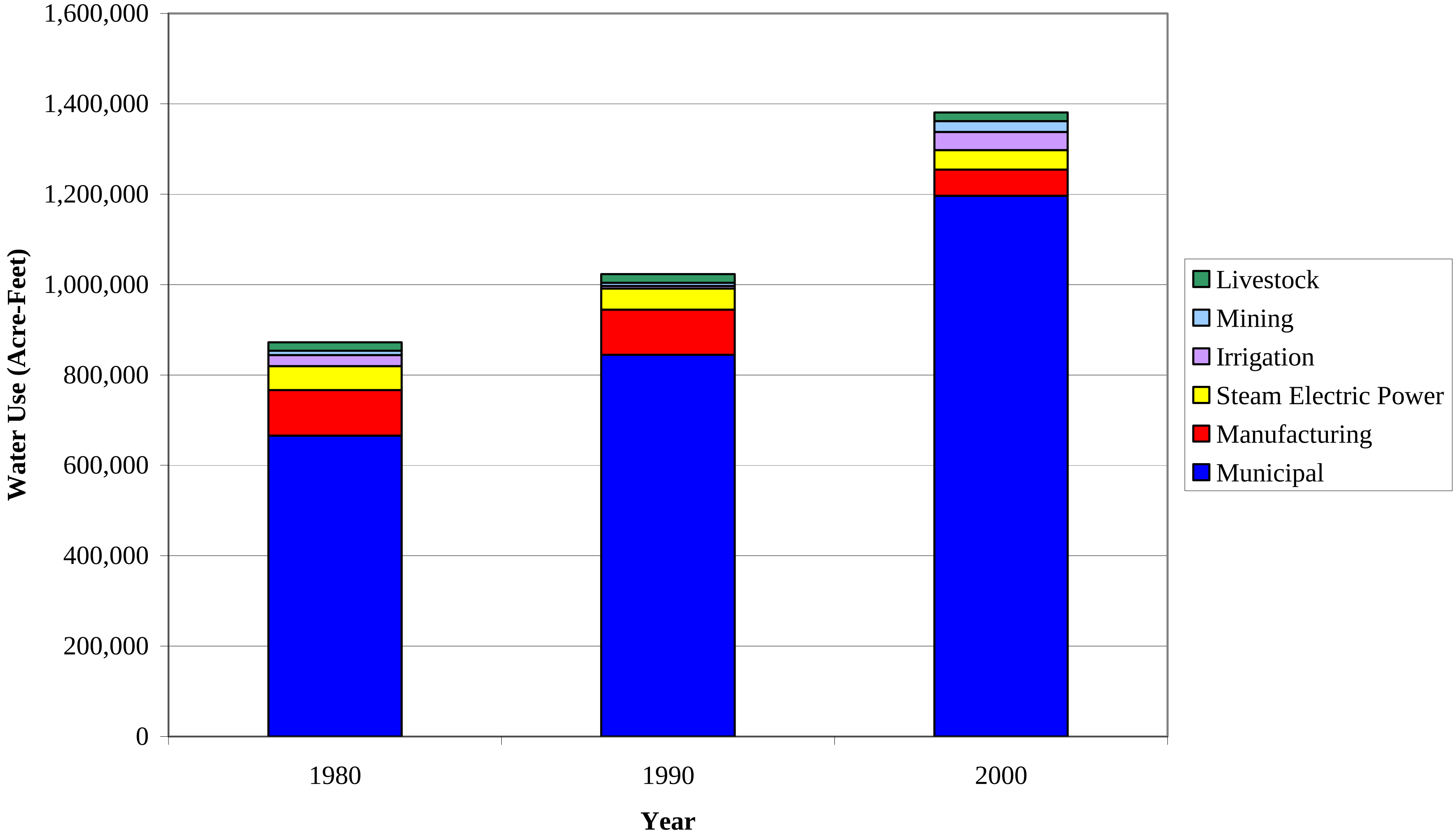


Figure 2.2
Historical Water Use by Category in Region C



(WUGs). The TWDB provided draft population projections for 2010, 2020, 2030, 2040, 2050 and 2060 for each WUG that provides municipal water [5]. The U.S. Census Bureau provided population data for cities and counties in Region C for the years 1980, 1990 and 2000 [1]. Data from NCTCOG included available population projections, city build-out projections, and land use data [6, 7]. The land use data from NCTCOG identified total and undeveloped land areas, and current and projected densities for many Region C cities. The NCTCOG region does not cover all of Region C, so the NCTCOG data does not include information for all cities in Region C.

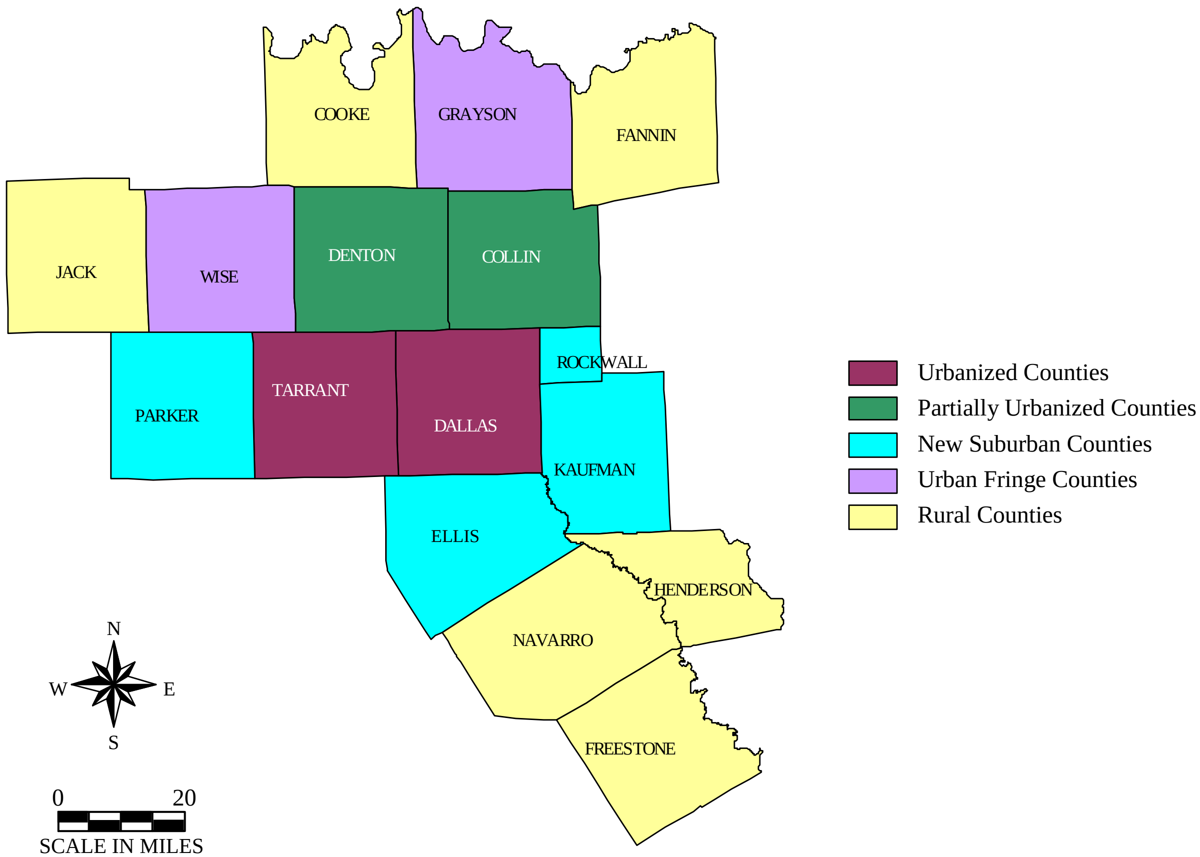
Methodology for Population Projections

The TWDB draft population projections by county were based on projected birth rates, death rates, and migration into and out of each county. For TWDB's initial draft projections, the migration rates into and out of each county were assumed to be 50 percent of the rates that occurred during the 1990's. Region C first modified the initial draft county population projections by analyzing the projected migration rates for each county on the basis of expected urbanization. Counties that are close to being fully developed will likely experience lower growth rates, as the TWDB draft projections had assumed. Counties that are currently undergoing rapid development or are bordering developed areas will likely experience increased migration compared to previous decades.

The sixteen counties in Region C have been divided into five classifications from the standpoint of population and water use. Figure 2.3 displays the counties with the following classifications assigned:

- **Urbanized counties** are characterized by dense population and by residential, industrial, and commercial development covering most of the land area. Population growth will come from development of the remaining open land and from redevelopment. Increased water demand will come primarily from population and employment growth (partially offset by water conservation). Dallas and Tarrant Counties are the urbanized counties in Region C.
- **Partially urbanized counties** have a significant land area that is highly developed, with dense population and industrial and commercial development. These counties also have sizeable undeveloped areas. Population growth in these counties is expected to be substantial and driven primarily by new development. Growth rates in these counties cannot be predicted from historical trends alone. Increased water demand will come primarily from population growth, although per capita municipal use may increase with development. Per capita municipal water demand is likely to increase with population in developing areas, even though conservation measures are implemented. Newly constructed homes in developing

Figure 2.3
Region C County Classifications



areas are likely to have higher per capita water demand than existing development because of irrigation systems, swimming pools, and water-using appliances. Additionally, the increase in per capita municipal water demand occurs as a result of commercial development and changes in the type of housing. Collin and Denton Counties are the partially urbanized counties in Region C.

- **New suburban counties** are urban fringe counties that, through development, are becoming partially urbanized counties. Population density is reaching high levels in developed areas. Yet, undeveloped land is still a significant portion of the total land area, although less so than in urban fringe counties. Population growth in the new suburban counties can be expected to be significant and will be derived primarily from new development. Water demand will increase with the growing population, and per capita municipal water demand will generally increase even with water conservation measures because of commercial development and changes in housing types. Ellis, Kaufman, Parker and Rockwall Counties are the new suburban counties in Region C.
- **Urban fringe counties** are located adjacent to urban counties, but they currently have minimal urbanized development. They generally have higher population density than rural counties, but most of the land area is undeveloped. These counties are expected to experience relatively high growth in the next fifty years as urban development expands from the urbanized counties. Population growth in the urban fringe counties can be expected to be significant and will be derived primarily from new development. Water demand will increase with the growing population, and per capita municipal water demand will generally increase even with water conservation measures because of commercial development and changes in housing types. The urban fringe counties in Region C are Grayson and Wise Counties.
- **Rural counties** are located beyond the immediate influence of the urban counties. Growth in these counties will generally be generated from local expansion and be dependent on local economic factors. In most cases, historical trends are a reasonable indication of future population growth. In some cases, recent economic or demographic changes, such as prison construction, have altered population growth and water demand trends. The rural counties in Region C are Cooke, Fannin, Freestone, Henderson, Jack and Navarro Counties.

Once the county population projections were completed, projections for individual WUGs within each county were adjusted based on historical trends and knowledge of expected future development. The county population projections served as controls in this process. Land use data from NCTCOG was important in determining ultimate build-out populations. WUGs at or near build-out were given a declining growth rate. All population not assigned to a particular WUG was included as “county-other” for that county. The “county-other” projections are much lower than in previous water plans because retail water suppliers (such as water supply corporations) that supply 0.25 mgd or more are listed individually rather than being included in the “county-other” total.

The population data were then assembled in tables and figures that could be reviewed by counties, cities, water suppliers, industries, and other interested parties. The revised draft population projections and questionnaires were sent to all Region C counties, cities with a population over 500, regional water suppliers, and retail water suppliers (supplying over 0.25 mgd). In all, 296 population surveys were mailed with a 67 percent response rate. (Questionnaires are included in Appendix C.) Many WUGs responded with suggestions for revisions to the population projections. Additionally, interviews were set up with certain WUGs to clarify comments and solicit more detailed information. Of those that responded, 60 percent either agreed with the draft projections or had no comment; 28 percent considered the draft projections to be too low; and 11 percent considered the draft projections to be too high. The data obtained from the questionnaires and interviews were compiled and used, where appropriate, to develop a final set of recommended population projections. As required by TWDB regulations, the projections balance, on a regional total basis, with the TWDB draft projections. Comparison of the original TWDB draft projections by county with the projections recommended by Region C and adopted by the TWDB shows the following:

- As required by TWDB rules, the projected total Region C populations in each decade are the same.
- Projected populations in Dallas and Tarrant Counties are lower due to anticipated build-out in those counties.
- Projected populations in Cooke, Denton, Ellis, Fannin, Freestone, Grayson, Jack, Kaufman, Navarro, Parker, and Wise Counties are higher due to the anticipated pattern of increasing development in areas further from the central urban counties.
- Projected populations in Collin, Henderson, and Rockwall Counties are essentially the same.

Water User Group Projections

The projected 2060 population for Region C is 13,087,849. Census data showed that previous water planning projections underestimated the population in Region C for the year 2000. This resulted in higher population projections for this round of regional planning than in the 2001 *Region C Water Plan* [(8)]. The rate of growth, compared to previous projections, also increased slightly for the same reason. It is important to note that the projected growth rate in Region C decreases significantly after the year 2010. Table 2.1 presents the historical and projected population for the Region C counties, as adopted by TWDB. Figures 2.4 and 2.5 show the

Table 2.1
Adopted County Population Projections for Region C

County	Historical 1990	Historical 2000	2010	2020	2030	2040	2050	2060
Collin	264,036	491,774	756,088	1,033,173	1,249,795	1,512,261	1,762,329	2,033,981
Cooke	30,777	36,363	42,675	47,792	53,379	58,273	66,099	72,428
Dallas	1,852,810	2,218,774	2,557,152	2,883,564	3,117,428	3,338,498	3,640,347	4,032,056
Denton	273,525	432,976	720,064	953,668	1,184,744	1,392,575	1,610,447	1,870,472
Ellis	85,167	111,360	149,627	188,280	230,402	277,956	334,794	402,573
Fannin	24,804	31,242	36,842	40,539	47,393	57,913	71,389	83,522
Freestone	15,818	17,867	20,882	22,508	23,863	25,121	26,265	27,410
Grayson	95,021	110,595	133,913	163,711	188,537	208,936	230,413	253,568
Henderson	41,309	51,984	62,504	74,186	86,297	99,147	114,759	134,176
Jack	6,981	8,763	9,567	10,275	10,915	11,415	11,915	12,415
Kaufman	52,220	71,313	112,971	148,580	177,072	205,571	237,625	277,783
Navarro	39,926	45,124	52,189	58,161	64,637	71,810	80,344	90,940
Parker	64,785	88,495	115,529	172,136	216,956	242,904	268,224	291,978
Rockwall	25,604	43,080	82,547	126,029	148,991	170,493	186,083	196,472
Tarrant	1,170,103	1,446,219	1,705,885	1,956,163	2,189,565	2,454,046	2,779,448	3,146,721
Wise	34,679	48,793	66,847	87,624	103,873	119,876	139,509	161,354
Region C Total	**4,077,565**	**5,254,722**	**6,625,282**	**7,966,389**	**9,093,847**	**10,246,795**	**11,559,990**	**13,087,849**

Figure 2.4
Historical and Projected Population in Region C

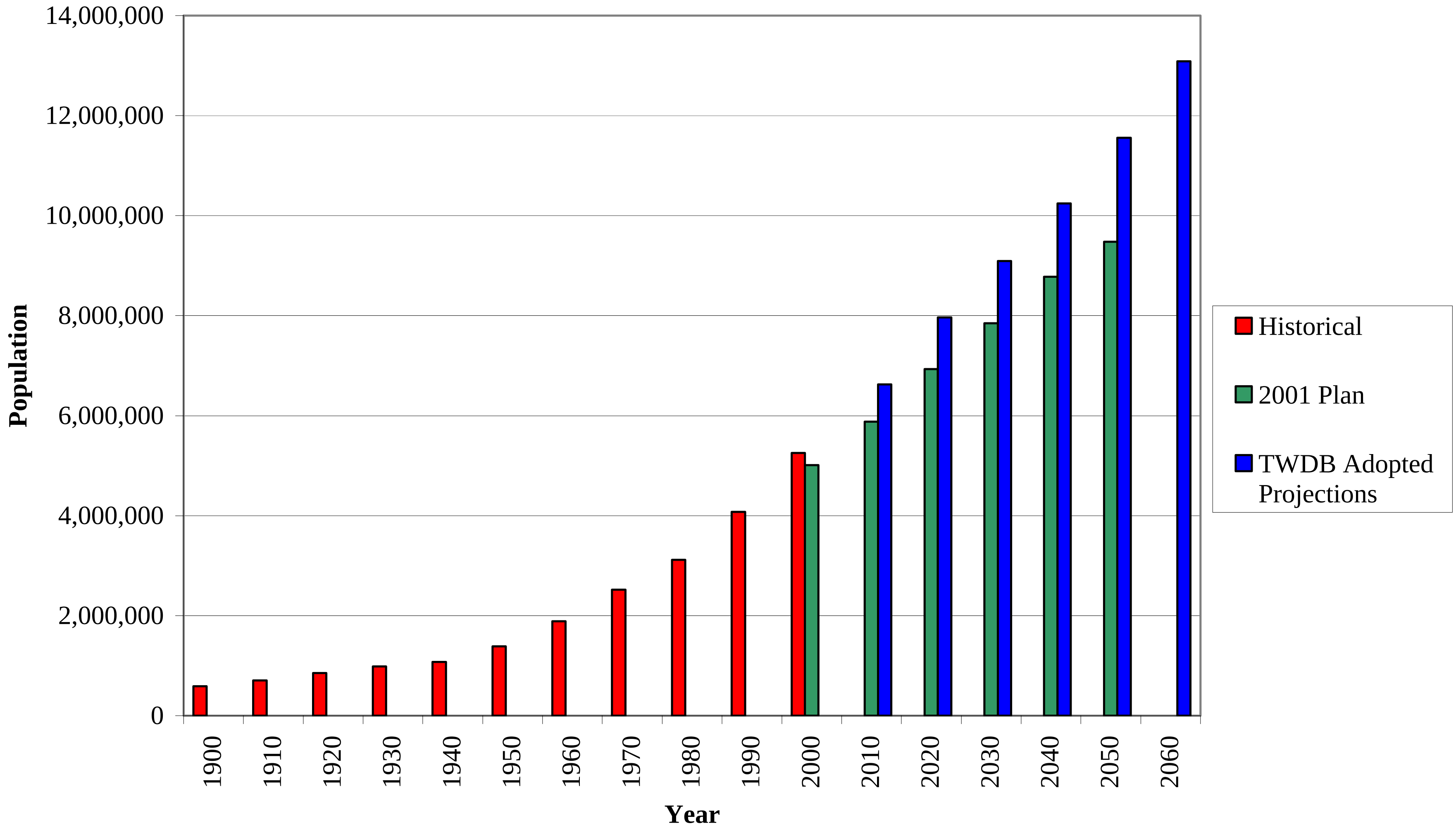
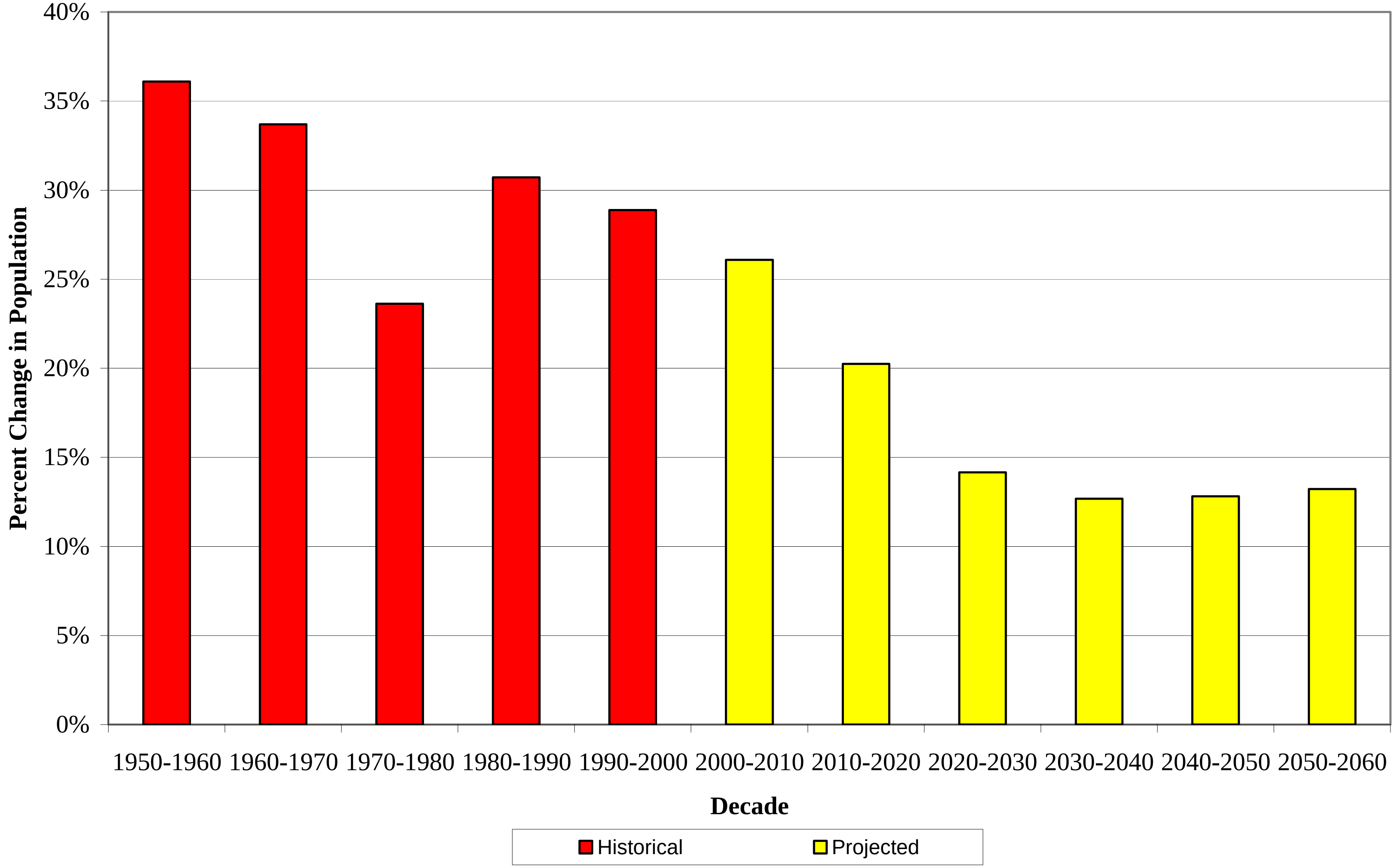


Figure 2.5
Historical and Projected Population Growth Rates by Decade in Region C



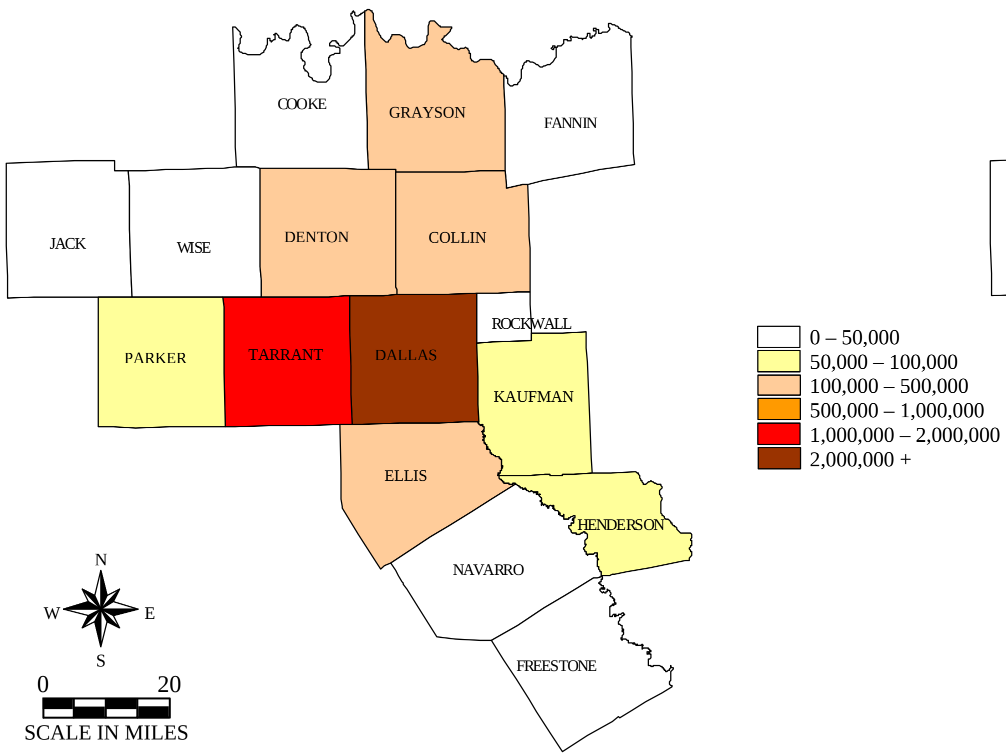
historical and projected population and the rate of growth for Region C, respectively. Figure 2.5 shows that the population projections for Region C represent a substantial slowing in the historical rate of growth. Figure 2.6 is a map of the year 2000 historical population and the 2060 projected population by county. Figure 2.7 is a map of the projected percent change in population between years 2000 and 2060 by county. Appendix D includes the projected populations for Region C, by water user group and county, as approved by the TWDB. Many of the water user groups have population that is split among multiple counties and regions. For convenience, Appendix D also includes the total projected populations for those water user groups in multiple counties.

Region C Population Projections and North Central Texas COG Projections

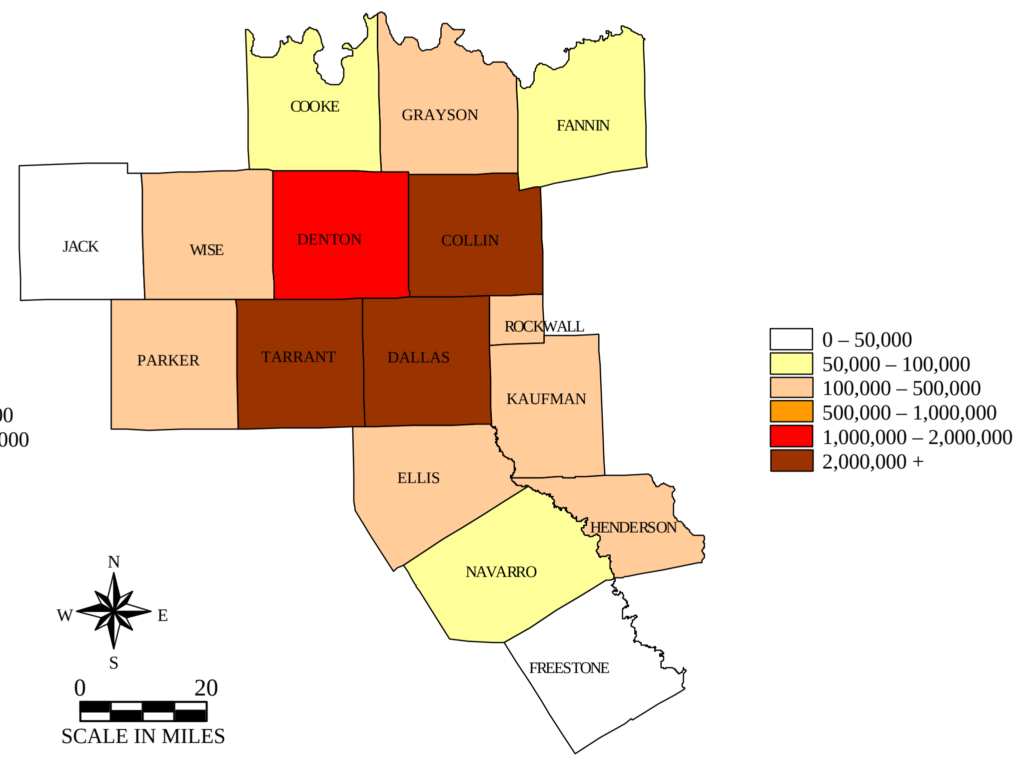
After the Region C population projections were finalized, the North Central Texas Council of Governments (NCTCOG) completed independent projections of population through 2030 for the more populous Region C counties [(6)]. Nine counties were included in both the Region C and NCTCOG projections (Collin, Dallas, Denton, Ellis, Kaufman, Parker, Rockwall, Tarrant, and Wise). These counties include 94 percent of the year 2000 population in Region C. Figure 2.8 shows the comparison between the Region C population projections and the NCTCOG projections. The NCTCOG year 2030 projected population for the nine counties was 0.5 percent higher than the Region C projection, indicating very close agreement. The only counties in which the two projections differed by more than 10 percent were Parker and Kaufman, where NCTCOG projects significantly more rapid population growth than does Region C.

The North Central Texas Council of Governments also provided projections for individual cities, but those projections consider population <u>within current city limits.</u> Since Region C projections assume that cities will annex additional land over time, a direct comparison of city population projections is not possible. However, the county data do not present this problem and can be compared.

Figure 2.6
Region C Population

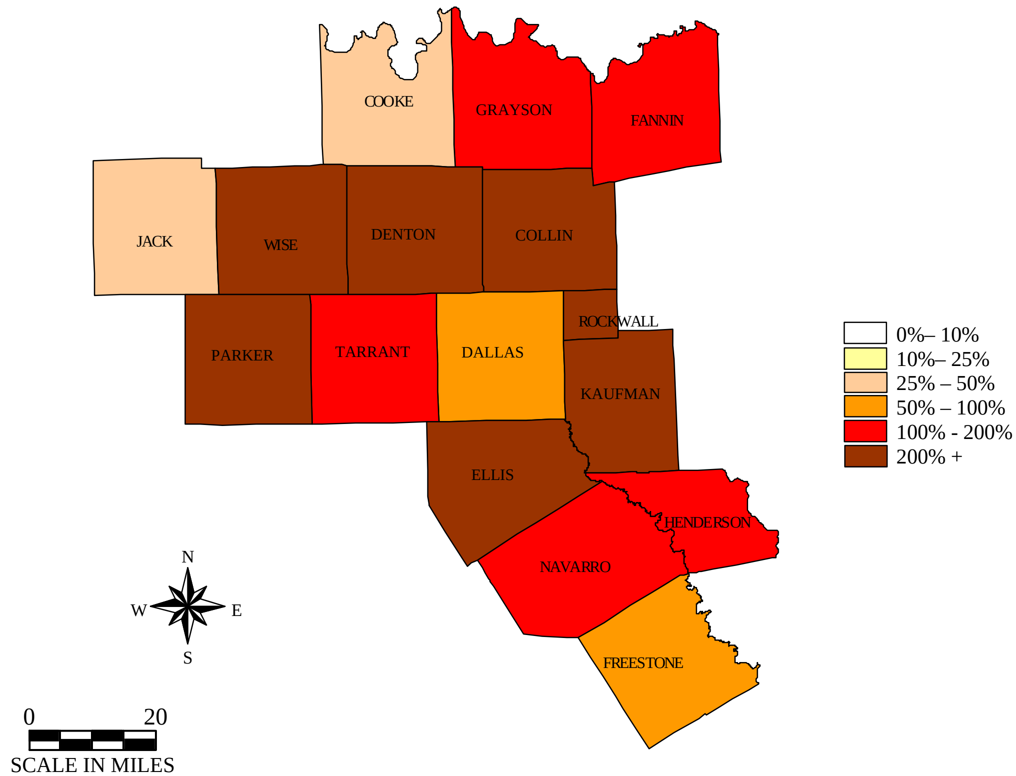


Historical 2000 Population



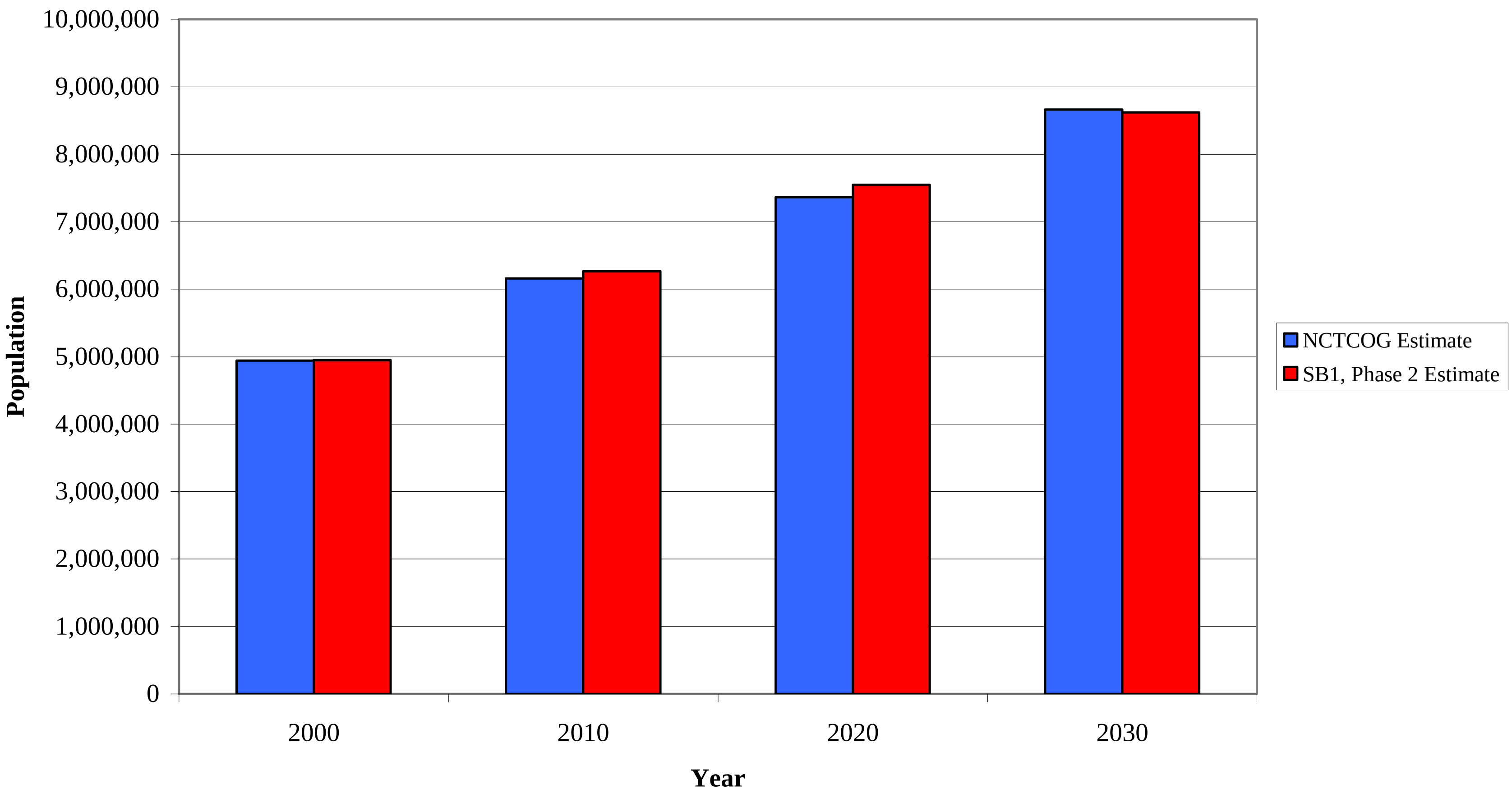
Projected 2060 Population

Figure 2.7
Projected 2000-2060 Population Increase



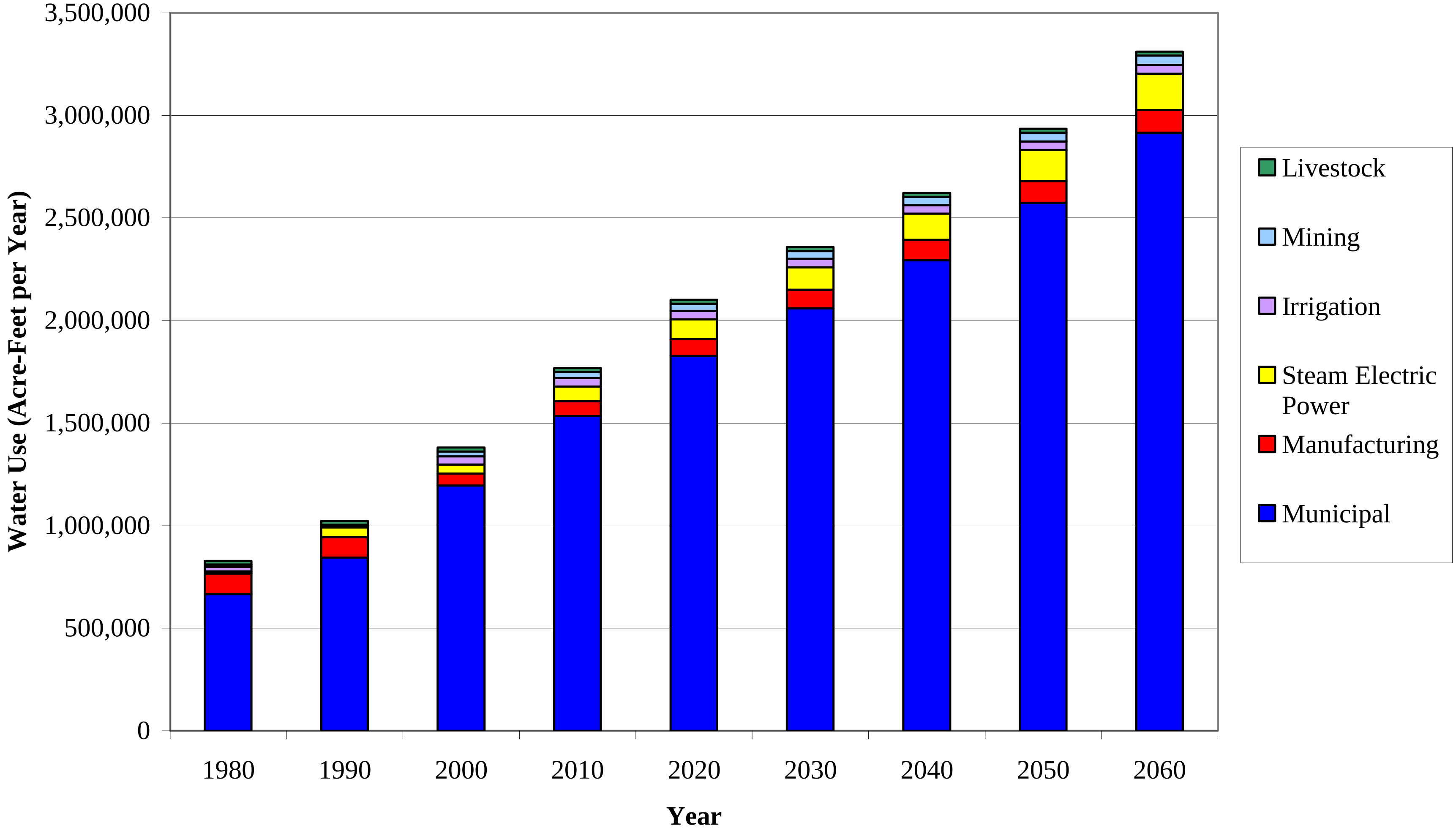
Projected Percent Increase 2000 - 2060

Figure 2.8
Comparison of Population Projections
2000-2030



Note: Nine counties included in the population comparison are Collin, Dallas, Denton, Ellis, Kaufman, Parker, Rockwall, Tarrant, and Wise.

Figure 2.9
Historical and Adopted Projections for Water Use by Category in Region C



2.3 Water Demand Projections

Basis for Water Demand Projections

The water demand projections presented in this section are based on per capita dry-year water use and the adopted population projections from the previous section. Per capita water use is determined by comparing available data regarding water use and population. Public water systems and industries report water usage annually in the Texas Water Development Board (TWDB) Survey of Ground and Surface Water Use [(9)]. The U.S. Census Bureau provided population data for Region C cities in 1980, 1990 and 2000. This information is supplemented by additional population data gathered from the State Data Center.

Methodology for Water Demand Projections

The TWDB draft per capita municipal water demand projections [(10)] were based on per capita water use in the year 2000, and were modified to include water savings from plumbing code requirements for low-flow fixtures. These data - including adopted population projections, draft per capita water usage, and draft annual water usage - were mailed to each WUG, along with a questionnaire. (Questionnaires are included in Appendix E.) In all, 310 surveys were mailed to Region C WUGs, with a 68 percent response rate. Of those that responded with regard to the per capita water usage, 78 percent either agreed with the draft projections or had no comment; 18 percent considered the draft projections to be too low; and 4 percent considered the draft projections to be too high. Additionally, 16 percent thought that the population projections were too low and 7 percent thought that they were too high. In some cases, phone calls and personal interviews were held to clarify comments and solicit more detailed information.

In the Region C revisions to the TWDB draft per capita use projections, population estimates for years 1981-1989 and 1991-1999 were corrected based on census data from 1980, 1990 and 2000. Census data and the corrected population estimates were then compared with recorded municipal water use to get a more accurate history of per capita water usage. For each WUG, the peak per capita water usage from the last 5 years was identified as the basis for future projections. Most often, the peak per capita water usage occurred during the years 1998-2000, which were dry years with high water use in Region C.

The data obtained from the questionnaires and interviews were combined, as appropriate, with historical trends and a general knowledge of urbanization and growth trends to project the future per capita water usage. The demographic classifications of Region C Counties are explained in the previous section. As urbanization occurs in Region C, history has shown that there is an increase in per capita water use. One explanation for this increasing trend is that as an area changes from rural to urban, the amount of commercial development increases. The influx of commercial development causes an increased demand for water without a corresponding increase in population base, increasing the per capita water use. Swimming pools and lawn watering also serve to increase the water demand as an area is developed. The actual per capita water demand is highly dependent on land use and the patterns of water use. Once an area has been fully developed, both commercially and residentially, the per capita water demand should remain relatively constant, with the exception of changing weather patterns. Plumbing code requirements for low flow fixtures will tend to decrease per capita municipal water use over time if other factors remain constant. Reductions due to low flow fixtures were included in the projections, with assumed total use of low flow fixtures by 2060. The per capita municipal water use projections are listed in Appendix F by water user group and county for Region C with and without the water savings from low-flow plumbing fixtures. Appendix F also includes the projected municipal water demands for Region C by water user group and county with and without the savings from low-flow plumbing fixtures. Finally, Appendix F includes a table explaining the changes made to the initial TWDB per capita water use for Region C water user groups.

Non-municipal water demand projections include irrigation, livestock, manufacturing, mining and steam-electric-power, and are reported on a county-wide basis. Projections of the non-municipal water demand relied on analysis of historical trends and TWDB draft projections. Where historical data appeared to be questionable, basic data was sought to confirm or correct the information. From the historical data, trends in water usage were identified and analyzed. When possible, additional information was sought from specific entities. TWDB’s ability to provide information on manufacturing and mining operations in Region C was restricted by state law at the time of review. To gather additional information regarding irrigation and livestock, questionnaires were mailed to the 16 County Agricultural Extension Agents.

Water User Group Projections

Table 2.2 presents the total historical and projected water demand for the Region C counties, as adopted by TWDB. The year 2060 projected water demand for Region C is 3,311,217 acre-feet per year. Table 2.3 and Figure 2.9 show the historical and projected water demand for the region by type of use. Additionally, Tables 2.4 through 2.19 show the historical and projected water demand for each Region C County by type of use. Figure 2.10 is a map of the year 2000 historical water usage and the 2060 projected water usage by county. Figure 2.11 is a map of the projected percent change in water demand between years 2000 and 2060 by county. The municipal water demand projections are listed by water user group and by county in Appendix G. Again, for convenience, Appendix G also lists the total projected municipal water demand for those water user groups that are split among multiple basins and counties.

Input for Future Planning

As required by TWDB guidance, the population and water demand projections were established relatively early in the planning process. As the planning effort proceeded, some water user groups and wholesale water providers offered additional input on population and demand projections. Table 2.20 lists the water suppliers that indicated that their population and/or water demands should be higher as well as those that indicated that demands should be lower. This input should be considered carefully in the next round of regional water planning. The entities should be contacted and projections should be adjusted where appropriate.

Wholesale Water Provider Projections

Table 2.21 shows the projected demand in Region C by Wholesale Water Provider, and Appendix H includes details on Wholesale Water Provider demand projections.

Table 2.2
Adopted County Water Demand Projections for Region C

County	Historical Year 2000 Demand (Acre-Feet)	Projected Water Demand (Acre-Feet per Year)					
		2010	2020	2030	2040	2050	2060
Collin	138,306	211,501	287,247	340,242	402,383	461,087	526,315
Cooke	7,270	9,854	10,644	11,468	12,083	13,119	14,093
Dallas	623,535	714,952	785,788	832,937	879,106	951,954	1,055,030
Denton	93,982	162,003	212,211	263,594	307,951	353,800	406,700
Ellis	25,469	46,567	59,550	70,648	83,300	98,595	116,967
Fannin	16,935	17,602	17,845	19,615	22,176	25,506	28,826
Freestone	17,107	23,035	25,658	29,277	33,642	38,965	45,446
Grayson	32,478	38,656	45,954	51,220	55,613	60,605	66,715
Henderson	11,244	13,649	15,512	17,467	19,439	22,008	25,263
Jack	2,600	2,793	6,530	7,196	7,979	8,947	10,129
Kaufman	15,523	31,936	47,306	54,886	62,777	72,079	83,724
Navarro	11,007	12,203	13,242	14,149	15,105	16,346	17,948
Parker	15,617	21,683	37,938	47,506	53,069	59,049	65,069
Rockwall	10,350	19,755	30,661	36,036	40,715	43,842	45,739
Tarrant	331,066	399,714	451,536	501,990	559,650	632,992	718,098
Wise	28,067	42,561	52,897	60,202	67,525	76,033	85,155
Region C Total	**1,380,556**	**1,768,464**	**2,100,519**	**2,358,433**	**2,622,513**	**2,934,927**	**3,311,217**

Table 2.3
Adopted Water Demand Projections for Region C by Type of Use

Use	Historical Year 2000 Demand (Acre-Feet)	Projected Water Demand (Acre-Feet per Year)					
		2010	2020	2030	2040	2050	2060
Municipal	1,196,452	1,534,703	1,828,831	2,060,118	2,294,491	2,574,265	2,915,773
Irrigation	40,153	40,776	40,966	41,165	41,373	41,596	41,831
Livestock	19,112	19,248	19,248	19,248	19,248	19,248	19,248
Manufacturing	58,289	72,026	81,273	90,010	98,486	105,808	110,597
Mining	23,479	30,240	34,561	37,350	40,206	43,155	45,920
Steam Electric Power	43,071	71,471	95,640	110,542	128,709	150,855	177,848
Region C Total	**1,380,556**	**1,768,464**	**2,100,519**	**2,358,433**	**2,622,513**	**2,934,927**	**3,311,217**

Table 2.4
Adopted Water Demand Projections for Collin County by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	2010	2020	2030	2040	2050	2060
Municipal	129,603	202,093	277,630	329,895	391,260	449,184	513,544
Irrigation	2,995	2,995	2,995	2,995	2,995	2,995	2,995
Livestock	884	884	884	884	884	884	884
Manufacturing	2,728	3,607	4,137	4,654	5,170	5,633	6,115
Mining	195	341	341	341	341	341	341
Steam-Electric-Power	1,901	1,581	1,260	1,473	1,733	2,050	2,436
Total	**138,306**	**211,501**	**287,247**	**340,242**	**402,383**	**461,087**	**526,315**

Table 2.5
Adopted Water Demand Projections for Cooke County by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	2010	2020	2030	2040	2050	2060
Municipal	4,998	6,918	7,662	8,450	9,029	10,033	10,969
Irrigation	0	444	444	444	444	444	444
Livestock	1,762	1,898	1,898	1,898	1,898	1,898	1,898
Manufacturing	221	273	306	335	364	389	421
Mining	289	321	334	341	348	355	361
Steam-Electric-Power	0	0	0	0	0	0	0
Total	**7,270**	**9,854**	**10,644**	**11,468**	**12,083**	**13,119**	**14,093**

Table 2.6
Adopted Water Demand Projections for Dallas County by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	2010	2020	2030	2040	2050	2060
Municipal	565,148	652,094	720,676	763,392	805,183	873,943	974,790
Irrigation	13,087	13,087	13,087	13,087	13,087	13,087	13,087
Livestock	482	482	482	482	482	482	482
Manufacturing	28,159	34,115	37,791	41,148	44,214	46,703	46,983
Mining	2,910	2,910	2,910	2,910	2,910	2,910	2,910
Steam-Electric-Power	13,749	12,264	10,842	11,918	13,230	14,829	16,778
Total	**623,535**	**714,952**	**785,788**	**832,937**	**879,106**	**951,954**	**1,055,030**

Table 2.7
Adopted Water Demand Projections for Denton County by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	2010	2020	2030	2040	2050	2060
Municipal	89,062	156,727	206,870	258,013	302,113	347,705	400,328
Irrigation	2,108	2,108	2,108	2,108	2,108	2,108	2,108
Livestock	1,235	1,235	1,235	1,235	1,235	1,235	1,235
Manufacturing	807	1,068	1,239	1,408	1,579	1,731	1,880
Mining	139	341	341	341	341	341	341
Steam-Electric-Power	631	524	418	489	575	680	808
Total	**93,982**	**162,003**	**212,211**	**263,594**	**307,951**	**353,800**	**406,700**

Table 2.8
Adopted Water Demand Projections for Ellis County by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	2010	2020	2030	2040	2050	2060
Municipal	19,820	27,008	33,645	41,126	49,430	59,502	71,808
Irrigation	583	583	583	583	583	583	583
Livestock	1,183	1,183	1,183	1,183	1,183	1,183	1,183
Manufacturing	3,049	3,466	3,670	3,841	3,987	4,089	3,912
Mining	90	90	90	90	90	90	90
Steam-Electric-Power	744	14,237	20,379	23,825	28,027	33,148	39,391
Total	**25,469**	**46,567**	**59,550**	**70,648**	**83,300**	**98,595**	**116,967**

Table 2.9
Adopted Water Demand Projections for Fannin County by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Municipal	5,349	6,487	7,125	8,451	10,471	13,145	15,665
Irrigation	4,608	4,608	4,608	4,608	4,608	4,608	4,608
Livestock	1,270	1,270	1,270	1,270	1,270	1,270	1,270
Manufacturing	58	73	82	90	98	105	114
Mining	12	12	12	12	12	12	12
Steam-Electric-Power	5,638	5,152	4,748	5,184	5,717	6,366	7,157
Total	**16,935**	**17,602**	**17,845**	**19,615**	**22,176**	**25,506**	**28,826**

Table 2.10
Adopted Water Demand Projections for Freestone County by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Municipal	2,471	3,173	3,472	3,610	3,734	3,887	4,069
Irrigation	8	8	8	8	8	8	8
Livestock	1,528	1,528	1,528	1,528	1,528	1,528	1,528
Manufacturing	0	0	0	0	0	0	0
Mining	96	116	126	132	138	144	149
Steam-Electric-Power	13,004	18,210	20,524	23,999	28,234	33,398	39,692
Total	**17,107**	**23,035**	**25,658**	**29,277**	**33,642**	**38,965**	**45,446**

Table 2.11
Adopted Water Demand Projections for Grayson County by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	2010	2020	2030	2040	2050	2060
Municipal	21,056	25,736	32,075	36,471	40,022	44,259	49,312
Irrigation	3,382	3,561	3,751	3,950	4,158	4,381	4,616
Livestock	1,297	1,297	1,297	1,297	1,297	1,297	1,297
Manufacturing	5,685	7,010	7,781	8,453	9,088	9,621	10,444
Mining	1,058	1,052	1,050	1,049	1,048	1,047	1,046
Steam-Electric-Power	0	0	0	0	0	0	0
Total	**32,478**	**38,656**	**45,954**	**51,220**	**55,613**	**60,605**	**66,715**

Table 2.12
Adopted Water Demand Projections for Henderson County (Region C) by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	2010	2020	2030	2040	2050	2060
Municipal	7,625	10,033	11,930	13,777	15,624	18,045	21,134
Irrigation	0	0	0	0	0	0	0
Livestock	854	854	854	854	854	854	854
Manufacturing	98	110	118	133	151	172	195
Mining	202	265	302	327	352	378	399
Steam-Electric-Power	2,465	2,387	2,308	2,376	2,458	2,559	2,681
Total	**11,244**	**13,649**	**15,512**	**17,467**	**19,439**	**22,008**	**25,263**

Table 2.13
Adopted Water Demand Projections for Jack County by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	2010	2020	2030	2040	2050	2060
Municipal	1,140	1,333	1,396	1,440	1,466	1,510	1,567
Irrigation	0	0	0	0	0	0	0
Livestock	1,025	1,025	1,025	1,025	1,025	1,025	1,025
Manufacturing	2	2	2	2	2	2	2
Mining	433	433	433	433	433	433	433
Steam-Electric-Power	0	0	3,674	4,296	5,053	5,977	7,102
Total	**2,600**	**2,793**	**6,530**	**7,196**	**7,979**	**8,947**	**10,129**

Table 2.14
Adopted Water Demand Projections for Kaufman County by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	2010	2020	2030	2040	2050	2060
Municipal	10,276	17,657	24,154	28,667	32,828	37,592	43,715
Irrigation	2,916	2,916	2,916	2,916	2,916	2,916	2,916
Livestock	1,545	1,545	1,545	1,545	1,545	1,545	1,545
Manufacturing	711	760	813	869	928	993	1,061
Mining	75	79	80	81	82	83	84
Steam-Electric-Power	0	8,979	17,798	20,808	24,478	28,950	34,403
Total	**15,523**	**31,936**	**47,306**	**54,886**	**62,777**	**72,079**	**83,724**

Table 2.15
Adopted Water Demand Projections for Navarro County by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	2010	2020	2030	2040	2050	2060
Municipal	8,426	9,399	10,282	11,049	11,866	12,984	14,444
Irrigation	0	0	0	0	0	0	0
Livestock	1,543	1,543	1,543	1,543	1,543	1,543	1,543
Manufacturing	949	1,172	1,328	1,468	1,607	1,730	1,872
Mining	89	89	89	89	89	89	89
Steam-Electric-Power	0	0	0	0	0	0	0
Total	**11,007**	**12,203**	**13,242**	**14,149**	**15,105**	**16,346**	**17,948**

Table 2.16
Adopted Water Demand Projections for Parker County by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	2010	2020	2030	2040	2050	2060
Municipal	12,621	18,498	30,052	38,735	43,242	47,970	52,470
Irrigation	422	422	422	422	422	422	422
Livestock	1,856	1,856	1,856	1,856	1,856	1,856	1,856
Manufacturing	607	779	879	974	1,068	1,150	1,248
Mining	75	98	112	122	132	142	150
Steam-Electric-Power	36	30	4,617	5,397	6,349	7,509	8,923
Total	**15,617**	**21,683**	**37,938**	**47,506**	**53,069**	**59,049**	**65,069**

Table 2.17
Adopted Water Demand Projections for Rockwall County by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	2010	2020	2030	2040	2050	2060
Municipal	9,046	18,446	29,349	34,721	39,397	42,521	44,415
Irrigation	1,125	1,125	1,125	1,125	1,125	1,125	1,125
Livestock	131	131	131	131	131	131	131
Manufacturing	15	20	23	26	29	32	35
Mining	33	33	33	33	33	33	33
Steam-Electric-Power	0	0	0	0	0	0	0
Total	**10,350**	**19,755**	**30,661**	**36,036**	**40,715**	**43,842**	**45,739**

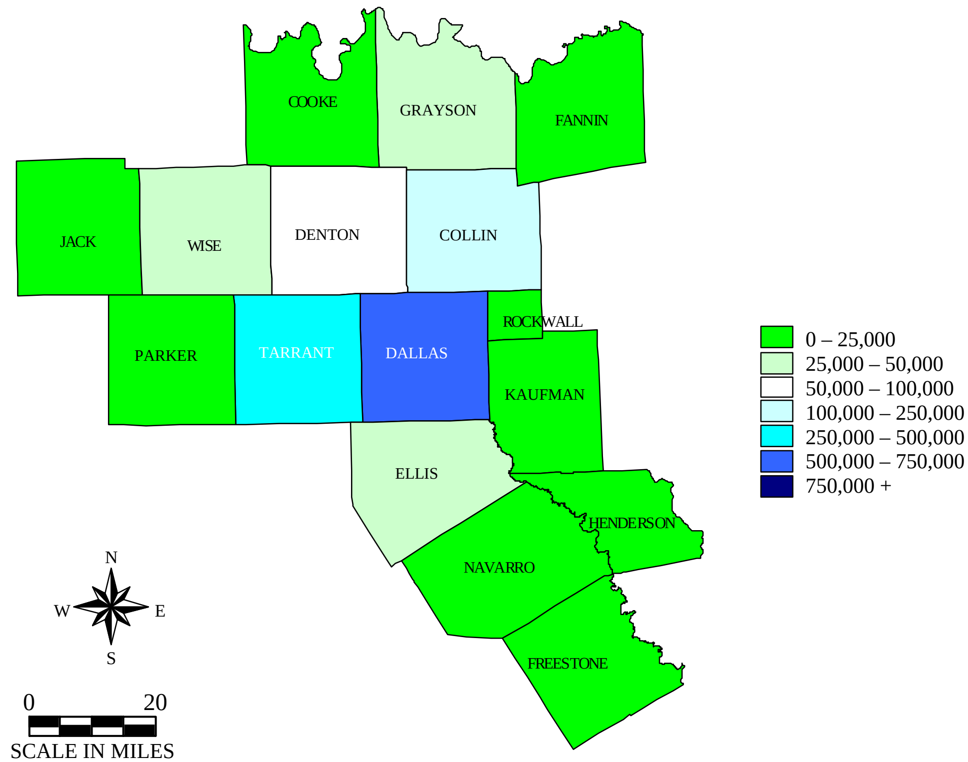
Table 2.18
Adopted Water Demand Projections for Tarrant County by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	2010	2020	2030	2040	2050	2060
Municipal	303,194	368,645	417,969	464,453	517,871	587,070	668,255
Irrigation	8,417	8,417	8,417	8,417	8,417	8,417	8,417
Livestock	803	803	803	803	803	803	803
Manufacturing	13,407	17,258	20,444	23,630	26,924	29,919	32,457
Mining	342	433	484	519	554	589	616
Steam-Electric-Power	4,903	4,158	3,419	4,168	5,081	6,194	7,550
Total	**331,066**	**399,714**	**451,536**	**501,990**	**559,650**	**632,992**	**718,098**

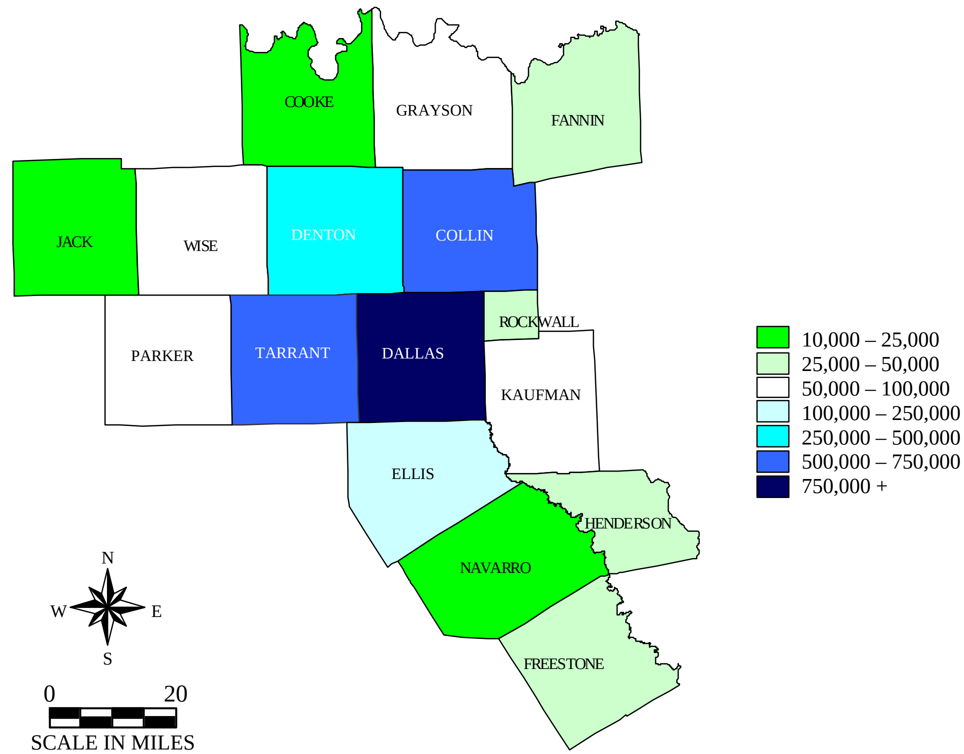
Table 2.19
Adopted Water Demand Projections for Wise County by Type of Use

Type of Use	Historical (Acre-Feet)	Projected (Acre-Feet per Year)					
	2000	2010	2020	2030	2040	2050	2060
Municipal	6,617	10,456	14,544	17,868	20,955	24,915	29,288
Irrigation	502	502	502	502	502	502	502
Livestock	1,714	1,714	1,714	1,714	1,714	1,714	1,714
Manufacturing	1,793	2,313	2,660	2,979	3,277	3,539	3,858
Mining	17,441	23,627	27,824	30,530	33,303	36,168	38,866
Steam-Electric-Power	0	3,949	5,653	6,609	7,774	9,195	10,927
Total	**28,067**	**42,561**	**52,897**	**60,202**	**67,525**	**76,033**	**85,155**

Figure 2.10
Region C Water Use

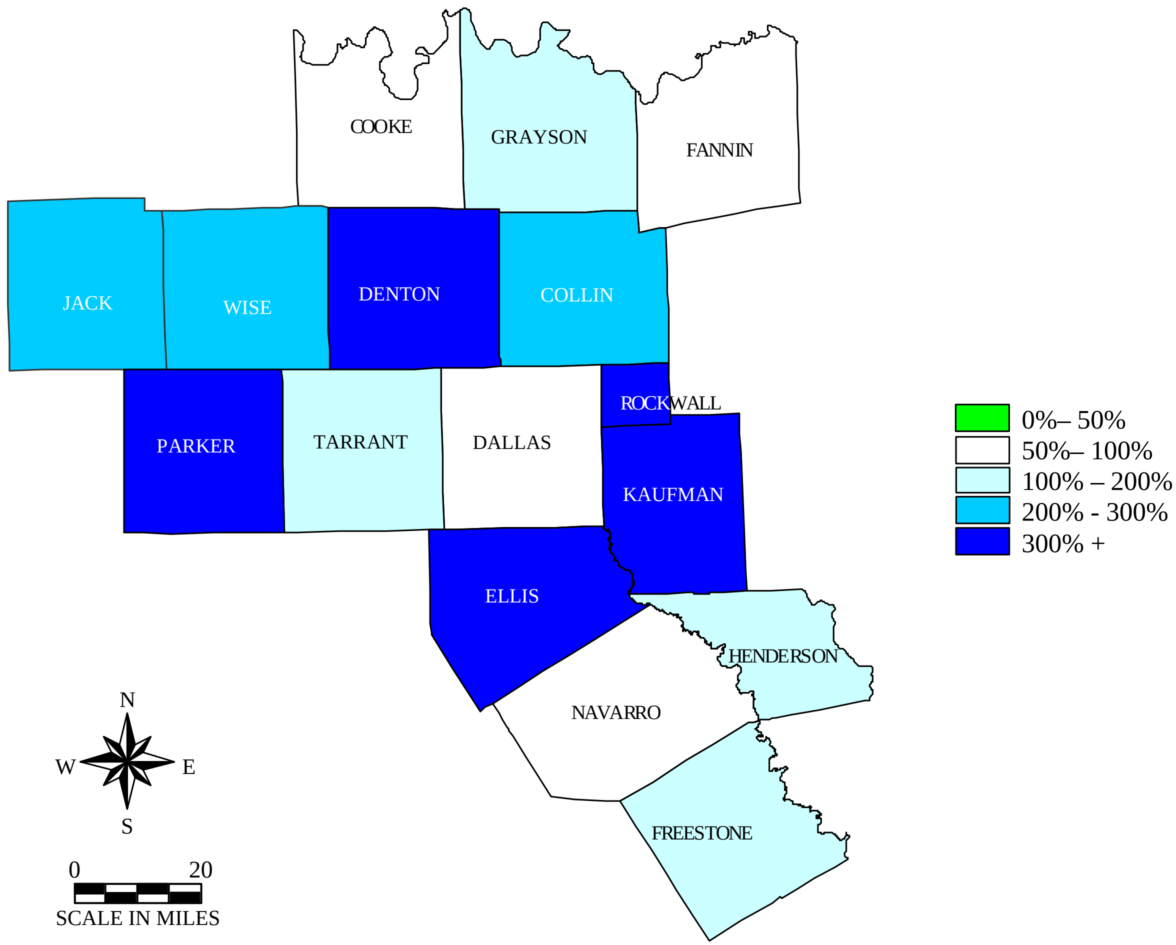


Historical 2000 Water Demand (Acre-Feet)



Projected 2060 Water Demand (Acre-Feet)

Figure 2.11
Projected 2000-2060 Water Use Increase



Projected Percent Increase 2000 - 2060

Table 2.20
Region C Entities That Requested Adjustments to Population and/or Demand Projections

Entity	Population		Demand	
	Entity Requested Higher Projections	Entity Requested Lower Projections	Entity Requested Higher Projections	Entity Requested Lower Projections
Able Springs WSC	x			
Allen	x			
Argyle WSC	x			
Athens	x			
Bedford		x		
Blue Mound		x		
Blue Ridge	x			
Carrollton		x		
Cash SUD	x			
Celina	x			
Collinsville	x			
Combine WSC		x		
Community WSC	x			
Coppell		x		
Dallas		x		x
Double Oak		x		
Ennis	x			
Everman		x		
Fairfield	x		Industrial	
Fairview	x			
Fannin	x			
Flo Community WSC		x		
Forest Hill		x		
Forney		x		
Frisco				Municipal
Gainesville	x			
Garland		x		
Gastonia-Scurry WSC	x			
Grand Prairie		x		
Grayson County			Livestock	Irrigation
Greater Texoma Utility Authority	x			

Table 2.20, Continued

Entity	Population		Demand	
	Entity Requested Higher Projections	Entity Requested Lower Projections	Entity Requested Higher Projections	Entity Requested Lower Projections
Gunter Rural WSC	x		Municipal	
Henderson County			Livestock	
Hickory Creek SUD	x			
High Point WSC	x		x	
Honey Grove	x			
Howe	x			
Hudson Oaks		x		
Hurst			Municipal	
Jacksboro	x		Municipal	
Johnson County SUD	x		Municipal	
Josephine	x			
Kaufman	x			
Lavon WSC	x		x	
Town of Little Elm	x			
Log Cabin		x		
Lucas		x		
McKinney	x			
McLendon - Chisholm	x			
MacBee SUD	x			
Mansfield	x			
Mesquite	x			
Mineral Wells	x			
Mountain Peak WSC	x			
Muenster	x			
North Collin WSC	x			
Pilot Point	x			
Plano		x		x
Prosper	x			
River Oaks		x		
Rockwall County-Other	x		x	
Rowlett		x		
Saginaw	x		x	
Seagoville		x		

Table 2.20, Continued

Entity	Population		Demand	
	Entity Requested Higher Projections	Entity Requested Lower Projections	Entity Requested Higher Projections	Entity Requested Lower Projections
Southmayd	x			
Springtown	x		Municipal	
Talty	x		x	
Trinity River Authority			x	x
Trophy Club MUD #1		x		
Upper Trinity Regional Water District	x			
Waxahachie	x			
West Wise Rural WSC	x			
Wylie	x		Municipal	
Total	**47**	**21**	**15**	**5**

Table 2.21
Projected Demands Placed on Wholesale Water Providers

Wholesale Water Provider	Projected Demand (Acre-Feet per Year)					
	2010	2020	2030	2040	2050	2060
City of Cedar Hill	9,089	10,083	11,839	13,192	14,460	15,519
City of Corsicana	10,690	11,685	12,571	13,501	14,739	16,338
City of Dallas (Dallas Water Utilities)	641,065	709,097	755,366	819,287	929,052	1,075,359
City of Denton	30,968	41,279	51,091	59,846	73,540	100,331
City of Ennis	6,336	7,810	9,690	11,239	13,167	15,625
City of Forney	12,934	22,407	24,035	25,590	27,188	28,984
City of Fort Worth	235,183	281,032	328,722	385,458	463,960	556,258
City of Gainesville	3,808	4,938	5,601	6,797	7,342	7,980
City of Garland	55,859	65,419	68,279	70,715	73,055	73,300
City of Mansfield	17,989	24,059	29,521	35,006	38,669	39,128
City of Midlothian	8,251	9,984	13,009	14,635	16,104	16,819
City of North Richland Hills	16,278	17,773	18,810	19,441	19,948	20,394
City of Rockwall	10,253	17,300	21,780	24,419	25,349	25,732
City of Seagoville	3,209	3,795	4,297	4,817	5,381	6,050
City of Terrell	5,279	6,030	6,685	7,126	7,620	8,388
City of Waxahachie	8,688	9,179	11,405	14,206	17,817	22,436

Table 2.21, Continued

Wholesale Water Provider	Projected Demand (Acre-Feet per Year)					
	2010	2020	2030	2040	2050	2060
City of Weatherford	6,039	13,878	15,333	16,532	17,820	19,353
Athens Municipal Water Authority	5,607	6,125	6,743	7,444	8,360	9,492
Dallas County Park Cities MUD	11,541	11,637	11,681	11,685	11,728	11,802
East Cedar Creek FWSD	3,741	4,479	5,221	5,963	6,923	8,152
Greater Texoma Utility Authority	31,544	23,780	31,977	42,957	55,757	72,956
Lake Cities MUA	2,065	2,739	3,120	3,507	4,032	4,634
Mustang SUD	1,909	3,543	5,123	7,316	10,097	12,387
North Texas Municipal Water District	371,170	482,856	567,856	650,027	722,158	799,386
Parker County Utility District #1	155	1,641	1,866	2,048	2,265	2,541
Rockett SUD	5,913	7,379	7,865	9,243	11,059	13,363
Sabine River Authority	486,594	485,226	483,857	482,490	481,121	479,752
Sulphur River Water District	23,406	23,657	23,838	23,951	23,861	23,848
Tarrant Regional Water District	428,966	518,976	595,992	678,304	779,509	893,510
Trinity River Authority	166,141	228,644	264,679	271,339	297,194	302,644
Upper Neches Municipal Water Authority	207,878	207,247	206,618	205,989	205,362	204,736
Upper Trinity Regional Water Dist.	31,769	56,353	80,904	109,456	136,932	155,831
Walnut Creek SUD	3,401	4,805	5,941	7,027	8,178	9,571
West Cedar Creek MUD	2,763	3,957	4,961	5,886	7,074	8,570
Wise County WSD	1,708	2,091	2,837	3,635	4,686	5,501

Notes: a. The projected demands include demands for potential future customers.

b. Demands for the Sabine River Authority are demands only on the Upper Basin Reservoirs. Demands for the Lower Basin are addressed in the East Texas Regional Water Plan.

c. Dallas Water Utilities has independently developed long-range water supply demands, and these demands differ slightly from the Region C water demands.

CHAPTER 2
LIST OF REFERENCES

(1) United States Census Bureau: Census 2000 Data for the State of Texas; Population by County, Population by Place, [Online], Available URL: http://www.census.gov/census2000/states/tx.html, May 2005.

(2) Texas Water Development Board: Historical Water Use Data files, Austin, May 2003 through November 2004.

(3) Dallas Morning News: *1998-99 Texas Almanac*, Dallas, 1997.

(4) Texas Water Development Board: Draft County Population Projections, Austin, March 2002.

(5) Texas Water Development Board: Draft Water User Group Population Projections, Austin, July 2002.

(6) North Central Texas Council of Governments: 2000 Current Population Estimates, Arlington, [Online], Available URL: http://www.nctcog.org/ris/population/index.html, 2004.

(7) North Central Texas Council of Governments: North Central Texas GIS Data Clearinghouse, Arlington, [Online], Available URL: http://gis.nctcog.org/geodata/, 2004.

(8) Freese and Nichols, Inc., Alan Plummer Associates, Inc., Chiang, Patel & Yerby, Inc., and Cooksey Communications, Inc.: *Region C Water Plan*, prepared for the Region C Water Planning Group, Fort Worth, January 2001.

(9) Texas Water Development Board: Annual Surveys of Ground and Surface Water Use, Austin, various dates.

(10) Texas Water Development Board: Draft Water Use Projections, Austin, December 2002.

3. Analysis of Water Supply Currently Available to Region C

This section gives an overall summary of the water supplies available to Region C. Appendix I includes further details on the development of this information. Under Senate Bill One planning guidelines, each region is to identify currently available water supplies to the region by source and user. The supplies available by source are based on the supply available during drought of record conditions. For surface water reservoirs, this is generally the equivalent of firm yield supply or permitted amount (whichever is lower). For run-of-the-river supplies, this is the minimum supply available in a year over the historical record. Available groundwater supplies are defined by county and aquifer. Generally, groundwater supply is the supply available with acceptable long-term impacts to water levels. These impacts may vary with users and locations. Where applicable, groundwater conservation district rules are considered.

Currently available water supplies to users are those water supplies that have been permitted or contracted and that have infrastructure in place to transport and treat the water. Some water supplies that are permitted or contracted for use do not yet have the infrastructure in place. Connecting such supplies is considered a water management strategy for use of this water in the future, and water management strategies are discussed in Section 4 of this report.

3.1 Overall Water Supply Availability

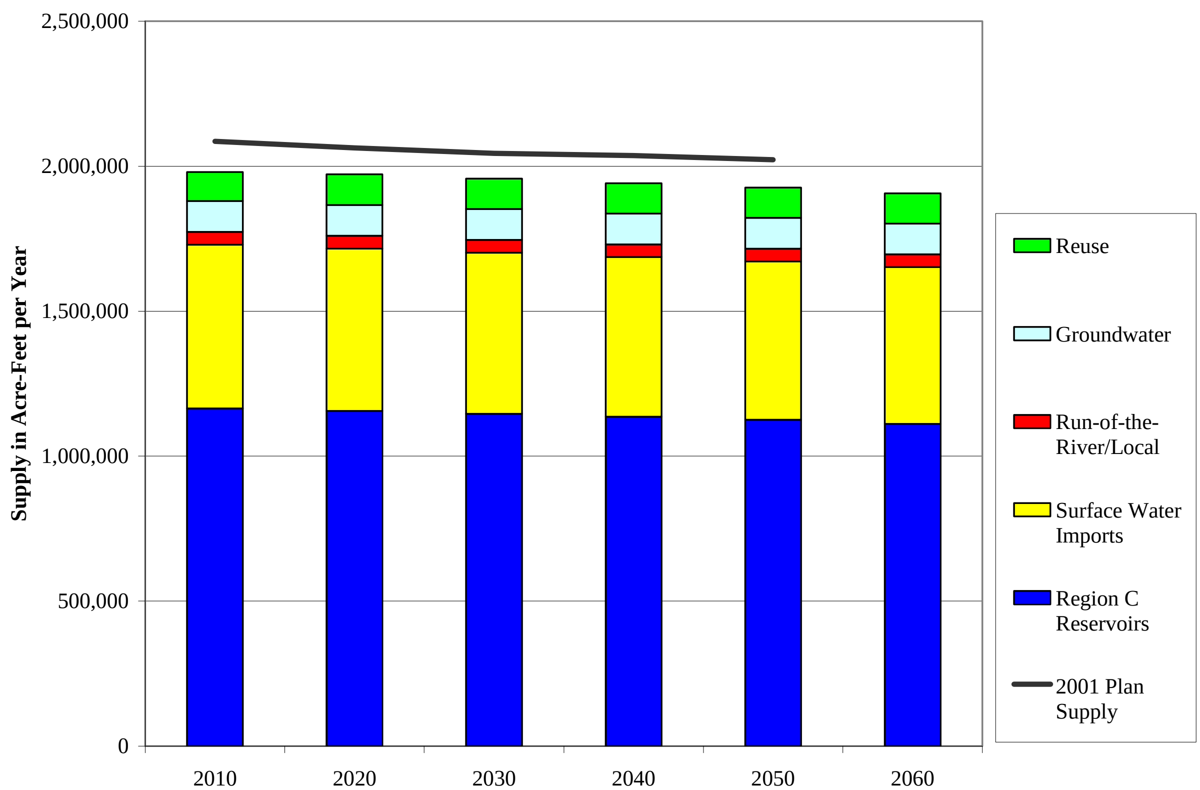
Table 3.1 and Figure 3.1 summarize the overall water supply availability in Region C, including both connected and unconnected water sources. Table 3.1 and Figure 3.1 show that:

- About 60 percent of the water supply available to Region C is from in-region reservoirs.
- Groundwater is approximately 5 percent of the overall supply available to Region C.
- Local supplies are only 2 percent of the overall supply available to Region C.
- Currently authorized reuse is about 4 percent of the overall supply available to Region C.
- Importation of water from other regions is over 28 percent of the water available to Region C.
- If all of the available supplies could be utilized, Region C would have 1,906,007 acre-feet per year available in 2060. The total water availability is less than in the 2001 *Region C Water Plan*[(1)] primarily due to the lower groundwater availability according to the Carrizo-Wilcox Groundwater Availability Model (GAM)[(2)]. Currently connected and available supplies are less than overall water supplies and are discussed in Section 3.2.

Table 3.1
Overall Water Supply Availability in Region C
- Values in Acre-Feet per Year -

Summary	2010	2020	2030	2040	2050	2060
Reservoirs in Region C	1,165,080	1,155,771	1,146,113	1,135,964	1,125,705	1,111,096
Local Irrigation	20,205	20,205	20,205	20,205	20,205	20,205
Other Local Supply	23,701	23,701	23,701	23,701	23,701	23,701
Surface Water Imports	564,302	560,292	555,492	550,689	545,898	541,117
Groundwater	106,460	106,460	106,460	106,460	106,460	106,460
Reuse	99,979	105,810	104,800	104,175	103,697	103,429
REGION C TOTAL	**1,979,727**	**1,972,240**	**1,956,770**	**1,941,194**	**1,925,666**	**1,906,007**

Figure 3.1
Overall Water Supply Availability in Region C



Surface Water Availability

Reservoirs. In its guidelines for Senate Bill One planning [3], the Texas Water Development Board (TWDB) requires that water availability for reservoirs be based on results of the TCEQ-approved Water Availability Models (WAMs) [4, 5, 6, 7, 8]. In Region C, most of the in-region reservoirs are located in the Trinity River Basin. Region C also uses water supplies originating in the Neches, Red, Sabine, and Sulphur River Basins.

The WAM models were developed for the purpose of reviewing and granting new surface water right permits. The assumptions in the WAM models are based on the legal interpretation of water rights, and in some cases do not accurately reflect current operations. For planning purposes, adjustments were made to the WAMs to better reflect current and future surface water conditions in the region. Generally, changes made to the WAM included:

- Assessment of reservoir sedimentation rates and calculation of area-capacity conditions for current (2000) and future (2060) conditions.
- Inclusion of subordination agreements.
- Inclusion of system operations where appropriate.
- Other specific corrections by river basin, as appropriate.

After evaluation, the Region C consultants decided that the yield figures from the Red River WAM were unreliable. Previous yield studies were used to establish yields for supplies in the Red River Basin [1]. According to the modified WAM results, the total available supply from Region C reservoirs is calculated at 1,165,080 acre-feet per year in 2010 and 1,111,096 acre-feet per year in 2060. The total available supply from imports from reservoirs in other regions is 564,302 acre-feet per year in 2010 and 541,117 acre-feet per year in 2060. Table 3.2 lists the reservoir water supplies available for use in Region C. More detail on the determination of available supplies from reservoirs is included in Appendix I.

Local Irrigation Supply. The local irrigation surface water supply is based on the availability of run-of-the-river water rights used in the WAMs. The total irrigation local supply in Region C is estimated at 20,205 acre-feet per year throughout the planning period. More detail on the determination of available supplies for run-of-the-river supply is shown in Table 3.3, as well as Appendix I.

Table 3.2
Surface Water Supplies Currently Available to Region C
- Values in Acre-Feet per Year -

Reservoir	2010	2020	2030	2040	2050	2060
Systems in Region C						
Lost Creek/Jacksboro System	1,440	1,440	1,440	1,440	1,440	1,440
West Fork System (TRWD)	108,500	107,000	105,500	104,000	102,500	101,000
Elm Fork/Lewisville/Ray Roberts (Dallas)	191,729	189,705	187,681	185,657	183,633	181,609
Grapevine (Dallas)	7,250	6,800	6,350	5,900	5,450	5,000
Subtotal of Systems in Region C	**308,919**	**304,945**	**300,971**	**296,997**	**293,023**	**289,049**
Reservoirs in Region C						
Cedar Creek	175,000	175,000	175,000	175,000	175,000	175,000
Richland-Chambers (TRWD)	210,000	210,000	210,000	210,000	210,000	205,650
Richland-Chambers (Corsicana))	12,625	12,500	12,375	12,250	12,125	12,000
Moss	4,500	4,500	4,500	4,500	4,500	4,500
Lake Texoma (Texas' Share – NTMWD)	77,300	77,300	77,300	77,300	77,300	77,300
Lake Texoma (Texas' Share – GTUA)	25,000	25,000	25,000	25,000	25,000	25,000
Lake Texoma (Texas' Share – Denison)	24,400	24,400	24,400	24,400	24,400	24,400
Lake Texoma (Texas' Share – TXU)	10,000	10,000	10,000	10,000	10,000	10,000
Lake Texoma (Texas' Share – RRA)	2,000	2,000	2,000	2,000	2,000	2,000
Randell	5,280	5,280	5,280	5,280	5,280	5,280
Valley	0	0	0	0	0	0
Bonham	5,340	5,340	5,340	4,850	4,250	3,650
Ray Roberts (Denton)	20,445	19,882	19,319	18,756	18,193	17,630
Lewisville (Denton)	7,702	7,507	7,313	7,119	6,924	6,730

Table 3.2, Continued

Reservoir	2010	2020	2030	2040	2050	2060
Benbrook	6,834	6,834	6,834	6,834	6,834	6,834
Weatherford	2,750	2,600	2,450	2,300	2,150	2,000
Grapevine (PCMUD)	16,167	15,533	14,900	14,267	13,633	13,000
Grapevine (Grapevine)	1,833	1,767	1,700	1,633	1,567	1,500
Arlington	8,333	8,267	8,200	8,133	8,067	8,000
Joe Pool	15,333	14,267	13,200	12,133	11,067	10,000
Mountain Creek	6,400	6,400	6,400	6,400	6,400	6,400
North	0	0	0	0	0	0
Lake Ray Hubbard (Dallas)	60,367	60,033	59,700	59,367	59,033	58,700
White Rock	5,083	4,267	3,450	2,633	1,817	1,000
Terrell	2,283	2,267	2,250	2,233	2,217	2,200
Clark	139	139	139	139	139	139
Bardwell	8,567	8,153	7,740	7,327	6,913	6,500
Waxahachie	2,667	2,573	2,480	2,387	2,293	2,200
Forest Grove	8,583	8,567	8,550	8,533	8,517	8,500
Trinidad City Lake	500	500	500	500	500	500
Trinidad	3,067	3,033	3,000	2,967	2,933	2,900
Navarro Mills	19,400	18,800	17,850	16,900	15,950	15,000
Halbert	0	0	0	0	0	0
Fairfield	1,567	1,433	1,300	1,167	1,033	900
Bryson	0	0	0	0	0	0
Mineral Wells	2,508	2,495	2,483	2,470	2,458	2,445
Teague City Lake	189	189	189	189	189	189
Lake Lavon	104,000	104,000	104,000	104,000	104,000	104,000
Muenster	0	0	0	0	0	0
Subtotal of Individual Reservoirs in Region C	**856,161**	**850,826**	**845,142**	**838,967**	**832,682**	**822,047**
Subtotal of Reservoirs in Region C	**1,165,080**	**1,155,771**	**1,146,113**	**1,135,964**	**1,125,705**	**1,111,096**
Imports						
Chapman (UTRWD)	49,976	49,150	48,324	47,498	46,672	45,843
Chapman (Irving)	47,168	46,388	45,608	44,828	44,048	43,268
Chapman (UTRWD)	14,068	13,835	13,602	13,369	13,136	12,905
Tawakoni (Terrell)	9,718	9,646	9,573	9,501	9,428	9,356
Tawakoni (Dallas)	183,619	182,251	180,882	179,515	178,146	176,777
Fork (Dallas)	120,000	119,943	119,095	118,248	117,400	116,551
Palestine (Dallas)	112,080	111,460	110,840	110,220	109,600	108,980
Lake Livingston (TXU)	20,000	20,000	20,000	20,000	20,000	20,000
Lake Aquilla	264	276	285	295	309	329

Table 3.2, Continued

Imports	2010	2020	2030	2040	2050	2060
Lake Athens (Athens MWA)	3,908	3,856	3,804	3,751	3,699	3,647
Lake Granbury	231	231	231	231	231	231
Vulcan Materials (from BRA-Possum Kingdom)	2,000	2,000	2,000	2,000	2,000	2,000
Parker County (from Lake Palo Pinto)	1,270	1,257	1,248	1,234	1,230	1,230
Subtotal of Imports	**564,302**	**560,292**	**555,492**	**550,689**	**545,898**	**541,117**
TOTAL	**1,729,382**	**1,716,064**	**1,701,604**	**1,686,653**	**1,671,603**	**1,652,213**

Table 3.3
Run-of-the-River and Other Local Water Supplies

County	Run-of-the-River Supply (Acre-Feet per Year)				Other Local Supply (Acre-Feet per Year)	
	Irrigation	Manufacturing	Mining	Municipal	Livestock	Mining
Collin	408	0	0	0	1,002	195
Cooke	23	0	0	0	1,187	237
Dallas	791	368	0	0	712	1,525
Denton	0	0	0	0	935	103
Ellis	3	0	0	0	1,688	0
Fannin	14,758	0	72	69	1,583	0
Freestone	87	0	0	41	1,043	120
Grayson	2,394	30	0	0	1,683	0
Henderson	415	0	0	0	341	0
Jack	110	0	0	0	1,665	370
Kaufman	64	0	0	0	1,622	86
Navarro	226	0	0	252	1,603	0
Parker	239	0	0	33	1,922	20
Rockwall	0	0	0	0	168	33
Tarrant	549	959	0	0	442	342
Wise	139	0	133	0	1,117	0
TOTAL	**20,205**	**1,357**	**205**	**395**	**18,713**	**3,031**

Other Local Supply. Other local supply includes run-of-the-river supplies associated with water rights and used for municipal, manufacturing, mining, and power generation. It also includes local surface water supplies used for mining and livestock. For livestock and mining supplies that are not associated with water rights (such as stock ponds and privately-owned water for mining), supplies are based on the historical use over the past 10 years [9]. The total other local supply available in Region C is 23,701 acre-feet per year. More detail on the determination of available other local supplies is included in Table 3.3 and Appendix I.

Reuse. The reuse supply considered as available to the region is from existing projects based on current permits, authorizations, and facilities. Categories of reuse include (1) currently permitted and operating indirect reuse projects, in which water is reused after being returned to the stream; (2) existing indirect reuse for industrial purposes (including recycled water for mining use); and (3) authorized direct reuse projects for which facilities are already developed. The specific reuse projects included are discussed in Appendix I.

The currently available supply for Region C includes indirect and direct reuse projects. The North Texas Municipal Water District (NTMWD) currently discharges nearly 36,000 acre-feet per year of treated wastewater into Lake Lavon for subsequent reuse. Other reuse projects include projects sponsored by the Trinity River Authority (TRA) and the Upper Trinity Regional Water District (UTRWD), as well as several reuse projects for irrigation, specifically golf courses. These projects were included in the 2001 Regional Water plan. Significant new reuse projects since the last plan include:

- Direct reuse of Garland effluent for new steam electric power plant in Kaufman County. (This water use is provided through sales to the city of Forney)
- Direct reuse of wastewater for steam electric power in Ellis County
- Indirect reuse of return flows to Grapevine Lake by the City of Grapevine.

Other new reuse supplies include several direct reuse projects for golf course irrigation and a small amount of manufacturing reuse.

It is likely that reuse will increase dramatically in Region C over the next 50 years, but proposed and potential direct reuse projects are not included as currently available supplies. There are a number of reuse projects being considered as potentially feasible management strategies as part of this planning process. Recommended water management strategies for reuse are discussed in Chapter 4 of this report.

Table 3.4 summarizes the currently available reuse supplies by county in Region C. The total available supply from reuse in Region C by 2010 is 99,979 acre-feet per year, increasing to 103,429 acre-feet per year in 2060.

Table 3.4
Currently Permitted and Available Reuse Supplies by County
- Values in Acre-Feet per Year -

County	2010	2020	2030	2040	2050	2060
Collin						
- NTMWD Lake Lavon	35,941	35,941	35,941	35,941	35,941	35,941
- Other	2,227	2,227	2,227	2,227	2,227	2,227
Cooke	9	9	9	9	9	9
Dallas	8,581	8,581	8,581	8,581	8,581	8,581
Denton	12,907	13,003	13,084	13,156	13,236	13,317
Ellis	8,361	8,492	8,492	8,492	8,492	8,492
Fannin	0	0	0	0	0	0
Freestone	0	0	0	0	0	0
Grayson	0	0	0	0	0	0
Henderson	32	32	32	32	32	32
Jack	412	412	411	411	410	410
Kaufman	9,555	16,358	16,527	16,716	16,959	17,259
Navarro	0	0	0	0	0	0
Parker	215	215	215	215	215	215
Rockwall	784	784	784	784	784	784
Tarrant	5,025	5,682	6,345	6,969	7,576	8,101
Wise	15,930	14,074	12,152	10,643	9,236	8,061
TOTAL	**99,979**	**105,810**	**104,800**	**104,175**	**103,697**	**103,429**

Groundwater Availability

The TWDB guidelines state that Groundwater Availability Models (GAMs) [2, 10, 11] are to be used to determine available groundwater supplies unless more site-specific information is available. The GAM program, which was overseen by the TWDB, has completed groundwater models for most of the major aquifers in Texas.

The GAMs include numerical representations of the groundwater flow through the respective aquifers. Rainfall, evaporation, evapotranspiration, and surface runoff are included in the models. The models also include recharge and historical groundwater pumpage information. While the input elements of the GAMs are similar, different assumptions have been made for different GAMs, and these assumptions can cause significant differences in estimates of available water supply.

Groundwater supplies in Region C are obtained from two major aquifers (Carrizo-Wilcox and Trinity), three minor aquifers (Woodbine, Nacatoch, and Queen City), and locally undifferentiated sediments, referred to as "other aquifer". The GAMs for the Carrizo-Wilcox aquifer [2, 10] and the Trinity-Woodbine aquifer [11] have been completed. The GAMs for the Queen City and Nacatoch aquifers have not been finalized by the TWDB and are not available for the regions to use.

Carrizo-Wilcox Aquifer. Supplies from the Carrizo-Wilcox aquifer are available in Freestone, Henderson, and Navarro counties in Region C. The TWDB developed three different models to cover the Carrizo-Wilcox aquifer. The three Region C counties are included in both the Northern Carrizo-Wilcox GAM [10] and the Central Carrizo-Wilcox GAM [2].

Region C requested that the TWDB run both models, and the two models resulted in significantly different water availabilities. Following discussions with the TWDB regarding the reasons for the differing results, the Region C Water Planning Group assumed that the Central Carrizo-Wilcox GAM better simulated the aquifer in Region C. After discussing the results with the groundwater conservation districts in the region, Region C assumed that the currently available groundwater supply from the Carrizo-Wilcox aquifer was equivalent to twice the current use from the aquifer in Freestone, Henderson, and Navarro counties. Table 3.5 shows the resulting groundwater availability by county to Region C from the Carrizo-Wilcox aquifer. As with reservoirs, this number represents the amount of water available from the aquifer, without considering limitations imposed by or current availability due to the capacity of wells and other facilities. The amount of groundwater currently available in Region C is discussed in Section 3.2.

Trinity and Woodbine Aquifers. The Northern Trinity-Woodbine GAM [11] covers the part of the Trinity and Woodbine aquifers located in Region C. The Woodbine aquifer is a separate aquifer from the Trinity aquifer, but the two are modeled together. The Woodbine overlies the Trinity aquifer. The Woodbine aquifer is in Collin, Dallas, Denton, Ellis, Fannin, Grayson, Kaufman, Navarro, and Parker counties in Region C. The Trinity aquifer is in Collin, Cooke, Dallas, Denton, Ellis, Fannin, Grayson, Jack, Navarro, Parker, Tarrant, and Wise counties in Region C. Most of the pumpage from the Trinity aquifer in Region C is from three layers: Paluxy, Hensel, and Hosston. To assess the groundwater availability to the region, the GAM model was run with current pumpage amounts for each layer over a 50-year period.

Under continued current pumping, it was found that the Woodbine aquifer would rebound in most areas in Region C, except for the eastern portion of Fannin County. Therefore, modeled pumpage was increased in all areas except eastern Fannin County to find the amount that could be used with acceptable drawdown levels. The amount of reliable supply considered to be available to Region C counties from the Woodbine aquifer is shown in Table 3.5.

The analysis for the Trinity aquifer found that under current pumping activity, the changes in water levels after 50 years resulted in significant rebounds as well as additional drawdowns, depending on the area. The greater drawdowns in the region were observed in the Paluxy layer. To reduce the drawdowns in the Paluxy layer, pumpage was reduced in Tarrant, Dallas, Ellis, and Johnson Counties. The amount of reliable supply from the Trinity aquifer that is considered available in Region C counties is shown in Table 3.5.

Groundwater Conservation Districts. Region C has two groundwater conservation districts, both of which are located in the area of the Carrizo-Wilcox aquifer. The Mid-East Texas Groundwater Conservation District includes Freestone County in Region C. The Neches and Trinity Valleys Groundwater Conservation District includes Henderson County in Region C. Both of these groundwater conservation districts were recently established by the Texas Legislature [(12, 13)].

Summary. In Region C, only the Northern Carrizo-Wilcox, Central Carrizo-Wilcox, and Northern Trinity/Woodbine GAMs are available for this cycle of regional water planning. For the aquifers not covered in those GAMs, available groundwater supplies are based on historical use [(9)]. The total available supply from groundwater in Region C is slightly over 106,000 acre-feet per year. More detail on the determination of available supplies from groundwater is included in Appendix I.

Table 3.5
Groundwater Supplies in Region C
- Values in Acre-Feet per Year -

Aquifer	County	2010	2020	2030	2040	2050	2060
Carrizo-Wilcox	Freestone	6,653	6,653	6,653	6,653	6,653	6,653
Carrizo-Wilcox	Henderson	5,370	5,370	5,370	5,370	5,370	5,370
Carrizo-Wilcox	Navarro	180	180	180	180	180	180
Carrizo-Wilcox Subtotal		**12,203**	**12,203**	**12,203**	**12,203**	**12,203**	**12,203**
Trinity	Collin	2,100	2,100	2,100	2,100	2,100	2,100
Trinity	Cooke	6,400	6,400	6,400	6,400	6,400	6,400
Trinity	Dallas	4,400	4,400	4,400	4,400	4,400	4,400
Trinity	Denton	10,400	10,400	10,400	10,400	10,400	10,400
Trinity	Ellis	4,000	4,000	4,000	4,000	4,000	4,000
Trinity	Fannin	700	700	700	700	700	700
Trinity	Grayson	9,400	9,400	9,400	9,400	9,400	9,400
Trinity	Jack	100	100	100	100	100	100
Trinity	Kaufman	0	0	0	0	0	0
Trinity	Navarro	0	0	0	0	0	0
Trinity	Parker	7,000	7,000	7,000	7,000	7,000	7,000
Trinity	Rockwall	0	0	0	0	0	0
Trinity	Tarrant	9,200	9,200	9,200	9,200	9,200	9,200
Trinity	Wise	4,400	4,400	4,400	4,400	4,400	4,400
Trinity Subtotal		**58,100**	**58,100**	**58,100**	**58,100**	**58,100**	**58,100**
Woodbine	Collin	2,500	2,500	2,500	2,500	2,500	2,500
Woodbine	Dallas	1,100	1,100	1,100	1,100	1,100	1,100
Woodbine	Denton	4,700	4,700	4,700	4,700	4,700	4,700
Woodbine	Ellis	4,400	4,400	4,400	4,400	4,400	4,400
Woodbine	Fannin	3,300	3,300	3,300	3,300	3,300	3,300
Woodbine	Grayson	12,100	12,100	12,100	12,100	12,100	12,100
Woodbine	Kaufman	200	200	200	200	200	200
Woodbine	Navarro	300	300	300	300	300	300
Woodbine	Parker	0	0	0	0	0	0
Woodbine	Tarrant	0	0	0	0	0	0
Woodbine Subtotal		**28,600**	**28,600**	**28,600**	**28,600**	**28,600**	**28,600**
Nacatoch	Henderson, Kaufman, Navarro, & Rockwall	558	558	558	558	558	558
Queen City	Freestone & Henderson	873	873	873	873	873	873
Other	all	6,126	6,126	6,126	6,126	6,126	6,126
Minor Aquifers Subtotal		**7,557**	**7,557**	**7,557**	**7,557**	**7,557**	**7,557**
TOTAL		**106,460**	**106,460**	**106,460**	**106,460**	**106,460**	**106,460**

3.2 Currently Available Water Supplies

Table 3.6 and Figure 3.2 show the currently available water supplies in Region C by different source types. Table 3.7 shows the currently available supplies to water user groups by county. Currently available supplies are supplies that can be used with currently existing water rights, contracts, and facilities. They are less than the overall supplies available to the region because the facilities needed to use some supplies have not yet been developed. (Common constraints limiting currently available supplies include the availability and capacity of transmission systems, treatment plants, and wells.) The comparison of overall water supply availability and currently available water supplies for Region C shows the following:

- The total currently available supply in Region C for 2060 is 1,391,001 acre-feet per year, of which 1,379,284 acre-feet per year is available to users in Region C (a portion is used to supply customers in adjacent regions). This is 516,006 acre-feet per year less than the overall supply. The difference is due primarily to transmission and treatment plant capacity limitations. This includes 225,531 acre-feet per year of unconnected supplies for Dallas Water Utilities (Lake Fork Reservoir and Lake Palestine).
- The currently available supplies from in-region reservoirs, local sources, groundwater and current reuse are nearly fully allocated by 2060. Some of the differences can be attributed to sources that are not currently used for water supplies (White Rock Lake, Lake Mineral Wells and Forest Grove Reservoir).
- Groundwater supplies, which represent only 5 percent of the total available supply to the region, are nearly 90 percent utilized by current water users. The total amount of groundwater supply that is available for future development is only 13,663 acre-feet per year.
- Permitted surface water imports to Region C are shown to be more than 500,000 acre-feet per year in Table 3.1. Approximately half of these supplies are not currently connected to water supply systems. The connection of these supplies will be considered as water management strategies in Section 4.

Table 3.6
Currently Available Water Supplies to Water Users by Source
- Values in Acre-Feet per Year -

Category	2010	2020	2030	2040	2050	2060
Reservoirs in Region C	988,253	959,608	934,560	913,030	892,078	871,755
Local Irrigation	19,455	19,455	19,455	19,455	19,455	19,455
Other Local Supply	22,862	22,814	22,846	22,884	22,931	22,989
Surface Water Imports	318,917	315,245	311,094	306,566	302,496	299,254
Groundwater	93,813	93,308	92,826	92,819	92,816	92,797
Reuse	79,342	80,665	81,855	82,702	83,902	84,751
REGION C TOTAL	**1,522,642**	**1,491,095**	**1,462,636**	**1,437,456**	**1,413,678**	**1,391,001**

Figure 3.2
Currently Available Supplies to Region C Water Users

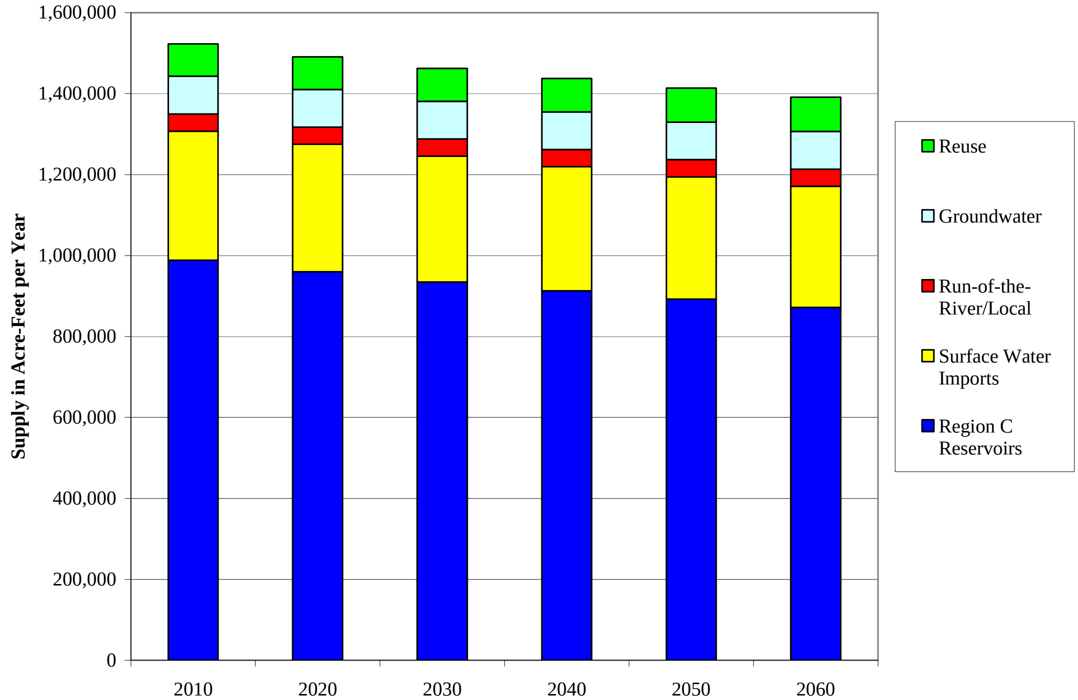


Table 3.7
Currently Available Supplies by County
- Values in Acre-Feet per Year -

County	2010	2020	2030	2040	2050	2060
Collin	151,022	159,887	160,145	163,170	165,153	168,031
Cooke	8,684	8,174	7,685	7,678	7,674	7,670
Dallas	534,587	508,062	489,326	472,256	456,491	445,723
Denton	137,250	142,695	150,283	153,531	155,652	150,289
Ellis	30,771	31,300	31,973	31,836	31,459	31,115
Fannin	36,802	36,806	36,812	36,809	36,810	36,640
Freestone	32,877	32,673	31,857	30,981	30,157	29,449
Grayson	44,530	44,605	44,647	44,685	44,714	44,743
Henderson	12,268	12,168	12,137	12,123	12,120	12,130
Jack	3,767	3,767	3,767	3,767	3,767	3,767
Kaufman	21,141	22,278	22,668	23,028	23,604	24,362
Navarro	13,814	13,744	13,669	13,610	13,539	13,489
Parker	22,956	30,241	33,212	32,835	32,287	31,355
Rockwall	14,100	17,109	17,306	17,339	17,022	16,223
Tarrant	411,060	382,114	364,255	352,865	343,374	336,339
Wise	38,384	36,923	34,194	31,902	29,786	27,959
Subtotal	**1,514,013**	**1,482,546**	**1,453,936**	**1,428,415**	**1,403,609**	**1,379,284**
Other Regions	8,629	8,549	8,700	9,041	10,069	11,717
TOTAL	**1,522,642**	**1,491,095**	**1,462,636**	**1,437,456**	**1,413,678**	**1,391,001**

3.3 Water Availability by Wholesale Water Provider (WWP)

As part of the Senate Bill One planning process, the Texas Water Development Board requires development of water availability for each designated wholesale water provider. A wholesale water provider is defined as "any person or entity, including river authorities and irrigation districts, that has contracts to sell more than 1,000 acre-feet of water wholesale in any one year during the five years immediately preceding the adoption of the last Regional Water Plan." [3] The planning groups are also required to designate any person or entity expected to contract to sell at least 1,000 acre-feet per year of wholesale water during the planning period as a WWP. There are 35 entities in Region C that qualify as wholesale water providers (17 cities, 2 river authorities, and 16 water districts). Twelve of the wholesale water providers provide a large amount of wholesale water supplies to a number of customers and are discussed below as regional wholesale water providers. The remaining 23 supply less water to fewer customers and are discussed as local wholesale water providers. The 12 regional wholesale water providers are:

- Dallas Water Utilities
- Tarrant Regional Water District
- North Texas Municipal Water District
- City of Fort Worth
- Sabine River Authority
- Trinity River Authority
- Upper Neches River Municipal Water Authority
- Upper Trinity Regional Water District
- Sulphur River Water District
- Dallas County Park Cities Municipal Utility District
- Greater Texoma Utility Authority
- City of Corsicana

The 23 local wholesale water providers include:

- City of Cedar Hill
- City of Denton
- City of Ennis
- City of Forney
- City of Gainesville
- City of Garland
- City of Mansfield

- City of Midlothian
- City of North Richland Hills
- City of Rockwall
- City of Seagoville
- City of Terrell
- City of Waxahachie
- City of Weatherford
- Athens Municipal Water Authority
- East Cedar Creek Freshwater Supply District
- Lake Cities Municipal Utility Authority
- Mustang Special Utility District
- Parker County Utility District #1
- Rockett Special Utility District
- Walnut Creek Special Utility District
- West Cedar Creek Municipal Utility District
- Wise County Water Supply District

3.4 Water Supplies Currently Available to Regional Wholesale Water Providers

Table 3.8 gives a summary of the supplies currently available to regional wholesale water providers serving Region C. As discussed in Section 3.2, currently available supplies are limited by existing physical facilities, including raw water transmission facilities, groundwater wells, and water treatment facilities (if needed).

Dallas Water Utilities

Figure 3.3 shows the currently available supply for Dallas Water Utilities (DWU). DWU's currently available supply sources include Lake Ray Hubbard, Lake Tawakoni (in Region D), the Ray Roberts/Lewisville Lake/Elm Fork System, and Dallas' share of Grapevine Lake. Lake Fork Reservoir (in Region D) and Lake Palestine (in Region I) are significant supply sources for DWU that are not currently connected to DWU's system. A transmission system from Lake Fork Reservoir is currently under construction and is scheduled to be completed by 2007. The estimated reliable supply for DWU from currently available sources (excluding Lake Fork Reservoir and Lake Palestine) is 443,525 acre-feet per year as of the year 2010 and 422,647 acre-feet per year in 2060.

Table 3.8
Currently Available Supplies to Regional Wholesale Water Providers in Region C

Provider	Source	Water Supply Currently Available (Acre-Feet per Year)					
		2010	2020	2030	2040	2050	2060
Dallas Water Utilities	Elm Fork/Ray Roberts Lake/Lewisville Lake	191,729	189,705	187,681	185,657	183,633	181,609
	Lake Ray Hubbard	60,367	60,033	59,700	59,367	59,033	58,700
	Lake Tawakoni	183,619	182,251	180,882	179,515	178,146	176,777
	Grapevine Lake	7,250	6,800	6,350	5,900	5,450	5,000
	Direct Reuse	561	561	561	561	561	561
	DWU Total	**443,525**	**439,350**	**435,174**	**431,000**	**426,823**	**422,647**
Tarrant Regional Water District	West Fork System [a]	98,975	98,150	97,325	96,500	95,675	94,850
	Benbrook Lake	6,834	6,834	6,834	6,834	6,834	6,834
	Cedar Creek Reservoir [a]	152,783	150,067	147,350	144,633	141,917	139,200
	Richland-Chambers Res. [a]	188,444	181,388	174,332	167,276	160,220	153,165
	TRWD Total	**447,036**	**436,439**	**425,841**	**415,243**	**404,646**	**394,049**
North Texas Municipal Water District	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
	Chapman Lake	49,976	49,150	48,324	47,498	46,672	45,843
	Wilson Creek Reuse	35,941	35,941	35,941	35,941	35,941	35,941
	Lake Bonham	5,340	5,340	5,340	4,850	4,250	3,650
	NTMWD Total	**272,557**	**271,731**	**270,905**	**269,589**	**268,163**	**266,734**
City of Fort Worth	TRWD Supplies	248,015	240,472	237,978	239,241	243,894	248,586
	Direct Reuse	897	897	897	897	897	897
	Fort Worth Total	**248,912**	**241,369**	**238,875**	**240,138**	**244,791**	**249,483**

Note: a. Tarrant Regional Water District operates the West Fork System, Cedar Creek Reservoir, and Richland-Chambers Reservoir on a safe yield basis, leaving a reserve at the end of the critical period.

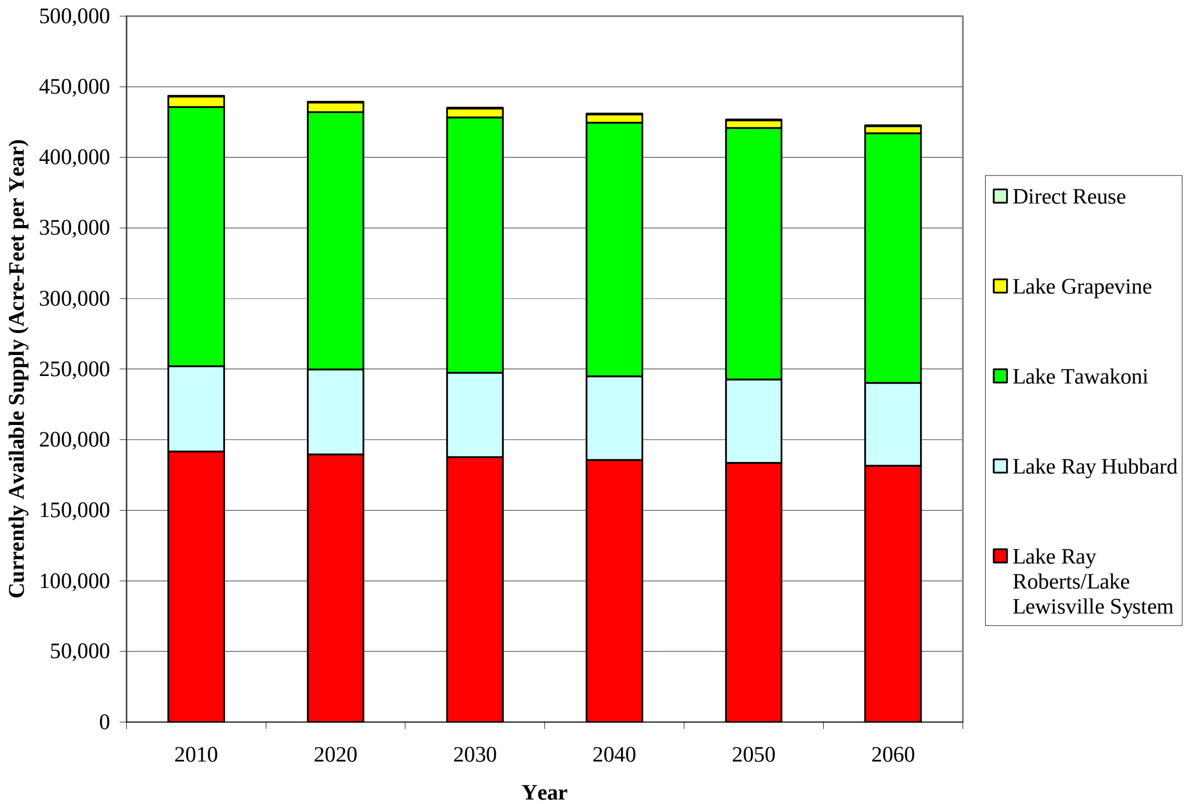
Table 3.8, Continued

Provider	Source	Water Supply Currently Available (Acre-Feet per Year)					
		2010	**2020**	**2030**	**2040**	**2050**	**2060**
Sabine River Authority	Lake Tawakoni (Dallas)	183,619	182,251	180,882	179,515	178,146	176,777
	Lake Tawakoni (Terrell)	9,718	9,646	9,573	9,501	9,428	9,356
	Lake Tawakoni (Others)	36,469	36,197	35,925	35,651	35,379	35,107
	Lake Fork Res. (Dallas) - Trinity Basin	120,000	119,943	119,095	118,248	117,400	116,551
	Lake Fork Res. (Dallas) - Sabine Basin	791					
	Lake Fork Res. (Others)	52,244	51,877	51,510	51,142	50,775	50,409
	Toledo Bend Lake	750,000	750,000	750,000	750,000	750,000	750,000
	Sabine Run-of-River	147,100	147,100	147,100	147,100	147,100	147,100
	SRA Total	**1,299,942**	**1,297,013**	**1,294,085**	**1,291,157**	**1,288,228**	**1,285,300**
	SRA Total Dallas and Terrell	**313,337**	**311,840**	**309,550**	**307,263**	**304,974**	**302,684**
Trinity River Authority	Joe Pool Lake	15,333	14,267	13,200	12,133	11,067	10,000
	Navarro Mills Lake	19,400	18,800	17,850	16,900	15,950	15,000
	Bardwell Lake	8,567	8,153	7,740	7,327	6,913	6,500
	Lake Livingston (Region C)	20,000	20,000	20,000	20,000	20,000	20,000
	Reuse (Region C)	16,361	16,492	16,492	16,492	16,492	16,492
	Subtotal	**79,661**	**77,712**	**75,282**	**72,852**	**70,422**	**67,992**
	TRWD	54,428	53,514	51,013	47,356	42,960	38,936
	TRA Total in Region C	**134,089**	**131,226**	**126,295**	**120,208**	**113,382**	**106,928**
Upper Neches River Municipal Water Authority	Lake Palestine (Dallas)	112,080	111,460	110,840	110,220	109,600	108,980
	Lake Palestine (Other Committed)	95,798	95,787	95,778	95,769	95,762	95,756
	Lake Palestine (Uncommitted)	13,055	12,419	11,782	11,144	10,504	9,864
	UNRMWA Total	**220,933**	**219,667**	**218,400**	**217,133**	**215,867**	**214,600**

Table 3.8, Continued

Provider	Source	Water Supply Currently Available (Acre-Feet per Year)					
		2010	**2020**	**2030**	**2040**	**2050**	**2060**
Upper Trinity Regional Water District	Chapman Lake	14,068	13,835	13,602	13,369	13,136	12,905
	DWU	10,302	11,026	14,476	19,883	28,137	27,450
	Direct Reuse	897	897	897	897	897	897
	UTRWD Total	**25,267**	**25,758**	**28,975**	**34,149**	**42,170**	**41,252**
Sulphur River Water District	Chapman Lake (UTRWD)	14,068	13,835	13,602	13,369	13,136	12,905
	Chapman Lake (NTMWD through Cooper)	2,808	2,762	2,716	2,670	2,624	2,575
	Chapman Lake (Other)	16,771	16,493	16,215	15,937	15,659	15,384
	SRWD Total	**33,647**	**33,090**	**32,533**	**31,976**	**31,419**	**30,864**
	SRWD to Region C	**16,876**	**16,597**	**16,318**	**16,039**	**15,760**	**15,480**
Dallas County Park Cities MUD	**Grapevine Lake**	**16,167**	**15,533**	**14,900**	**14,267**	**13,633**	**13,000**
Greater Texoma Utility Authority	Lake Texoma Raw Water	25,000	25,000	25,000	25,000	25,000	25,000
	Delivery Limited by WTP Capacity	**11,210**	**11,210**	**11,210**	**11,210**	**11,210**	**11,210**
City of Corsicana	Navarro Mills Lake (from TRA)	19,400	18,800	17,850	16,900	15,950	15,000
	Navarro Mills Lake (Limited by WTP Capacity)	**11,210**	**11,210**	**11,210**	**11,210**	**11,210**	**11,210**

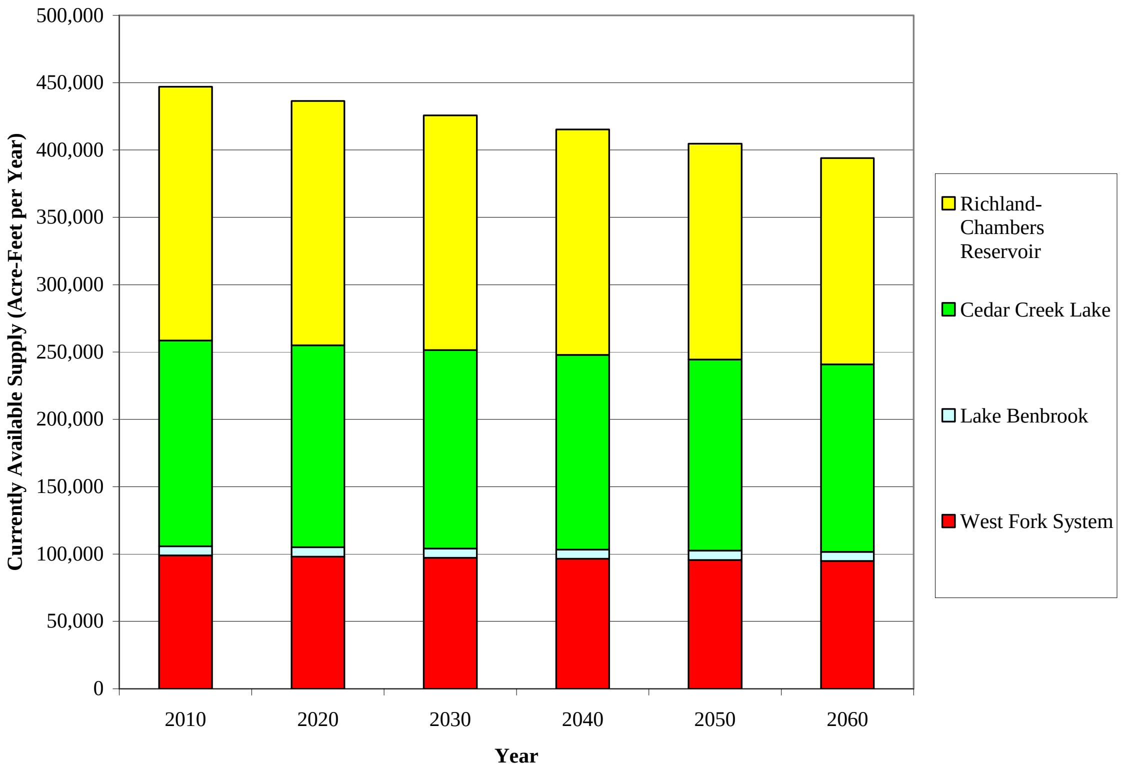
Figure 3.3
Currently Available Water Supplies for Dallas Water Utilities



Tarrant Regional Water District

Figure 3.4 shows the currently available water supply for Tarrant Regional Water District (TRWD). TRWD's water supply system includes Cedar Creek Reservoir, Richland-Chambers Reservoir, Benbrook Lake, Lake Bridgeport, Eagle Mountain Lake and Lake Worth (owned by Fort Worth). Lakes Bridgeport, Eagle Mountain, and Worth are operated as the West Fork system. TRWD operates its system on a safe yield basis, and the currently available water supply as of 2060 is 394,049 acre-feet per year on a safe yield basis. TRWD has recently received water rights allowing it to divert return flows of treated wastewater from the Trinity River into Cedar Creek Reservoir and Richland-Chambers Reservoir. When this project is implemented, it will increase the safe yield of the two lakes to the permitted diversion amount and will also provide substantial supplemental yield for TRWD.

Figure 3.4
Currently Available Water Supplies for the Tarrant Regional Water District



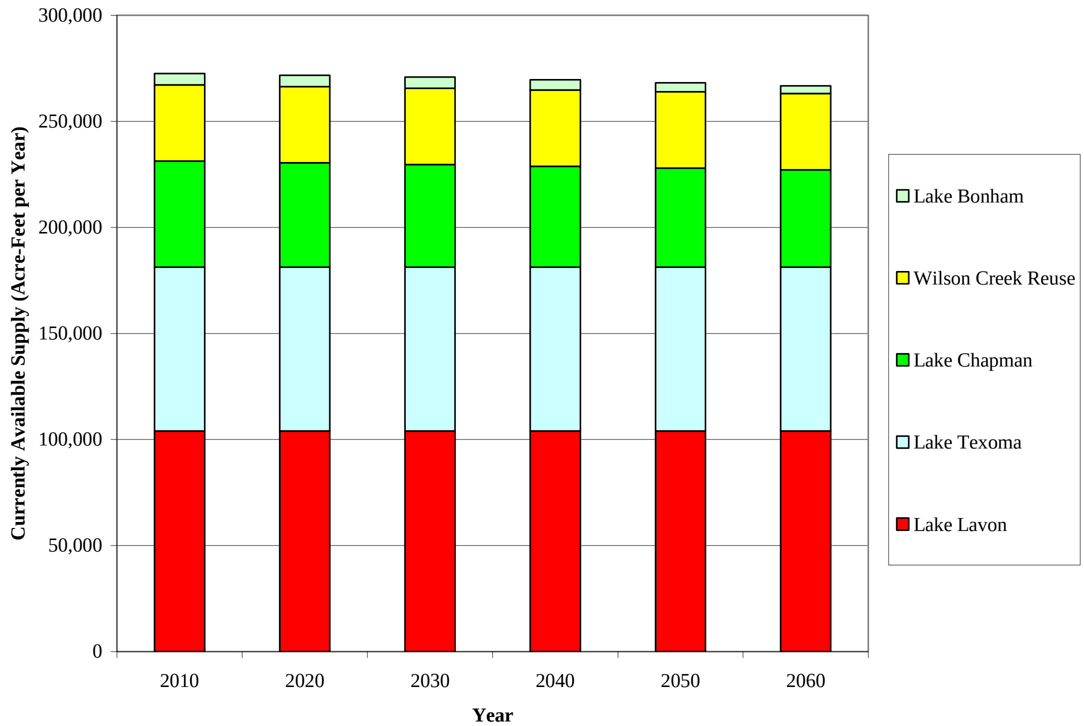
North Texas Municipal Water District

Figure 3.5 shows the currently available supply for the North Texas Municipal Water District (NTMWD). NTMWD's sources of supply include Lake Lavon, Lake Texoma, Chapman Lake (in Region D), the reuse of treated wastewater effluent discharged into the Lake Lavon watershed, and Bonham Lake. NTMWD is seeking water rights to allow additional reuse and the use of additional Lake Texoma water.

City of Fort Worth

Fort Worth obtains raw water from the Tarrant Regional Water District and sells treated water to wholesale and retail customers. It also uses approximately 900 acre-feet per year of direct reuse for irrigation. As shown in Table 3.8, Fort Worth's currently available supply is between 238,000 acre-feet per year and 250,000 acre-feet per year throughout the planning period.

Figure 3.5
Currently Available Water Supplies for the North Texas Municipal Water District



Sabine River Authority

As shown in Table 3.8, the Sabine River Authority (SRA) has water supplies available from Lake Tawakoni and Lake Fork Reservoir in Region D and from Toledo Bend Reservoir and a run-of-the-river water right in Region I. SRA supplies water to Region C from Lake Tawakoni and Lake Fork Reservoir through sales to Dallas Water Utilities and Terrell. SRA also supplies water to other water suppliers in the Upper Sabine Basin, mostly located in Region D (but with some service in Region C). SRA's supplies from Lake Tawakoni and Lake Fork Reservoir are fully committed, but SRA has significant uncommitted supplies in Toledo Bend Reservoir.

Trinity River Authority

The Trinity River Authority (TRA) has water rights in Joe Pool Lake, Navarro Mills Lake, and Bardwell Lake in Region C. TRA also imports water from Lake Livingston in Region H (by an upstream diversion from the Trinity River) and has permits and authorization for three reuse projects, two of which are in operation. TRA purchases water from the Tarrant Regional Water District for its Tarrant County water supply project and has plans to purchase water from TRWD for use in Ellis County. Based on the WAM and reuse permit amounts, TRA's independent supply in Region C from current sources is projected to be 67,992 acre-feet as of 2060. This is in addition to the water it purchases from the Tarrant Regional Water District. The TRA has applied for a water right that would allow additional reuse in Region C.

Upper Neches River Municipal Water Authority

The Upper Neches River Municipal Water Authority (UNRMWA) holds water rights in Lake Palestine in Region I and has a contract to provide water to Dallas Water Utilities in Region C. UNRMWA also provides water from Lake Palestine to suppliers in Region I. DWU has not yet developed the facilities to deliver Lake Palestine water to DWU and plans to connect this supply in the future.

Upper Trinity Regional Water District

As shown in Table 3.8, the Upper Trinity Regional Water District (UTRWD) has water supply available from Chapman Lake (in Region D, purchased from the Sulphur River Water District), Dallas Water Utilities, and reuse projects. UTRWD provides treated water to customers in Denton County and surrounding counties. UTRWD has water right applications before TCEQ for an indirect reuse project and for the proposed Lake Ralph Hall in Fannin County.

Sulphur River Water District

The Sulphur River Water District (SRWD) holds water rights in Chapman Lake in Region C. SRWD supplies raw water from Chapman Lake to UTRWD in Region C and to suppliers in Region D.

Dallas County Park Cities MUD

Dallas Cities Park Cities Municipal Utility District (PCMUD) holds water rights in Grapevine Lake and supplies treated water to Highland Park and University Park in Dallas County. PCMUD also has a contract with the City of Grapevine allowing Grapevine to reuse return flows of treated wastewater discharged to Grapevine Lake from Grapevine's Peach Street Wastewater Treatment Plant.

Greater Texoma Utility Authority

The Greater Texoma Utility Authority (GTUA) has water rights for 25,000 acre-feet per year from Lake Texoma and sells raw water to Sherman, which operates a desalination and treatment plant. The yield of Lake Texoma is sufficient to provide 25,000 acre-feet per year through the year 2060.

Congress allocated 50,000 acre-feet of storage in Lake Texoma from hydropower to municipal use for the GTUA. GTUA plans to pursue this water. This strategy is discussed and recommended in Section 4E.

City of Corsicana

The City of Corsicana purchases water from Navarro Mills Lake from the Trinity River Authority. The firm yield of the lake ranges from 19,400 acre-feet per year in 2010 to 15,000 acre-feet per year in 2060. The currently available supply for the City of Corsicana is limited by the capacity of its Navarro Mills water treatment plant to 11,210 acre-feet per year. Corsicana also has water rights in Lake Halbert, which has no firm yield and does not provide a reliable supply, and in Richland-Chambers Reservoir, which is not connected to the city's system. Over time, Corsicana plans to develop additional supplies by expanding its water treatment plants and connecting to Richland-Chambers Reservoir.

3.5 Current Water Supplies Available to Local Wholesale Water Providers

The supplies currently available to local wholesale water providers are summarized in Table 3.9. Many of the local wholesale water providers purchase their water from the regional suppliers and sell that water to their customers. Entities buying and selling water in this manner include:

- City of Cedar Hill purchases water from Dallas Water Utilities.
- City of Denton purchases some of their supply from Dallas Water Utilities.
- The City of Ennis purchases water from the Trinity River Authority (Bardwell Lake, with plans for Tarrant Regional Water District supplies through the Trinity River Authority as well).
- City of Forney purchases water from North Texas Municipal Water District and purchases reuse water from Garland for Steam Electric Power.

- City of Garland purchase water from North Texas Municipal Water District and sells reuse water to Forney for Steam Electric Power.
- City of Mansfield purchases water from the Tarrant Regional Water District.
- City of Midlothian purchases water from Trinity River Authority (Joe Pool Lake, with plans for Tarrant Regional Water District supplies through the Trinity River Authority as well).
- City of North Richland Hills purchases water from Tarrant Regional Water District through Fort Worth and Trinity River Authority.
- City of Rockwall purchases the water from North Texas Municipal Water District.
- City of Seagoville purchases water from Dallas Water Utilities.
- City of Terrell purchases some of its water from the Sabine River Authority. Terrell plans to purchase treated water from North Texas Municipal Water District.
- City of Waxahachie purchases some of its water from the Trinity River Authority (Bardwell Lake).
- City of Weatherford purchases some of its water from Tarrant Regional Water District.
- East Cedar Creek Freshwater Supply District purchases water from Tarrant Regional Water District (Cedar Creek Reservoir).
- Lake Cities Municipal Utility Authority purchases water from Upper Trinity Regional Water District.
- Mustang Special Utility District purchases most of its water from Upper Trinity Regional Water District.
- Parker County Utility District Number 1 plans to purchase water from Weatherford.
- Rockett Special Utility District purchases water from Midlothian and Waxahachie and plans to purchase water from Dallas Water Utilities and from Trinity River Authority. Rockett SUD also obtains a small amount of water from the Trinity aquifer.
- Walnut Creek Special Utility District purchases water from Tarrant Regional Water District.
- West Cedar Creek Municipal Utility District purchases water from Tarrant Regional Water District.
- Wise County Water Supply District purchases water from Tarrant Regional Water District.

The remaining local wholesale water providers supply water to their customers from their own water supplies.

3.6 Water Availability by Water User Group (WUG)

As part of the Senate Bill One planning process, the Texas Water Development Board requires development of information on currently available water supplies for each water user group (WUG) by river basin and county. (Water user groups are cities with populations greater than 500, water suppliers who serve an average of at least 0.25 million gallons per day (mgd) annually, "county-other" municipal uses, and countywide manufacturing, irrigation, mining, livestock, and steam electric uses.) The availability figures by water user group are limited by contracts and existing physical facilities, including transmission facilities, groundwater wells, and water treatment. The supplies available to each WUG are shown in Appendix V.

As the information on currently available water supply for WUGs was developed, several important points became apparent:

- Most water user groups in Region C will need additional facilities over the next 50 years to meet growing demands.
- Current groundwater use in several areas exceeds the long-term reliable supply.
- There are some significant water supplies that can be made available by the development of additional water transmission facilities. Examples include Dallas Water Utilities' share of Lake Fork Reservoir in the Sabine Basin and Lake Palestine in the Neches Basin.

3.7 Impacts of Recent Droughts in Region C

Region C experienced summer droughts and high water use in 1996, 1998, 1999, and 2000. Winter and spring runoff filled most area lakes after these droughts, but the short-term droughts provided a test of local water supplies. Lessons learned from these recent droughts include the following:

- Short-term droughts, like those of recent years, have put some amount of stress on major reservoirs in Region C. Most major reservoirs in Region C are designed for a 5 to 7 year drought similar to the drought of the 1950s.
- The dry summers in 1996, 1998, 1999, and 2000 showed that the low water use of the early 1990s in Region C was a result of mild summers rather than a change in water use patterns. For many Region C suppliers, 1998 and 2000 were years of record high per capita water use.
- The high demands of 1996, 1998, 1999, and 2000 exposed supply limitations for many smaller suppliers that depend on groundwater supplies. As a result, many smaller suppliers are developing additional well capacity and/or seeking to purchase water from larger, regional suppliers.
- The high demands of 1996, 1998, 1999, and 2000 exposed treatment and distribution system limitations for many Region C water suppliers. Area suppliers are making significant investments to overcome these limitations.
- Because most water supply systems were able to provide the needed supplies to municipal and manufacturing users, the most significant economic impacts of the recent droughts were on agricultural production. There is very little irrigation water use for agriculture in Region

Table 3.9
Currently Available Supplies to Local Wholesale Water Providers in Region C

Provider	Source	Water Supply Currently Available (Acre-Feet per Year)					
		2010	2020	2030	2040	2050	2060
Athens Municipal Water Authority	Lake Athens (firm yield)	6,064	5,983	5,903	5,822	5,741	5,660
	Lake Athens (operational yield)	2,900	2,900	2,900	2,900	2,900	2,900
	Total (limited by operation)	**2,900**	**2,900**	**2,900**	**2,900**	**2,900**	**2,900**
Cedar Hill	Trinity aquifer	275	275	275	275	275	275
	DWU	6,477	6,458	6,986	7,119	6,857	6,345
	Total	**6,752**	**6,733**	**7,261**	**7,394**	**7,132**	**6,620**
Denton	Lewisville Lake	7,702	7,507	7,313	7,119	6,924	6,730
	Ray Roberts Lake	20,445	19,882	19,319	18,756	18,193	17,630
	Indirect Reuse	1,682	2,130	2,915	3,475	4,372	5,381
	DWU	1,931	8,256	12,676	15,741	19,817	27,321
	Subtotal (limited by WTP capacity)	**31,760**	**31,949**	**31,949**	**31,949**	**31,949**	**31,949**
	Reuse (Steam Electric Power and Irrigation)	1,233	2,242	2,690	3,251	3,924	4,708
	Total	**32,993**	**34,191**	**34,639**	**35,200**	**35,873**	**36,657**
East Cedar Creek	**TRWD (limited by contract)**	**1,157**	**1,157**	**1,157**	**1,157**	**1,157**	**1,157**
Ennis	**Bardwell Lake (TRA)**	**4,712**	**4,484**	**4,257**	**4,030**	**3,802**	**3,575**
Forney	NTMWD	2,691	3,630	3,861	4,043	4,268	4,491
	Reuse from Garland (Steam Electric)	3,000	3,000	3,000	3,000	3,000	3,000
	Total	**5,691**	**6,630**	**6,861**	**7,043**	**7,268**	**7,491**
Gainesville	Trinity aquifer	2,108	1,615	1,121	1,121	1,121	1,121
	Moss Lake (limited by WTP)	1,121	1,121	1,121	1,121	1,121	1,121
	Direct Reuse	9	9	9	9	9	9
	Total	**3,238**	**2,745**	**2,251**	**2,251**	**2,251**	**2,251**

Table 3.9, Continued

Provider	Source	Water Supply Currently Available (Acre-Feet per Year)					
		2010	**2020**	**2030**	**2040**	**2050**	**2060**
Garland	NTMWD	32,889	27,041	24,465	22,575	21,386	19,538
	Reuse sold to Forney (Steam Electric)	8,979	15,600	15,600	15,600	15,600	15,600
	Total	**41,868**	**42,641**	**40,065**	**38,175**	**36,986**	**35,138**
Lake Cities MUA	UTRWD	1,473	1,245	1,196	1,237	1,449	1,461
	Trinity aquifer	129	129	129	129	129	129
	Woodbine aquifer	279	279	279	279	279	279
	Total	**1,881**	**1,653**	**1,604**	**1,645**	**1,857**	**1,869**
Mansfield	**TRWD**	**11,210**	**11,210**	**11,210**	**11,210**	**11,210**	**11,210**
Midlothian	Trinity aquifer	36	36	36	36	36	36
	Joe Pool Lake	6,011	5,593	5,174	4,756	4,338	3,920
	Total	**6,047**	**5,629**	**5,210**	**4,792**	**4,374**	**3,956**
Mustang SUD	Trinity aquifer	331	331	331	331	331	331
	UTRWD Sources	1,398	1,687	2,048	2,665	3,596	3,765
	Total	**1,729**	**2,018**	**2,379**	**2,996**	**3,927**	**4,096**
North Richland Hills	TRWD (through Ft Worth & TRA)	14,534	13,499	12,715	11,989	10,719	9,305
	Trinity aquifer	14	14	14	14	14	14
	Total	**14,548**	**13,513**	**12,729**	**12,003**	**10,733**	**9,319**
Parker Co. Utility District #1	**No supplies currently available**	**0**	**0**	**0**	**0**	**0**	**0**
Rockwall	**NTMWD**	**7,236**	**9,426**	**10,227**	**10,032**	**9,466**	**8,750**
Rockett SUD	Midlothian	1,590	0	0	0	0	0
	Waxahachie	1,085	0	0	0	0	0
	Trinity aquifer	71	71	71	71	71	71
	Total	**2,746**	**71**	**71**	**71**	**71**	**71**
Seagoville	**DWU**	**2,360**	**2,501**	**2,598**	**2,657**	**2,602**	**2,518**

Table 3.9, Continued

Provider	Source	Water Supply Currently Available (Acre-Feet per Year)					
		2010	**2020**	**2030**	**2040**	**2050**	**2060**
Terrell	SRA (from Lake Tawakoni)	9,718	9,646	9,573	9,501	9,428	9,356
	Lake Terrell	2,200	2,200	2,200	2,200	2,200	2,200
	Subtotal	11,918	11,846	11,773	11,701	11,628	11,556
	Total (limited to infrastructure capacity)	**5,125**	**5,125**	**5,125**	**5,125**	**5,125**	**5,125**
Walnut Creek SUD	TRWD	3,481	3,920	4,061	4,060	3,936	3,835
	Total (limited by WTP capacity)	**2,800**	**2,800**	**2,800**	**2,800**	**2,800**	**2,800**
Waxahachie	Lake Waxahachie	2,667	2,573	2,480	2,387	2,293	2,200
	TRA (Bardwell)	3,855	3,669	3,483	3,297	3,111	2,925
	TRA (Reuse)	4,998	5,129	5,129	5,129	5,129	5,129
	Subtotal	**11,520**	**11,371**	**11,092**	**10,813**	**10,533**	**10,254**
	Total (limited to WTP capacity)	**8,408**	**8,408**	**8,408**	**8,408**	**8,408**	**8,408**
Weatherford	Lake Weatherford	2,750	2,600	2,450	2,300	2,150	2,000
	Benbrook Lake (TRWD)	1,802	1,937	2,082	2,228	2,377	2,531
	Trinity aquifer	50	50	50	50	50	50
	Subtotal	**4,602**	**4,587**	**4,582**	**4,578**	**4,577**	**4,581**
	Total (limited to WTP capacity)	**4,484**	**4,484**	**4,484**	**4,484**	**4,484**	**4,484**
West Cedar Creek	**TRWD (limited by contract)**	**1,714**	**1,714**	**1,714**	**1,714**	**1,714**	**1,714**
Wise Co. WSD	**Tarrant Regional Water District**	**1,834**	**1,822**	**2,097**	**2,308**	**2,520**	**2,511**

C, and natural variations in rainfall are likely to continue to affect agricultural production in the region.

3.8 Summary of Current Water Supply in Region C

1. Region C water suppliers are currently using most of the reliable supply available from in-region reservoirs. Some in-region reservoirs are being overdrafted, with current use in excess of reliable supplies that would be available in an extended drought. (In all cases where this is being done, the water suppliers have developed or are developing access to other supplies.)
2. The projected overall water supply available to Region C in 2060 from current sources is 1,906,007 acre-feet per year. (This figure does not consider supply limitations due to the capacities of current raw water transmission facilities and wells.) The sources of supply for Region C in 2060 include:
   - 1,111,096 acre-feet per year (60%) from in-region reservoirs
   - 106,460 acre-feet per year (5%) from groundwater
   - 43,906 acre-feet per year (2%) from local supplies
   - 103,429 acre-feet per year (5%) from reuse
   - 541,117 acre-feet per year (28%) from imports from other regions
3. The supply available to Region C from existing sources in 2060 (1.9 million acre-feet per year) is significantly less than the projected 2060 water use, which is over 3.3 million acre-feet per year.
4. Considering supply limitations due to the capacities of current raw water transmission facilities and wells, the currently available supply for Region C water users in 2060 is 1,379,284 acre- feet per year, with 11,717 acre-feet per year for water users in other regions. The total available supply is 1,391,001 acre-feet per year, which is 516,006 acre-feet per year less than the overall supply from existing sources. Most water user groups will have to make improvements to their facilities to provide for projected needs.
5. Several major water suppliers will require additional raw water transmission facilities to make full use of their existing sources.
6. Current groundwater use in a number of areas in Region C exceeds the projected long-term water supply availability. Supplies from other sources will be needed in these areas so that groundwater use can be reduced to sustainable levels.
7. Some sources of supply will probably not be utilized fully during the period covered by this plan, but these will generally be the smaller local supplies.
8. The recent drought summers have caused high water use for many Region C water suppliers. These short-term droughts have put stress on some of the region's major reservoirs, which are designed for a 5 to 7 year drought like that of the 1950's. The high demands also exposed supply limitations for many smaller suppliers (especially those dependent on groundwater) and exposed treatment and distribution limitations for other suppliers.

CHAPTER 3
LIST OF REFERENCES

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(8) R.J. Brandes Company: *Final Report Water Availability Modeling for the Sulphur River Basin,* prepared for the Texas Natural Resource Conservation Commission, Austin, June 1999.

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(10) Intera and Parsons, *Final Report Groundwater Availability Model for the Northern Carrizo-Wilcox Aquifer,* prepared for the Texas Water Development Board, Austin, January 31, 2003.

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(12) Mid-East Texas Groundwater Conservation District created by the Texas Legislature, Chapter 1507, Art. 4 (HB 1784) and Ch. 966, Art. 3, Part 15, (SB 1), 77th Leg., September 2001, confirmed November 2002.

(13) Neches and Trinity Valleys Groundwater Conservation District created by the Texas Legislature, Ch. 1387, 77th Leg., September 2001 (SB 1821), confirmed November 2001.

4. Identification, Evaluation, and Selection of Water Management Strategies

This chapter of the report covers the heart of the *2006 Region C Water Plan* - the identification, evaluation, and selection of water management strategies. Since the required content of Chapter 4 covers a great deal of material, we have divided the chapter into sections as follows:

4A – Comparison of Current Water Supply and Projected Demand

4B – Water Conservation and Reuse of Treated Wastewater Effluent in Region C

4C – Methodology for Evaluation and Selection of Water Management Strategies

4D – Evaluation of Major Water Management Strategies

4E – Recommended Water Management Strategies for Wholesale Water Providers

4F – Recommended Water Management Strategies for Water User Groups by County

4A. Comparison of Current Water Supply and Projected Demand

Texas Water Development Board (TWDB) guidelines require that surpluses and needs for additional water supply be developed for each water user group in the region based on the comparison of current water supply and projected demand. The specific surpluses and needs shown should be treated with caution because their development requires certain assumptions:

- TWDB guidelines require that the comparison be based on currently connected supplies, without considering future connection of already developed supplies [(1)].
- The division of existing supplies among users can be made in many ways. For example, the amount of groundwater available in a county on a sustainable basis was divided among users based on historical use or on well capacities. The actual future groundwater use may differ from these assumptions.

The resulting comparison shows the surpluses and needs that will exist in Region C <u>if no steps are taken to connect existing water supplies or develop to additional water supplies</u>. This comparison is specifically required by Texas Water Development Board planning guidelines [(1)]. Development of infrastructure to make existing supplies available to users and development of new supplies are treated as water management strategies, and they will be discussed in Sections 4C, 4D, 4E, and 4F.

In the remainder of this section, projected water demands are compared to currently available water supplies, and projected water shortages and surpluses are identified for Region C as a whole (Section 4A.1), for wholesale water providers (Section 4A.2), and for water user groups (Section 4A.3). Finally, the projected shortages are summarized (Section 4A.4), and the socio-economic impacts of not meeting the projected shortages are discussed (Section 4A.5).

4A.1 Regional Comparison of Supply and Demand

Table 4A.1 and Figure 4A.1 summarize the comparison of total currently connected water supply and total projected water demand in Region C, considering all water user groups. If only water user groups with projected shortages (and not surpluses) are considered, there is a need for approximately 336,400 acre-feet per year of additional supply by 2010, growing to a need for 1.97 million acre-feet per year of additional supply by 2060, based on currently connected supplies. Figure 4A.2 shows the projected distribution of shortages. Over eighty-nine percent of the projected shortage is for municipal users.

Table 4A.1
Comparison of Connected Supply with Projected Demand by Decade in Region C
-Values in Acre-Feet per Year-

Item	2010	2020	2030	2040	2050	2060
Connected Supply in Region C	1,514,013	1,482,546	1,453,936	1,428,415	1,403,609	1,379,284
Projected Demand	1,768,464	2,100,519	2,358,433	2,622,513	2,934,927	3,311,217
Total Regional Surplus or (Need)	(254,451)	(617,973)	(904,497)	(1,194,098)	(1,531,318)	(1,931,933)
Regional Surplus or (Need) Considering Only Water User Groups With Needs	(336,383)	(668,427)	(947,591)	(1,233,915)	(1,570,351)	(1,969,619)
Counties with Needs	9	13	14	15	15	15
User Groups with Needs	199	268	275	278	279	280

Figure 4A.1
Comparison of Connected Supply with Projected Demand by Decade for Region C

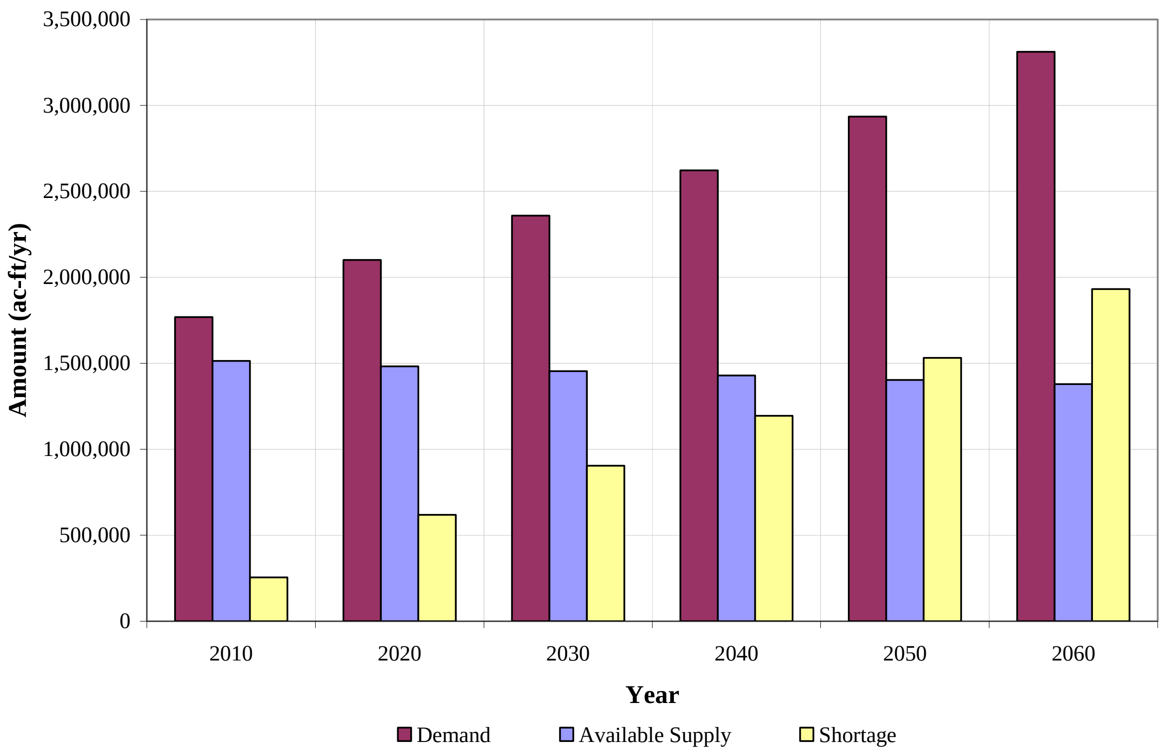


Figure 4A.2
Projected Shortage by Use Type for Region C

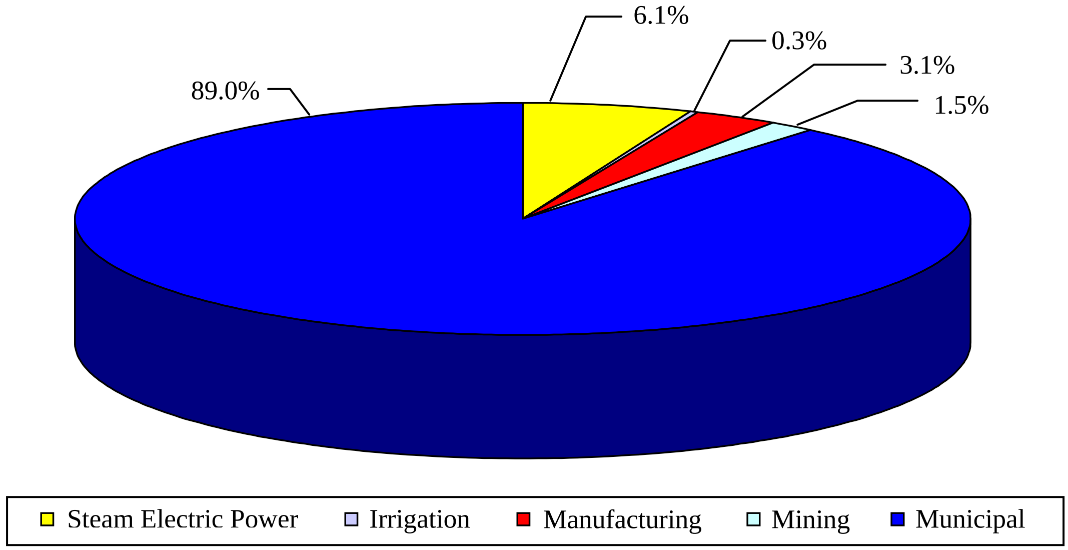


Table 4A.2 shows the comparison of supply and demands by county. In 2010, Collin, Cooke, Dallas, Denton, Ellis, Henderson, Kaufman, Rockwall, and Wise Counties (9 out of 16 in the region) show a net need for more water. By 2060, only Fannin County shows a net surplus. Most of the surplus in Fannin County is attributed to surplus supply for irrigation from run-of-the-river water rights in the Red River Basin. There are eight water user groups with projected 2060 shortages in Fannin County, totaling over 9,000 acre-feet per year. On a regional basis, 280 out of 351 water users in Region C are predicted to have a need for additional water by 2060. In general, the largest water needs are in Collin, Dallas, Denton and Tarrant Counties, with lesser but significant needs in other counties.

The comparison of supply and demand in Table 4A.1 and Figure 4A.1 focuses on currently connected supplies. Region C also has a significant amount of unconnected supplies that could be made available to the region. An unconnected water supply is an existing and permitted supply that is not currently available due to infrastructure limitations. Table 4A.3 and Figure 4A.3 show the comparison of total supply with demand for Region C, including connected and unconnected supply. By 2020, the projected demand for Region C exceeds total connected and unconnected supply.

Table 4A.2
Surplus or (Need) by County for Region C
-Values in Acre-Feet per Year-

County	2010	2020	2030	2040	2050	2060
Collin	(60,479)	(127,360)	(180,097)	(239,213)	(295,934)	(358,284)
Cooke	(1,170)	(2,470)	(3,783)	(4,405)	(5,445)	(6,423)
Dallas	(180,365)	(277,726)	(343,611)	(406,850)	(495,463)	(609,307)
Denton	(24,753)	(69,516)	(113,311)	(154,420)	(198,148)	(256,411)
Ellis	(15,796)	(28,250)	(38,675)	(51,464)	(67,136)	(85,852)
Fannin	19,200	18,961	17,197	14,633	11,304	7,814
Freestone	9,842	7,015	2,580	(2,661)	(8,808)	(15,997)
Grayson	5,874	(1,349)	(6,573)	(10,928)	(15,891)	(21,972)
Henderson	(1,381)	(3,344)	(5,330)	(7,316)	(9,888)	(13,133)
Jack	974	(2,763)	(3,429)	(4,212)	(5,180)	(6,362)
Kaufman	(10,795)	(25,028)	(32,218)	(39,749)	(48,475)	(59,362)
Navarro	1,611	502	(480)	(1,495)	(2,807)	(4,459)
Parker	1,273	(7,697)	(14,294)	(20,234)	(26,762)	(33,714)
Rockwall	(5,655)	(13,552)	(18,730)	(23,376)	(26,820)	(29,516)
Tarrant	11,346	(69,422)	(137,735)	(206,785)	(289,618)	(381,759)
Wise	(4,177)	(15,974)	(26,008)	(35,623)	(46,247)	(57,196)
Total	**(254,451)**	**(617,973)**	**(904,497)**	**(1,194,098)**	**(1,531,318)**	**(1,931,933)**

Table 4A.3
Comparison of Total Connected and Unconnected Supply with Region C Demand
- Values in Acre-Feet per Year -

Item	2010	2020	2030	2040	2050	2060
Total Connected and Unconnected Supply	1,979,727	1,972,240	1,956,770	1,941,194	1,925,666	1,906,007
Demand	1,768,464	2,100,519	2,358,433	2,622,513	2,934,927	3,311,217
Surplus/(Need)	211,263	(128,279)	(401,663)	(681,319)	(1,009,261)	(1,405,210)

4A.2 Comparison of Connected Supply and Projected Demand by Wholesale Water Provider

Under the planning rules, a wholesale water provider (WWP) is defined as an entity that sold or had contracts to sell more than 1,000 acre-feet of water on a wholesale basis in recent years or that is projected to sell more than 1,000 acre-feet per year on a wholesale basis during the planning period (1). The Region C Water Planning Group has designated 35 wholesale water providers for Region C. Table 4A.4 summarizes the comparison of supply and demand and shows the surpluses or needs for additional supply for each wholesale water provider. As a group, the wholesale water providers are projected to have a need for additional supply in each decade of the planning period. Steps to meet these projected needs will be discussed in Section 4E.

Three wholesale water providers do not have a projected shortage in Region C within the planning period: Dallas County Park Cities Municipal Utility District, Sulphur River Water District, and Upper Neches River Municipal Water Authority. Five wholesale water providers (Dallas Water Utilities, Tarrant Regional Water District, North Texas Municipal Water District, Trinity River Authority and Upper Trinity Regional Water District) provide water to meet approximately 90 percent of the total demand in Region C.

Figure 4A.3
Comparison of Connected and Unconnected Supply and Demand for Region C

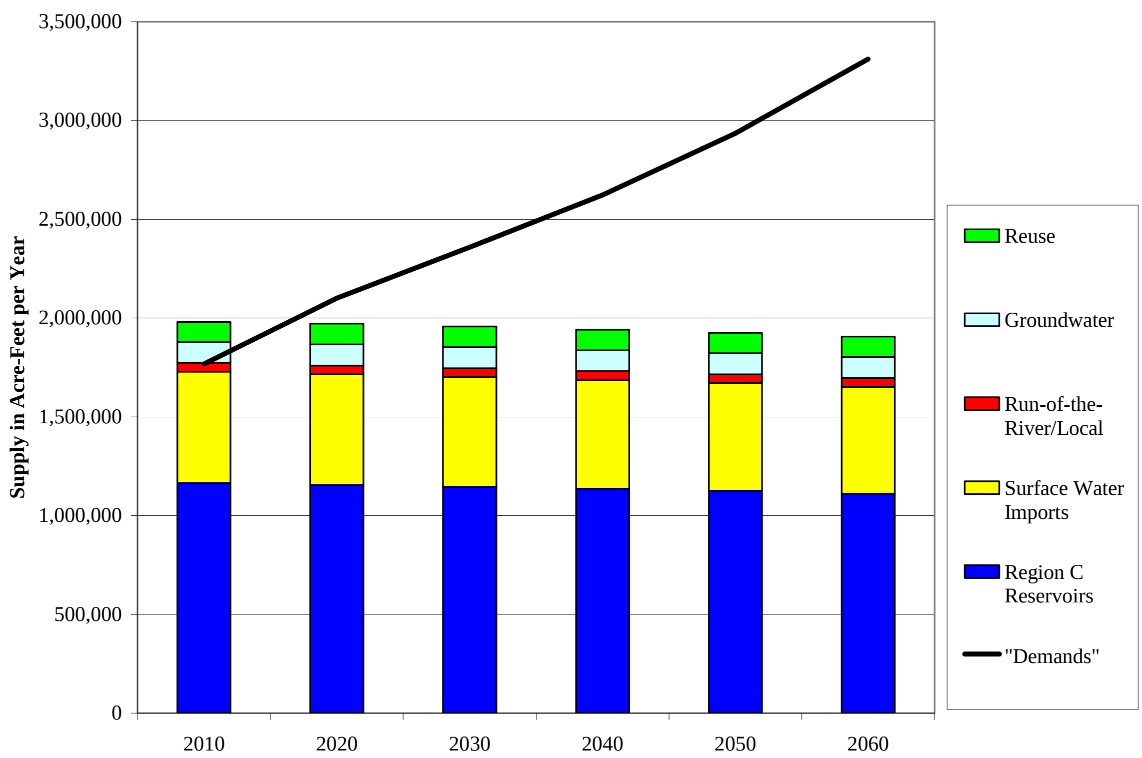


Table 4A.4
Surplus or (Need) by Wholesale Water Provider Using Only Connected Supplies
- Values in Acre-Feet per Year -

Wholesale Water Provider	Projected Needs for Current and Future Customers					
	2010	2020	2030	2040	2050	2060
City of Cedar Hill	(2,338)	(3,350)	(4,578)	(5,798)	(7,327)	(8,899)
City of Corsicana	0	(475)	(1,361)	(2,291)	(3,529)	(5,128)
City of Dallas (Dallas Water Utilities)	(197,540)	(269,747)	(320,192)	(388,288)	(502,229)	(652,712)
City of Denton	0	(9,330)	(19,142)	(27,897)	(41,591)	(68,383)
City of Ennis	0	(711)	(2,131)	(3,846)	(6,001)	(8,687)
City of Forney	(7,243)	(15,778)	(17,173)	(18,547)	(19,920)	(21,493)
City of Fort Worth	0	(39,663)	(89,847)	(145,320)	(219,169)	(306,775)
City of Gainesville	(570)	(1,346)	(2,253)	(2,583)	(2,956)	(3,457)
City of Garland	(13,991)	(22,778)	(28,214)	(32,540)	(36,069)	(38,162)
City of Mansfield	(4,537)	(10,607)	(16,069)	(21,554)	(25,217)	(25,676)
City of Midlothian	(2,204)	(4,355)	(7,799)	(9,843)	(11,730)	(12,863)
City of North Richland Hills	0	(4,260)	(6,081)	(7,438)	(9,216)	(11,075)
City of Rockwall	(3,017)	(7,874)	(11,553)	(14,387)	(15,883)	(16,982)
City of Seagoville	(849)	(1,294)	(1,699)	(2,160)	(2,779)	(3,532)
City of Terrell	(154)	(905)	(1,560)	(2,001)	(2,495)	(3,263)
City of Waxahachie	(280)	(771)	(2,997)	(5,798)	(9,409)	(14,028)
City of Weatherford	(1,555)	(9,394)	(10,849)	(12,048)	(13,336)	(14,869)
Athens Municipal Water Authority	(2,707)	(3,225)	(3,843)	(4,544)	(5,460)	(6,592)
Dallas County Park Cities MUD	0	0	0	0	0	0
East Cedar Creek FWSD	(2,584)	(3,322)	(4,064)	(4,806)	(5,766)	(6,995)
Greater Texoma Utility Authority	(6,544)	(12,570)	(20,767)	(31,747)	(44,547)	(61,746)
Lake Cities MUA	(184)	(1,086)	(1,516)	(1,862)	(2,175)	(2,765)
Mustang SUD	(180)	(1,525)	(2,744)	(4,320)	(6,170)	(8,291)
North Texas Municipal Water District	(113,316)	(225,787)	(311,611)	(395,258)	(466,998)	(545,366)
Parker County Utility District #1	(53)	(1,539)	(1,764)	(1,946)	(2,163)	(2,439)
Rockett SUD	(3,167)	(7,308)	(7,794)	(9,172)	(10,988)	(13,292)
Sabine River Authority (Upper Basin)	(83,753)	(85,313)	(86,872)	(88,433)	(89,993)	(91,552)
Sulphur River Water District	0	0	0	0	0	0
Tarrant Regional Water District	0	(82,538)	(170,152)	(263,062)	(374,865)	(499,461)
Trinity River Authority	(32,051)	(97,418)	(138,384)	(151,131)	(183,812)	(195,716)
Upper Neches Municipal Water Authority	0	0	0	0	0	0
Upper Trinity Regional Water Dist.	(7,721)	(31,838)	(53,333)	(76,970)	(96,826)	(116,597)
Walnut Creek SUD	(601)	(2,005)	(3,141)	(4,227)	(5,378)	(6,771)
West Cedar Creek MUD	(1,049)	(2,243)	(3,247)	(4,172)	(5,360)	(6,856)
Wise County WSD	0	(268)	(741)	(1,328)	(2,167)	(2,989)

4A.3 Comparison of Connected Supply and Projected Demand by Water User Group

Projected supplies, demands, surpluses, and shortages are summarized for each water user group in Appendix V. As shown on Table 4A.1, there are 280 water user groups with projected water shortages by 2060. These shortages range from 22 acre-feet per year for the City of Palmer to nearly 359,000 acre-feet per year for the City of Dallas.

Sections 4C through 4F of this report discusses the selection of water management strategies to address the requirements for additional supply. Many water user groups in Region C are served by wholesale water providers, and the needs of these water user groups will be addressed by obtaining additional supplies from the wholesale water providers. Other water user groups will require the development of individual water management strategies to address their needs.

4A.4 Summary of Projected Water Shortages

- If no new supplies are developed, the total of projected shortages in Region C is 336,383 acre-feet per year by 2010, growing to 1,969,619 acre-feet per year by 2060.
- There are substantial unconnected supplies in Region C that could be made available by completing water transmission facilities.
- The number of Region C counties with net needs for more water changes from 9 out of 16 counties in 2010 to 15 out of 16 counties in 2060.
- There are 351 individual water user groups in Region C. Of these, 199 water user groups are projected to need more supply in 2010, growing to 280 water user groups by 2060.
- Many Region C water suppliers depend on the region's wholesale water providers for all or part of their supplies. All but three of the wholesale water providers will need to develop additional supplies by 2060.

4A.5 Socio-Economic Impacts of Not Meeting Projected Shortages

If no additional water supplies are developed, Region C will face substantial shortages in water supply over the next 55 years. The Texas Water Development Board (TWDB) provided technical assistance to regional water planning groups in the development of specific information on the socio-economic impacts of failing to meet projected water needs. This information is presented in Appendix Q. A summary of the TWDB's socio-economic report [(2)] is presented in this section.

The TWDB analysis of socio-economic impacts is based on information on potential shortages in Region C provided to TWDB in March 2005. Table 4A.5 and Figures 4A.4 and 4A.5 summarize the TWDB's analysis of the impacts of a severe drought occurring in a single year at each decadal period in Region C. It was assumed that all of the projected shortage was attributed to drought. Under these assumptions, the TWDB's findings can be summarized as follows:

- The currently connected supplies in Region C meet only 43 percent of the projected 2060 demand.
- Without any additional supplies, the projected water needs would reduce the region's projected 2060 population by 1,007,000, a reduction of 7.7 percent.
- Without any additional supplies, the projected water needs would reduce the region's projected 2060 employment by 691,060 jobs, a reduction of 17 percent.
- Without any additional supplies, the projected water needs would reduce the region's projected annual income in 2060 by $58.8 billion, a reduction of 21 percent.

Subsequent analyses by the TWDB evaluated the impacts of water shortages due to infrastructure constraints and increased demands associated with growth[(3)]. The lost income and tax revenues from failing to take steps to provide sufficient water for the projected growth are nearly $161 billion. The distribution of these impacts by county is shown in Table 4A.6.

Table 4A.5
Socio-Economic Impacts in Region C for a Single Year Extreme Drought if No Additional Supplies Are Developed

Year	Sales ($ millions)	Income ($ millions)	State and Local Taxes ($ millions)	Jobs	Population
2010	$4,807	$3,021	$128	27,760	38,500
2020	$15,205	$9,159	$351	91,670	130,700
2030	$21,765	$13,408	$515	137,340	199,500
2040	$35,995	$22,190	$866	245,050	356,700
2050	$62,713	$37,366	$1,391	423,405	616,600
2060	$96,778	$58,800	$2,506	691,060	1,007,000

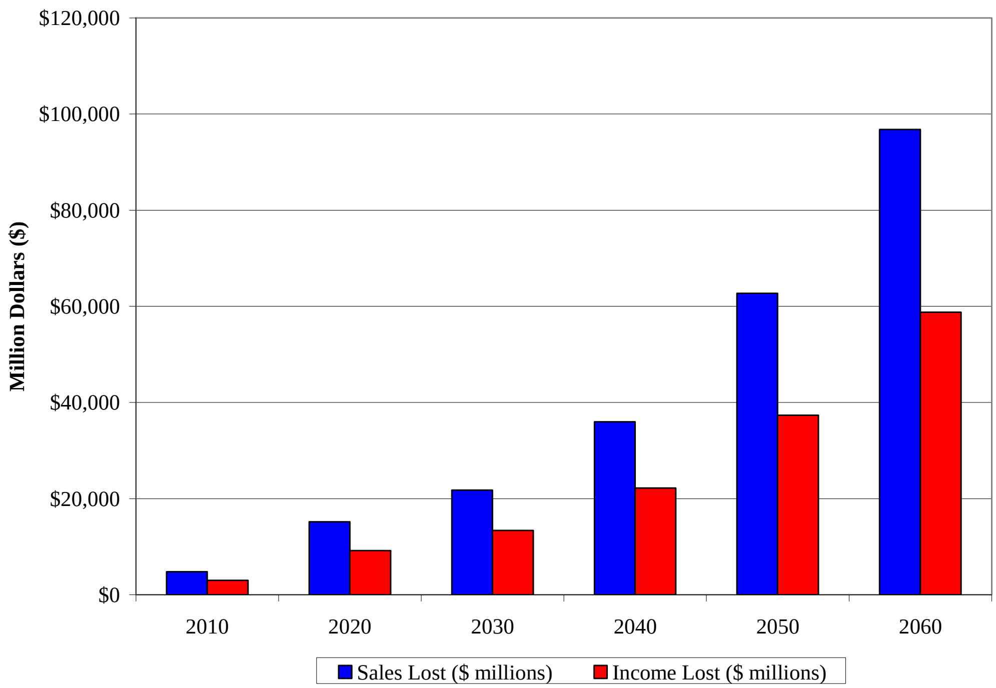
Note: These impacts are based on data provided to the TWDB by Region C in March 2005.

Table 4A.6
Impacts in Region C if No Additional Supplies Are Developed to Meet Demands from Growth

County	Impacts ($ million)		
	Income	Taxes	Total Regional Gross Product
Collin	($22,314)	($1,956)	($24,269)
Cooke	($483)	($32)	($515)
Dallas	($75,110)	($7,311)	($82,421)
Denton	($11,179)	($1,098)	($12,277)
Ellis	($2,240)	($161)	($2,401)
Fannin	($366)	($30)	($396)
Freestone	($56)	($6)	($62)
Grayson	($1,272)	($92)	($1,364)
Henderson (P)	($1,173)	($114)	($1,287)
Jack	($22)	($2)	($23)
Kaufman	($1,716)	($145)	($1,862)
Navarro	($134)	($13)	($147)
Parker	($1,516)	($146)	($1,662)
Rockwall	($1,964)	($209)	($2,173)
Tarrant	($26,473)	($2,499)	($28,972)
Wise	($837)	($72)	($909)
Planning Region Totals	**($146,854)**	**($13,885)**	**($160,739)**

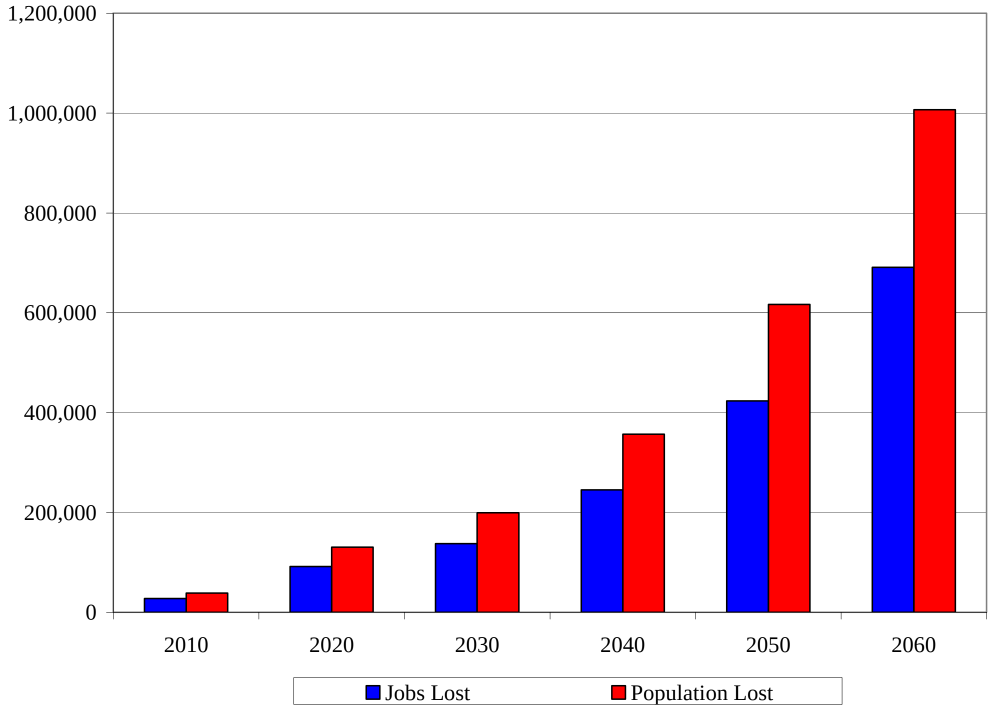
Note: Analysis provided by the TWDB on November 2, 2005 based on data from March 2005.

Figure 4A.4
Annual Economic Impacts of Not Meeting Water Needs for Region C



Notes: These impacts are based on shortage data provided to the TWDB by Region C in March 2005. The data for each decade are assumed to be independent.

Figure 4A.5
Socio-Economic Impacts of Not Meeting Water Needs for Region C



Notes: These impacts are based on shortage data provided to the TWDB by Region C in March 2005. The data for each decade are assumed to be independent.

SECTION 4A
LIST OF REFERENCES

(1) Texas Water Development Board, *Exhibit B Guidelines for Regional Water Plan Development*, Austin, [Online] Available URL: http://www.twdb.state.tx.us/RWPG/2nd_cycle_docs.asp, July 16, 2002.

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4B. Water Conservation and Reuse of Treated Wastewater Effluent in Region C

During development of this plan, the Region C Water Planning Group placed strong emphasis on water conservation and reuse as a means of meeting projected water needs. This section provides overviews of water conservation (Section 4B.1), reuse of treated wastewater effluent (Section 4B.2), drought management measures (Section 4B.3), and a summary of recommended water conservation and reuse strategies for Region C (Section 4B.4). Chapter 6 includes more detailed discussions of Region C water conservation (including reuse) and drought management strategies and recommendations.

4B.1 Water Conservation

The Texas Water Code §11.002(8) [1] defines *conservation* as "the development of water resources; and those practices, techniques, and technologies that will reduce the consumption of water, reduce the loss or waste of water, improve the efficiency in the use of water, or increase the recycling and reuse of water so that a water supply is made available for future or alternative uses." By this definition, it is clear that reuse of treated wastewater effluent is a water conservation measure.

Although water conservation measures and drought or emergency water management measures both save water, they are fundamentally different. *Drought/emergency management measures* are defined as temporary measures that are implemented when certain criteria are met and are terminated when these criteria are no longer met, while water conservation measures are designed to provide long-term or permanent water savings.

Currently implemented water conservation strategies and water conservation assumptions implicit in the water demand projections (Chapter 2) are discussed below.

Currently Implemented Water Conservation Strategies in Region C

To provide a basis for assessment of potentially feasible water conservation strategies in Region C, it is necessary to identify currently implemented water conservation strategies in the region. To accomplish this, the Region C Water Planning Group surveyed water user groups, reviewed existing water conservation plans, conducted a study of water conservation on a neighborhood scale, and identified existing reuse strategies in the region. A full discussion of the findings of these studies is contained in Chapter 6.

Table 4B.1 shows the percentage of water user groups (WUGs) and wholesale water providers (WWPs) that have implemented certain water conservation strategies. In Region C, a significant percentage of WUGs and WWPs report having implemented system/utility water conservation strategies. Few report having implemented customer-based water conservation strategies aimed at indoor, outdoor, or industrial, commercial, and institutional (ICI) water use. A small percentage of WUGs and a large percentage of WWPs report reusing treated wastewater effluent.

Table 4B.1
Implemented Water Conservation Strategies in Region C

Type	Method	WUGs	WWPs
System/Utility	Public information/school education	37%	62%
	Water conservation pricing	47%	36%
	System water audit and water loss prevention	68%	73%
	Pressure control and leak detection	49%	45%
	Water waste prohibition	18%	22%
Indoor	Customer indoor water audit	3%	0%
	Showerhead/faucet aerator retrofit program	7%	9%
	Toilet replacement program	4%	0%
	Clothes washer rebate program	0%	0%
Outdoor	Customer irrigation audit	7%	9%
	Landscape irrigation systems rebate	1%	0%
	Landscape design and conversion program	11%	18%
Industrial, Commercial, and Institutional (ICI)	General ICI rebate	0%	0%
	Site-specific ICI program	0%	11%
Reuse	Reuse of treated effluent	16%	69%

Conservation Assumptions in Water Demand Projections

Significant savings in water use due to water conservation are assumed in the projected demands for Region C adopted by the regional water planning group and the Texas Water Development Board. The projected municipal water demands for Region C include projected savings from conversion to low-flow plumbing fixtures. By 2060, low-flow plumbing fixtures are projected to save approximately 5 percent of total regional water demand. In addition, the water demand projections assume that future steam electric power plants will be more efficient, resulting in an additional 2060 savings of approximately 27 percent of steam electric power demand, which is 1.8 percent of the total regional water demand.

Potentially Feasible Water Conservation Strategies

A list of water conservation strategies for Region C was compiled from sources that include a Texas Water Development Board-sponsored study of the effectiveness of various water conservation methods in Texas [(2)] and the Water Conservation Implementation Task Force Best Management Practices Guide [(3)]. The resulting strategies were screened to determine whether they are potentially feasible for use in Region C. Discussion of the screening process and each potentially feasible water conservation strategy is presented below.

Strategies that were identified as possible conservation strategies are listed in Tables 4B.2 through 4B.4. Each of these strategies are appropriate for the end use of the water, meet existing federal and state regulations, and are based on proven technology. However, for other reasons some of the strategies were not selected as potentially feasible strategies in Region C. Athletic Field Conservation and Park Conservation were deemed infeasible for regional water planning purposes due to a lack of data with which to estimate the potential water savings. Metering of water use is virtually universal in Region C, so it is not expected to achieve future water savings in the region. Conservation Coordinators and Wholesale Agency Assistance Programs are not water conservation strategies that result in direct water savings, but instead are ways to implement conservation strategies and should be reflected in the cost of other conservation strategies. New Construction Graywater systems and Rainwater Harvesting/Condensate Reuse are likely to receive limited public participation and have relatively high implementation costs. The remaining municipal conservation strategies in Table 4B.2 were deemed to be potentially feasible. Further discussion of the evaluation of potentially feasible conservation strategies is included in Appendix M.

Table 4B.2
Screening of Municipal Water Conservation Strategies

Strategy Name	Potentially Feasible?	If No, Why?
System Water Audit and Water Loss Prevention	Yes	
Water Conservation Pricing	Yes	
Prohibition on Wasting Water	Yes	
Showerhead, Aerator, and Toilet Flapper Retrofit Program	Yes	
Residential Toilet Replacement Program	Yes	
Residential Clothes Washer Incentive	Yes	
Coin-Operated Clothes Washer Incentive Program	Yes	
School Education	Yes	
Water Survey for Single- and Multi-Family Customers	Yes	
Landscape Irrigation Conservation and Incentives	Yes	
Water Wise Landscape Design and Conversion Programs	Yes	
Athletic Field Conservation	No	Insufficient data to estimate potential water savings.
Metering of All New Connections and Retrofit of Existing Connections	No	Already implemented. Few unmetered connections in Region C.
Wholesale Agency Assistance Programs	No	No direct savings. This is a potential funding source, not a conservation method.
Conservation Coordinator	No	No direct savings. This is administrative overhead included in other conservation methods.
Public Information	Yes	
Rainwater Harvesting and Condensate Reuse	No	Limited public participation and relatively high cost.
New Construction Graywater	No	Limited public participation and relatively high cost.
Park Conservation	No	Insufficient data to estimate potential water savings.
Conservation Programs for Industrial, Commercial, and Institutional Accounts	Yes	
Federal Residential Clothes Washer Standards	Yes	
Water Use Reduction Due to Increasing Water Prices	Yes	
Water Reuse	Yes	

Table 4B.3
Screening of Industrial Water Conservation Strategies

Strategy Name	Potentially Feasible?	If No, Why?
Water Audit	No	No identified sponsor or authority to implement these programs. These strategies are included as elements of potentially feasible municipal water conservation strategies for ICI accounts and wholesale sales to manufacturers.
Water Waste Reduction		
Submetering		
Cooling Tower Conservation		
Cooling Systems (Other Than Cooling Towers)		
Alternative Sources and Reuse of Process Water		
Rinsing/Cleaning Conservation		
Water Treatment Conservation		
Boiler and Steam Systems Conservation		
Refrigeration (Including Chilled Water) Conservation		
Once-Through Cooling		
Management and Employee Programs		
Landscape Conservation		
Site-Specific Conservation		
Water Reuse	Yes	

Table 4B.4
Screening of Agricultural Water Conservation Strategies

Strategy Name	Potentially Feasible?	If No, Why?
Irrigation Scheduling	No	No identified sponsor or authority to implement these programs. There is little irrigated agriculture in Region C.
Volumetric Measurement of Irrigation Water Use		
Crop Residue Management and Conservation Tillage		
On-Farm Irrigation Audit		
Furrow Dikes		
Land Leveling		
Contour Farming		
Conversion of Supplemental Irrigated Farmland to Dry-Land Farmland		
Brush Control/Management		
Lining of On-Farm Irrigation Ditches		
Replacement of On-Farm Irrigation Ditches with Pipelines		
Low Pressure Center Pivot Sprinkler Irrigation Systems		
Drip/Micro Irrigation Systems		
Gated and Flexible Pipe for Field Water Distribution Systems		
Surge Flow Irrigation for Field Water Distribution Systems		
Linear Move Sprinkler Systems		
Lining of District Irrigation Canals		
Replacement of Irrigation District Canals and Laterals with Pipelines		
Tailwater Recovery and Reuse System		
Nursery Production Systems		
Water Reuse	Yes	
Golf Course Conservation	Yes	

With the exception of Water Reuse, the industrial conservation strategies in Table 4B.3 were deemed infeasible for regional water planning purposes due to a lack of necessary data. These strategies are too detailed for regional water planning. They must be applied on a plant-by-plant basis, and there is insufficient information available about specific industries to make a meaningful plan. For example, available data do not identify the number of cooling towers in use in Region C, where they are located, and how much water they use. However, many of the industrial strategies are included as elements of the Conservation Programs for Industrial, Commercial, and Institutional (ICI) Accounts strategy shown as a potentially feasible municipal water conservation strategy in Table 4B.2.

With the exception of Water Reuse and Golf Course Conservation, the agricultural conservation strategies in Table 4B.4 were deemed infeasible for regional water planning purposes for two reasons: there is relatively little irrigated agriculture in Region C, and there are insufficient data with which to identify the agricultural water users that will implement these strategies and how much water savings will result. Many of these strategies must be applied on a farm-by-farm basis, and there is not sufficient information available about specific agricultural users to make a meaningful regional plan. Much of the projected irrigation water demand in Region C is for golf course irrigation, and the Golf Course Conservation and the Water Reuse strategies are potentially feasible water conservation strategies.

The fact that a particular water conservation strategy is considered infeasible for regional water planning purposes does not mean that the strategy should not be implemented for specific local applications where it is found to be appropriate.

The screening of water conservation strategies as shown in Tables 4B.2 through 4B.4 resulted in a list of potentially feasible water conservation strategies for Region C. During the analysis of these strategies, it became advantageous to combine or subdivide the various strategies due to data availability, targeted customer types, etc. For example, the Public Information and School Education strategies shown in Table 4B.2 were combined to form a Public and School Education strategy. The final set of potentially feasible water conservation strategies is discussed below:

Low-Flow Plumbing Fixture Rules. In 1991, the 72nd Texas Legislature passed the Water Saving Performance Standards for Plumbing Act [9]. The Act, implemented in 1992, prohibited the sale, distribution, or importation of plumbing fixtures that do not meet certain low-flow performance standards. Therefore, low-flow plumbing fixtures are used in new construction and in remodeling projects. Projected savings from the Act are included in the regional water demand projections, and the total projected 2060 regional water demand is about 5 percent less than it would be without the Water Saving Performance Standards for Plumbing Act.

Public and School Education. Public and school education programs conserve water by teaching water-conserving behavior to water customers and reinforcing such behavior through periodic reminders. The goal is to make the public aware of the importance of water conservation in managing and sustaining existing water supplies and avoiding or delaying the building of new sources or facilities. Tools to effectively communicate water conservation to the public include the use of print, radio, and television advertising; direct distribution of conservation literature; special events; and informative websites. School education programs provide water conservation curriculum material at appropriate grade levels. A secondary benefit is that students share the water conservation information with their parents.

Water Use Reduction Due to Increasing Water Prices. Water consumption generally decreases with increasing water rates. Therefore, increases in real water prices over time can conserve water. Note, however, that this effect can be offset by increases in real income.

Water System Audit, Leak Detection and Repair, and Pressure Control. In 2003, the 78th Texas Legislature passed House Bill (HB) 3338, which requires all retail public utilities that provide potable water to perform a water system audit to identify system water losses. Apparent water losses include water that was actually used but not accounted for, such as customer meter errors or theft. Accounting for apparent losses increases a utility's revenue but does not reduce water usage. Real losses include overflows at the water treatment plant and leakage from the water distribution system. Identifying and preventing real losses decreases a utility's costs and decreases water usage. Real losses are the target of this water conservation strategy. Leak detection and repair and pressure control are two elements of a proactive water loss control program.

Federal Residential Clothes Washer Standards. Title 10 Part 430 of the Code of Federal Regulations (CFR) requires residential clothes washers manufactured on or after January 1, 2004, to be 22 percent more energy-efficient than pre-2004 models and clothes washers manufactured on or after January 1, 2007, to be 35 percent more energy-efficient than pre-2004 models. The new energy standards are also projected to produce significant water conservation savings.

Water Conservation Pricing Structure. As water rates increase, water consumption generally declines and vice versa. Therefore, changes in water pricing structure can conserve water. Customers respond to changes in average price (the total water bill) and, to a lesser extent, changes in marginal price (the rate paid for an additional gallon of water). A water conservation pricing structure increases marginal prices with increased water consumption. Potential conservation rate structures include increasing block rates, base and excess usage rates, and seasonal rates.

Water Waste Prohibition. To eliminate water waste, a utility may enact and enforce ordinances to prohibit wasteful activities including, but not limited to: irrigation water waste, once-through use of water in commercial equipment, non-recirculation systems in all new conveyer and in-bay automatic car washes and commercial laundry systems, non-recycling decorative water fountains, and installation of water softeners that do not meet certain regeneration efficiency and waste discharge standards [(3)].

Coin-Operated Clothes Washer Rebate. Coin-operated clothes washers are not covered under the federal residential clothes washer rules in Title 10 CFR Part 430. Therefore, a municipal water user group could offer a rebate or other incentive for coin-operated clothes washer owners to upgrade clothes washers to water-efficient models.

Industrial, Commercial, and Institutional (ICI) General Rebate. Under this strategy, water user groups would encourage ICI customers to convert to water-saving equipment and practices by rebating a portion of the acquisition and installation cost of water-saving equipment. Examples of equipment changes or practices that might be eligible for a rebate include [(4, 5)]:

- Replacement of single-pass cooling systems with recirculating or air-cooling systems
- Reuse of high quality rinse water for landscape irrigation or for wash cycles in laundry equipment
- Improvements in cleaning processes
- Installation of water-saving equipment in a car wash.

Industrial, Commercial, and Institutional (ICI) Water Audit, Water Waste Reduction, and Site-Specific Conservation Program. On a regional basis, ICI water use is difficult to characterize in general terms. ICI customers use water for a wide variety of purposes and have a wide variety of use patterns. As such, the most feasible water conservation strategies for an individual ICI customer may be highly site-specific. The ICI water audit, water waste reduction program, and site-specific water conservation program is a regional strategy that is intended to serve as a way to identify, evaluate, and implement water conservation for individual ICI customers. With the assistance of the customer, the ICI water audit will:

- Accurately measure all water entering the facility.
- Inventory and calculate all on-site water uses.
- Identify any unused water sources or waste streams available.
- Calculate water-related costs.
- Identify potential water conservation measures within a facility.

Potential water efficiency measures may include water waste reduction and/or best management practices.

Residential Customer Water Audit. Under this strategy, an auditor reviews a customer's bill to determine whether it is within normal seasonal parameters, reviews water use habits with the customer, and performs an on-site walk-through, if necessary, to teach the customer how to read the water meter, to evaluate the landscaping and irrigation system, to check for leaks, to review conservative water use habits, and, if the customer wishes, to install water saving devices. The auditor then provides a report and water saving suggestions.

Showerhead and Faucet Aerators Retrofit. The 1991 Water Saving Performance Standards for Plumbing Act (9) effectively required the use of low-flow plumbing fixtures in new construction and remodeling projects. The maximum allowable flowrates are 3.0 gallons per minute (gpm) for showerheads and 2.5 gpm for faucets. Showerheads and faucet aerators have a useful life of approximately 5 to 15 years (3). Some fraction of existing inefficient showerheads and aerators has already been replaced with efficient fixtures, and all inefficient fixtures will eventually be replaced without a retrofit program.

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.

Water-Efficient Toilet Rebate. The 1991 Texas Water Saving Performance Standards for Plumbing Act [9] effectively required the use of low-flow plumbing fixtures in new construction and remodeling projects. Under this law, the maximum flowrate for toilets is 1.6 gallons per flush. Toilets have a useful life of approximately thirty years [6]. Some fraction of existing inefficient toilets has already been replaced with efficient fixtures, and all inefficient toilets will eventually be replaced without a rebate program. 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.

Single-Family Water-Efficient Clothes Washer Rebate. 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. As discussed above, federal residential clothes washer energy standards that take effect in 2007 are projected to result in significant water savings. A residential clothes washer has a useful life of approximately 13 years [2], and all inefficient clothes washers will eventually be replaced without a rebate program. However, a single-family water-efficient clothes washer rebate program would accelerate the natural replacement of inefficient clothes washers.

Landscape Irrigation Systems Rebate. Improving the efficiency of irrigation systems can reduce outdoor water usage while maintaining a healthy landscape. 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. A landscape irrigation systems rebate program is targeted toward residential and ICI customers that use automatic irrigation systems.

Landscape Design and Conversion Rebate. Landscape design and conversion programs, involving both plant selection and water wise landscape design principles, are intended for municipal water user groups with residential and ICI customers having high-water-use landscaping that results in substantial irrigation. Financial assistance would be provided to the customer to convert existing high-water-use landscaping to water wise landscaping. In addition, the water user group would either require or provide incentives for new construction to use water wise landscaping on all or part of the property [3].

Efficient New Steam Electric Power Plants. During the development of projected steam electric power water demands [7], it was determined that existing power plants consume approximately 0.60 gallons per kilowatt-hour (gal/kWh). It was also assumed that half of future steam electric power plants would consume water at the current consumption rate and half would consume 0.23 gal/kWh [7]. Projected savings from this assumption are included in the water demand projections, and the total projected 2060 steam electric power water demand is about 1.8 percent less than it would be without assuming efficient new steam electric power plants.

Manufacturing General Rebate. This strategy is modeled after the ICI general rebate strategy for municipal water user groups. Under this strategy, municipal water user groups would encourage wholesale manufacturing customers to convert to water-saving equipment and practices by rebating a portion of the acquisition and installation cost of new water-saving equipment. Examples of equipment changes or practices that might be eligible for a rebate are as follows [4, 5]:

- Replacement of single-pass cooling systems with recirculating or air-cooling systems
- Reuse of high quality rinse water for landscape irrigation or for wash cycles in laundry equipment
- Improvements in cleaning processes
- Installation of water-saving equipment in a car wash.

Golf Course Conservation. Golf course conservation is a potentially feasible water conservation strategy for the irrigation water user groups. Under this strategy, golf course operators would conserve water using computer-controlled irrigation systems, soil moisture sensors, weather stations, irrigation scheduling, efficient irrigation equipment, reduced irrigation area, and other best management practices. Implementation alternatives include voluntary implementation for self-supplied golf courses, rebates for courses supplied by a municipal water user group, and ordinances if supplied by a city.

Recycling of Water in Operations. Recycling of water in operations is a potentially feasible water conservation strategy for the mining water user groups. Under this strategy, a mining water user would conserve water by cycling water through the washing/rinsing process multiple times before discharge. This strategy would be implemented by the owner/operator of the mining operations.

Reuse of Treated Wastewater Effluent. Indirect reuse is a potentially feasible municipal water conservation strategy. Direct reuse is a potentially feasible water conservation strategy for manufacturing, steam electric power, irrigation, and mining water user groups, and has limited potential for non-potable municipal use such as municipal irrigation. Water suppliers in Region C are developing a number of reuse projects that will substantially increase the supply available to the region from reuse. The proposed and recommended reuse projects are discussed in Section 4B.2.

TWDB planning guidelines require that each potentially feasible water management strategy be evaluated to ensure the selection of strategies that provide adequate water supply at a reasonable cost, while providing protection for the state's resources.

During this evaluation process it was found that some of the potentially feasible conservation strategies provided small amounts of water at relatively high costs. These strategies also had low to medium estimates of reliability because they relied on individuals to implement them. Table 4B.5 shows opinions of probable cost for the potentially feasible water conservation strategies. The opinions of probable cost are regional averages and do not necessarily represent the probable cost for an individual water user group. Figure 4B.1 shows a comparison of the projected water supply amount versus the probable unit cost for potentially feasible municipal water conservation strategies.

The potentially feasible water conservation strategies were divided into three groups based on potential water savings, opinions of probable cost, and likelihood and difficulty of implementation. The three groups are:

- Basic Package: substantial amount of projected water savings; low cost; relatively easy to implement
- Expanded Package: substantial savings from reuse, with lesser but significant amount of projected water savings from other measures; competitive cost; somewhat more difficult to implement

- Less Cost-Effective Strategies: small amount of projected water savings; relatively high cost; relatively difficult to implement.

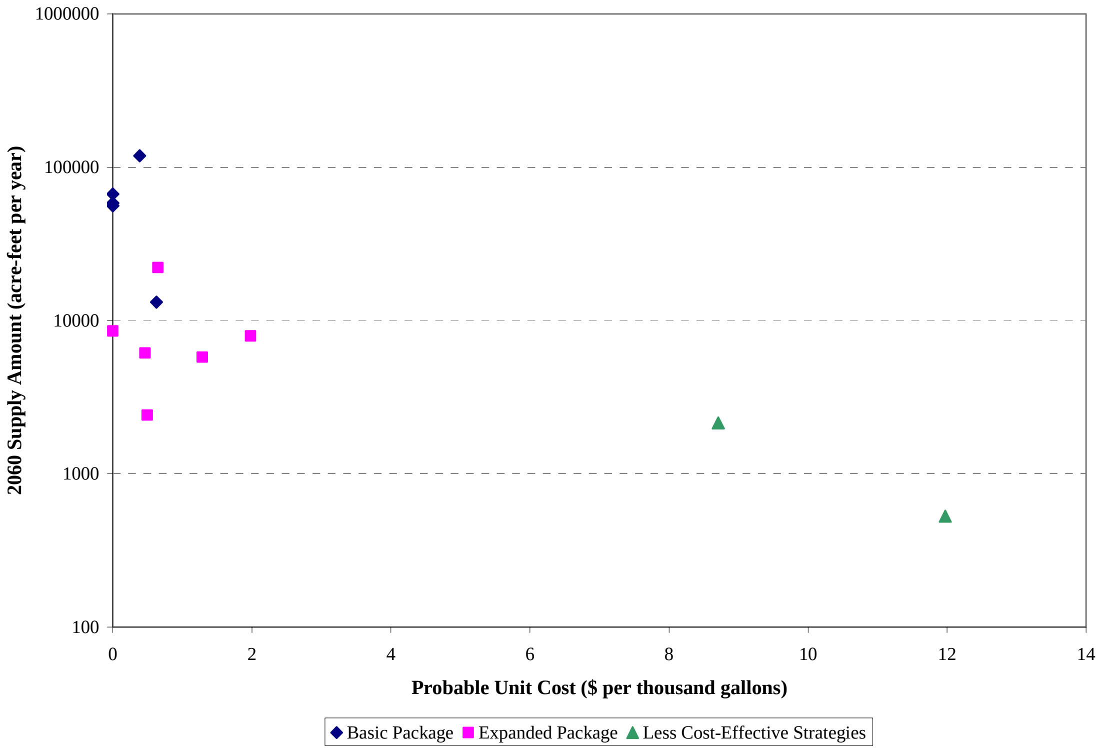
The specific strategies associated with each group are listed in Table 4B.5. The water savings associated with the implementation low-flow plumbing fixture is incorporated into the approved water demands. It is assumed that this strategy will be implemented as part of this plan.

Table 4B.5
Summary of Costs for Potential Water Conservation Strategies
- Cost per 1,000 Gallons of Water Saved -

Strategy	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Low-flow plumbing fixture rules	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Municipal Basic Package						
Public and school education	$0.91	$0.72	$0.60	$0.51	$0.44	$0.39
Water use reduction due to increasing water prices	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Water system audit, leak detection and repair, pressure control	$2.26	$0.66	$0.63	$0.64	$0.63	$0.63
Federal residential clothes washer standards	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Municipal Basic Average	***$0.70***	***$0.37***	***$0.32***	***$0.28***	***$0.25***	***$0.22***
Municipal Expanded Package						
Water conservation pricing structure	$0.11	$0.04	$0.00	$0.00	$0.00	$0.00
Water waste prohibition	$0.00	$1.11	$0.52	$0.49	$0.47	$0.46
Coin-operated clothes washer rebate	$0.00	$0.49	$0.49	$0.49	$0.49	$0.49
Residential customer water audit	$1.93	$1.90	$1.91	$1.93	$1.95	$1.98
ICI general rebate	$0.00	$0.65	$0.65	$0.65	$0.65	$0.65
ICI water audit, water waste reduction, and site-specific conservation program	$0.00	$1.17	$1.20	$1.23	$1.27	$1.29
Municipal Expanded Average	***$0.62***	***$0.93***	***$0.76***	***$0.77***	***$0.77***	***$0.78***
Municipal Less Cost-Effective						
Showerhead and faucet aerator retrofit program	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Toilet replacement program	$5.36	$3.87	$0.00	$0.00	$0.00	$0.00
Single-family water-efficient clothes washer rebate	$4.27	$0.00	$0.00	$0.00	$0.00	$0.00
Landscape irrigation systems rebate	$11.78	$10.70	$9.77	$9.24	$8.92	$8.71
Landscape design and conversion program	$11.93	$11.72	$11.71	$11.74	$11.84	$11.97
Municipal Less Cost-Effective Average	***$4.98***	***$5.19***	***$10.20***	***$9.76***	***$9.52***	***$9.35***

Interbasin Transfer Considerations. According to the planning rules, the *Region C Water Plan* must include a conservation water management strategy for each water user group or wholesale water provider that is to obtain water from a proposed interbasin transfer to which

Figure 4B.1
Supply versus Cost for Water Conservation Strategies



Texas Water Code §11.085 [(l)] applies that will result in the highest practicable level of water conservation and efficiency achievable. During the strategy evaluation process, a set of recommended water conservation strategies was identified (discussed below) that represent the highest practicable level of water conservation and efficiency achievable, based on currently available data and evaluation of competing water supply strategies. In future planning cycles, as new data and information become available, as Region C water user groups gain practical experience in the implementation of water conservation strategies, and as the economics of water supply evolve, it is expected that the standard of "highest practicable level of water conservation and efficiency achievable" will be reevaluated and that the recommended water conservation strategies will be revised.

Recommended Water Conservation Strategies

Regional Summary and Discussion. During the evaluation process, the potentially feasible water conservation strategies for municipal water user groups were divided into groups based on potential water savings, opinions of probable cost, and likelihood and difficulty of implementation. The basic package is recommended for all municipal water user groups. All or part of the expanded conservation package is recommended for 129 out of 271 municipal water user groups. The less cost-effective strategies are not recommended for any municipal water user groups.

The basic package consists of the following water conservation strategies:

- Low-flow plumbing fixture rules (included in the water demand projections)
- Public and school education
- Water use reduction due to increasing water prices
- Water system audit, leak detection and repair, and pressure control
- Federal residential clothes washer standards.

The expanded package consists of one or more of the following water conservation strategies:

- Water conservation pricing structure
- Water waste prohibition
- Coin-operated clothes washer rebate
- Residential customer audit
- Industrial, commercial, and institutional (ICI) general rebate
- ICI water audit, water waste reduction, and site-specific conservation program
- Reuse of treated wastewater effluent (for selected providers).

The recommended water conservation strategies for non-municipal water user groups are:

- Efficient new steam electric power plants (included in demand projections)
- Reuse of treated wastewater (manufacturing, irrigation and steam electric power)
- Golf course conservation
- Manufacturing general rebate
- Recycling of process water for mining.

4B.2 Reuse of Treated Wastewater Effluent

Reuse of treated wastewater effluent is becoming an increasingly important source of water in Region C and across Texas. There are a number of water reuse projects in operation in Region C, and many others are currently in the planning and permitting process.

Direct reuse and indirect reuse have significantly different permitting requirements and potential applications. Direct reuse occurs when treated wastewater is delivered from a wastewater treatment plant to a water user, with no intervening discharge to waters of the state. Direct reuse requires a notification to the Texas Commission on Environmental Quality (TCEQ), which is routinely accepted so long as requirements to protect public health are met. Direct reuse is most commonly used to supply water for landscape irrigation (especially golf courses) and industrial uses (especially cooling for steam electric power plants).

Indirect reuse occurs when treated wastewater is discharged to a stream or reservoir and is diverted downstream or out of the reservoir for reuse. The discharged water mixes with ambient water in the stream or reservoir as it travels to the point of diversion. Many of the water supplies within Region C have historically included return flows from treated wastewater as well as natural runoff. These return flows provide a supplement to supply that can be used as long as the return flows continue. An entity can ensure the ability to use its return flows through a water right permit from the TCEQ. A wastewater discharge permit from the TCEQ may also be required if the discharge location were to be changed as part of the reuse project.

Potential applications for water reuse in Region C include:

- Landscape irrigation (parks, school grounds, freeway medians, golf courses, cemeteries, residential)
- Agricultural irrigation (crops, commercial nurseries)
- Industrial and power generation reuse (cooling, boiler feed, process water, heavy construction, mining)
- Recreational/environmental uses (lakes and ponds, wetlands, stream flow augmentation)
- Supplementing potable water supplies.

There are a number of benefits associated with water reuse as a water management strategy, including:

- Water reuse represents an effective water conservation measure.

- Water reuse provides a reliable source that remains available in a drought.
- Water reuse quantities increase as population increases.
- Water demands that can be met by reuse are often near reuse sources.
- Water reuse is a viable way to defer and avoid construction of new surface water impoundments.

Reuse has been a source of water supply in Region C for a number of years. Currently Region C is reusing nearly 100,000 acre-feet per year of wastewater return flows for water supplies. Under current permits and infrastructure, this use is expected to increase to 103,400 acre-feet per year by 2060. There are also several reuse projects that have been permitted, but do not have infrastructure in place. The largest of these are the Tarrant Regional Water District reuse projects at Richland-Chambers Reservoir and Cedar Creek Reservoir. These projects will provide a permitted supply of 115,500 acre-feet per year and supplement the safe yield of the reservoirs by 73,265 acre-feet per year in 2060, making a total of 188,765 acre-feet per year available to the Tarrant Regional Water District. A number of other reuse projects have already been defined, and planning is in the early stages. These will be considered as potentially feasible strategies. A list of the current reuse projects in Region C is shown on Table 6.3 in Section 6 and discussed in detail in Appendix I.

In general, reuse strategies will require the use of multiple barriers (such as advanced wastewater treatment, blending, residence time, and/or advanced water treatment) to mitigate potential negative impacts to the environment, agricultural resources, and other resources. Sources of wastewater effluent needed for new reuse projects are generally limited to owners and operators of large wastewater treatment plants. These include the Trinity River Authority, which operates several wastewater treatment plants in the region, North Texas Municipal Water District, the cities of Fort Worth and Dallas, and several smaller cities.

The potential for additional reuse projects in Region C is dependent upon the amount of wastewater generated and the ability of the user to use treated effluent. Approximately 90 percent of the 1.4 million acre-feet of water currently used in the Trinity River Basin in Region C is attributed to municipal and manufacturing use. Municipal and manufacturing use in Region C is expected to increase to 2.9 million acre-feet per year by 2060. Currently, much of the water is supplied from sources in the Trinity River Basin, although nearly 364,500 acre-feet per year is obtained from sources outside the basin. By 2060, 1.5 million acre-feet per year of water supply will be obtained from outside the Trinity River Basin. Of the total amount of water projected for use in Region C, a considerable amount is expected to be returned to the Trinity River Basin through return flows.

Return flow is the term used to describe water that has been beneficially used and then is discharged to a receiving stream or reservoir. Existing streams and reservoirs have historically relied on these return flows for water supplies and instream uses. Recommending reuse projects that have a significant impact to the historical return flows can have an impact to the health of the river system. Discussions with the regional and local water providers identified several potential reuse projects that could be used to help meet the projected shortages in Region C. A list of the recommended reuse projects in Region C is shown in Table 4B.6.

As part of this plan, Region C evaluated the potential impacts of the recommended reuse projects on stream flows in the Trinity River Basin in Region C. This study assessed current return flows [(8)], projected future return flows, and evaluated the impacts on future return flows due to the recommended reuse strategies. The future return flows were estimated from the projected demands for municipal and manufacturing water use in the Trinity River Basin (adjusted for projected demand reductions due to conservation) and return flow factors determined from historical data (69 percent for the Metroplex and 50 percent for other counties). All indirect reuse projects (current and recommended future projects) and future direct reuse projects identified in the Region C plan were subtracted from the projected return flows to provide an estimate of the net return flows in the Trinity River Basin. Table 4B.7 presents a summary of the return flow calculations for the region, and the projected net return flows by county are listed in Table 4B.8. A comparison of the historical return flows to the projected total and net return flows is shown in Figure 4B.2.

Potential for Reclaimed Water in Water Management Strategies

The potential for reclaimed water in Region C water management strategies is a function of the amount of water used and wastewater treated in the basin. Based on the total projected return flows to the Trinity River Basin in Region C, there is the potential to reuse approximately 400,000 acre-feet per year in 2010 while maintaining the same level of historical return flows. By 2060, over 1 million acre-feet per year of treated wastewater effluent could be reused while maintaining historical flows. While this water may be discharged to the Trinity River Basin, the ability to use these flows to meet water needs depends on the location of the discharges, the type of water needs and the ability of existing surface water sources to assimilate large quantities of wastewater effluent. The Region C plan proposes to reuse over 330,000 acre-feet of return flows in 2010 through both direct and indirect reuse projects, with most of this additional reuse occurring in the Trinity River Basin. By 2060, the proposed reuse in the region is expected to reach nearly 800,000 acre-feet per year. As shown in Figure 4B.2 the level of reuse proposed in the Region C plan will result in net return flows in the Trinity River Basin remaining near historical levels through 2030 and increasing substantially from 2040 on.

Table 4B.6
Recommended Water Reuse Projects in Region C
- Values in Acre-feet per Year -

Reuse Project	User	2010	2020	2030	2040	2050	2060
NTMWD Additional Wilson Creek Indirect Reuse	NTMWD	26,956	35,941	35,941	35,941	35,941	35,941
NTMWD East Fork Reuse	NTMWD	81,400	96,400	102,000	102,000	102,000	102,000
DWU Direct Reuse	DWU	20,456	20,456	20,456	20,456	20,456	20,456
DWU Southside Indirect Reuse	DWU	0	67,253	67,253	67,253	67,253	67,253
DWU Lewisville Indirect Reuse	DWU and customers	0	0	67,253	67,253	67,253	67,253
DWU and UTRWD Indirect Reuse of Return Flows above Dallas Lakes	DWU and UTRWD	34,366	44,746	53,141	60,640	69,854	79,605
TRWD Trinity River Indirect Reuse (Richland-Chambers)	TRWD	63,000	63,000	63,000	63,000	63,000	63,000
TRWD Trinity River Indirect Reuse (Cedar Creek)	TRWD	0	52,500	52,500	52,500	52,500	52,500
TRWD Additional Yield from Richland-Chambers due to reuse project	TRWD	21,556	28,612	35,668	37,465	37,465	37,465
TRWD Additional Yield from Cedar Creek due to reuse project	TRWD	0	24,934	27,651	30,368	33,085	35,800
TRA Joe Pool Lake Indirect Reuse	Johnson County SUD (Region G)	0	20,000	20,000	20,000	20,000	20,000
TRA Joe Pool Lake Indirect Reuse	Unknown	0	3,500	3,500	3,500	3,500	3,500
TRA Tarrant County Reuse (Tarrant County-Other)	Grapevine/ Irrigation		7,500	7,500	7,500	7,500	7,500
UTRWD Indirect Reuse of Chapman Lake	UTRWD	8,441	8,301	8,161	8,021	7,882	7,743
Athens Indirect Reuse	Athens MWA	1,662	1,966	2,325	2,677	2,677	2,677
Ennis Indirect Reuse	Ennis	0	0	74	1,037	2,269	3,696
TRA Mountain Creek Direct Reuse SEP (Dallas County)	Dallas County-SEP	0	3,000	3,000	3,000	3,000	3,000

Table 4B.6, Continued

Reuse Project	User	2010	2020	2030	2040	2050	2060
TRA Ellis County Direct Reuse SEP	Ellis County-SEP	20,000	20,000	30,000	30,000	40,000	40,000
TRA Additional Las Colinas Indirect Reuse	Dallas County-Irrigation		7,000	7,000	7,000	7,000	7,000
TRA Direct Reuse for Tarrant County Irrigation	Tarrant County-Irrigation	3,750	3,750	3,750	3,750	3,750	3,750
TRA Direct Reuse for Denton County Irrigation	Denton County-Irrigation	3,750	3,750	3,750	3,750	3,750	3,750
Gainesville Indirect	Gainesville	0	561	561	561	561	561
TRA Contract With Irving	TRA/Irving	28,000	28,000	28,000	28,000	28,000	28,000
TRA Freestone County Direct Reuse SEP	Freestone County-SEP			10,000	10,000	20,000	20,000
TRA Kaufman County Direct Reuse SEP	Kaufman County-SEP		7,500	15,000	15,000	15,000	15,000
Fort Worth Direct Reuse from Village Creek WWTP	Tarrant County-SEP	500	500	1,100	2,000	2,600	2,600
Fort Worth Direct Reuse - Mary's Creek	Tarrant County Irrigation	0	1,240	1,570	1,570	1,570	1,570
Fort Worth Direct Reuse - Central Business District	Tarrant County Irrigation	0	2,240	3,360	3,360	3,360	3,360
Fort Worth Direct Reuse - Alliance Corridor	Tarrant County Irrigation	0	1,120	2,240	3,360	3,360	3,360
Waxahachie Additional Reuse	Waxahachie	3,112	2,963	2,684	2,405	2,125	1,846
UTRWD Indirect Reuse of flows from Lake Ralph Hall	UTRWD		17,760	17,760	17,760	17,760	17,760
Weatherford Indirect Reuse	Parker County SEP		5,000	5,000	5,000	5,000	5,000
Bridgeport Direct Reuse	Wise County SEP	0	0	0	1,500	2,000	2,000
Decatur Direct Reuse	Wise County SEP	0	0	0	2,000	2,000	2,000
Local Mining Reuse	Wise County	14,337	14,133	22,428	19,652	24,648	28,520
Total Reuse Projects in Region C		**331,286**	**593,627**	**723,627**	**739,279**	**778,119**	**795,466**
Total Amount used in Region C		**329,071**	**569,353**	**699,097**	**714,602**	**753,567**	**770,988**

Note: It is assumed that a portion of reuse supply to TRWD and Athens MWA will be provided to customers outside of Region C. This is accounted for in the total supply from reuse to Region C.

Table 4B.7
Summary of Projected Return Flows Associated with Municipal and Manufacturing Water Use in the Trinity River Basin in Region C

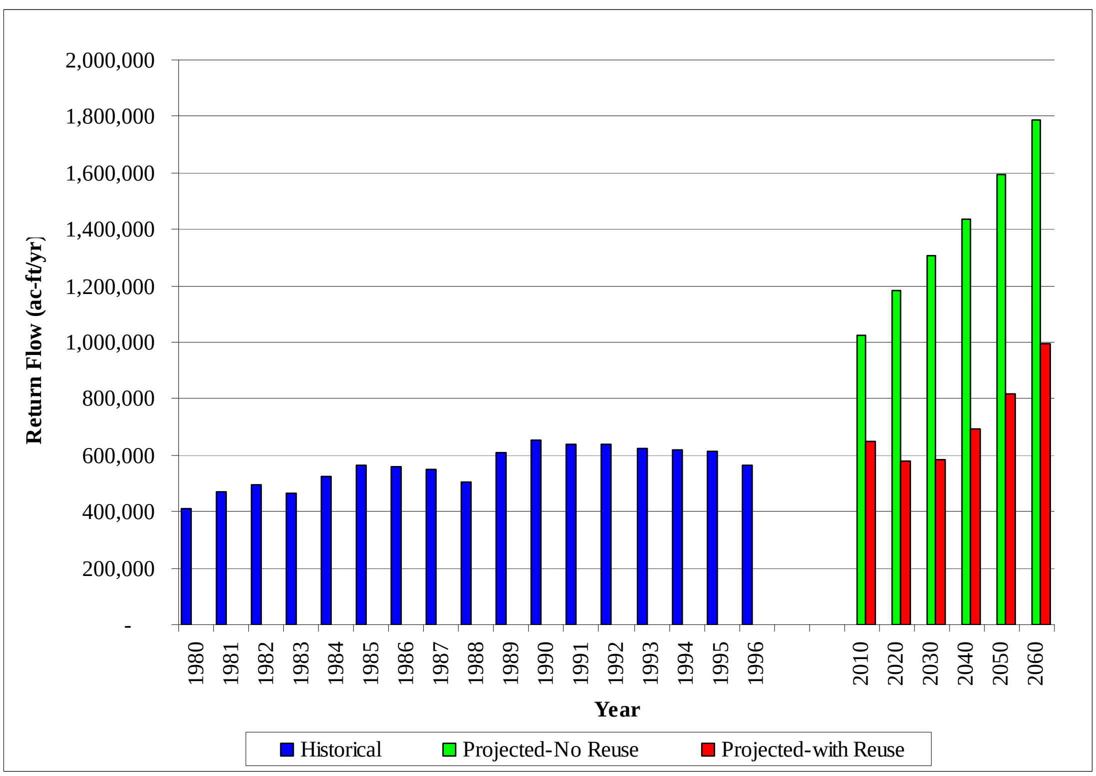
	2010	2020	2030	2040	2050	2060
Demands	1,563,725	1,858,601	2,092,965	2,328,370	2,607,058	2,943,509
Conservation Savings	51,370	106,427	148,159	188,500	230,232	277,434
Net Demands	1,512,355	1,752,174	1,944,806	2,139,870	2,376,826	2,666,075
Projected Return Flows	1,022,392	1,181,415	1,307,898	1,437,611	1,595,689	1,789,184
Proposed Reuse	372,112	601,685	724,073	743,867	780,471	796,279
Net Return Flows	650,279	579,730	583,825	693,745	815,218	992,905

Table 4B.8
Projected Net Return Flows in the Trinity River Basin in Region C

County	2010	2020	2030	2040	2050	2060
Group [a]	602,013	522,438	514,718	618,872	729,174	893,624
Cooke	3,385	3,640	3,990	4,246	4,696	5,110
Ellis	9,380	11,348	13,820	16,372	19,452	23,106
Fannin	336	360	480	690	959	1,200
Freestone	1,355	1,424	1,471	1,509	1,558	1,619
Grayson	2,189	3,338	4,109	4,595	5,059	5,501
Henderson	3,310	3,721	4,150	4,594	5,652	6,996
Jack	526	542	561	574	594	618
Kaufman	8,584	11,162	13,006	14,640	16,500	18,903
Navarro	5,237	5,631	6,039	6,373	6,887	7,594
Parker	7,695	7,893	11,611	13,409	15,437	17,317
Wise	6,272	8,235	9,873	7,873	9,253	11,321
Total	650,279	579,730	583,825	693,745	815,218	992,905

Note: a. The grouped counties include Collin, Dallas, Denton, Rockwall and Tarrant.

Figure 4B.2
Summary of the Historical and Projected Return Flows in the Trinity River Basin in Region C



4B.3 Drought Management Measures

Drought management and emergency response planning are intended to preserve water resources for the most essential uses when water supplies are threatened by an extraordinary condition such as a multi-year drought, an unexpected increase in demand, or a water supply system component failure.

Drought management and emergency response measures are important planning tools for all water suppliers. They provide protection in the event of water supply shortages, but they are not a reliable source of additional supplies to meet growing demands. They provide a backup plan in case a supplier experiences a drought worse than the drought of record, or a water management strategy is not fully implemented when it is needed. Therefore, drought management measures are not recommended as a water management strategy to provide additional supplies for Region C.

4B.4 Summary of Water Conservation and Reuse Recommendations

The Region C Water Planning Group recommends the basic conservation package (as described in Section 4B.1) for all municipal water user groups. All or part of the expanded package is recommended for 129 out of 271 municipal water user groups. The less cost-effective strategies are not recommended for any municipal water user groups. Recommended non-municipal water conservation strategies include manufacturing general rebates, golf course conservation and reuse.

Table 4B.9 shows a regional summary of estimated water savings from recommended water conservation and reuse strategies. By 2060, the projected water supplies and/or savings from water conservation are expected to be over one million acre-feet per year. Estimated costs for these strategies by entity are included in Appendix U. The recommended water conservation for each water user group is shown in Appendix V.

Table 4B.9
Summary of Water Conservation Strategies
- Values in Acre-Feet per Year -

Strategy	2010	2020	2030	2040	2050	2060
Municipal						
Low-flow plumbing fixture rules[a]	0	0	0	0	0	0
Municipal Basic Package	42,659	94,252	123,878	156,586	195,957	240,866
Municipal Expanded Package[b]	10,345	18,986	32,702	42,049	46,478	51,036
Non-Municipal Conservation						
Efficient new steam electric power plants[a]	0	0	0	0	0	0
Manufacturing strategies	0	132	1,530	2,257	2,457	2,618
Irrigation strategies	57	937	1,804	2,261	2,690	3,119
Reuse Strategies	329,071	569,353	699,097	714,602	753,567	770,988
Total Conservation and Reuse	**382,132**	**683,660**	**859,011**	**917,755**	**1,001,149**	**1,068,627**

Notes: a. Savings associated with these strategies are incorporated into the approved water demands and are shown in this table as a recommended strategy with no additional supply. The total estimated water savings from these strategies in 2060 is 241,923 acre-feet per year (see Table 6.5).

b. Includes accelerated conservation for the city of Dallas.

SECTION 4B
LIST OF REFERENCES

(1) Texas Water Code, Chapter 11 Water Rights, Austin, [Online], Available URL: http://www.capitol.state.tx.us/statutes/wa.toc.htm, May 2005.

(2) GDS Associates, Inc.: *Quantifying the Effectiveness of Various Water Conservation Techniques in Texas*, prepared for the Texas Water Development Board, Austin, [Online], Available URL: http://www.twdb.state.tx.us/assistance/conservation/gdsstudy.asp May 2002.

(3) GDS Associates, Inc., Chris Brown Consulting, Axiom-Blair Engineering, Inc., and Tony Gregg, P.E.: *Texas Water Development Board Report 362 Water Conservation Best Management Practices Guide,* prepared for the Water Conservation Implementation Task Force, Austin, [Online], Available URL: http://www.twdb.state.tx.us/assistance/conservation/TaskForceDocs/WCITFBMPGuide.pdf, November 2004.

(4) City of Austin: *Commercial Incentive Program Guide*, Austin, [Online], Available URL: http://www.ci.austin.tx.us/watercon/downloads/cguidelines0503.pdf, July 2004.

(5) San Antonio Water System: *Large-Scale Retrofit Rebate Program*, [Online], Available URL: http://www.saws.org/conservation/commercial/retrofit.shtml, July 2004.

(6) Montgomery Watson: *Water Conservation Plan*, prepared for the City of Austin, March 1993.

(7) Texas Water Development Board: *Power Generation Water Use in Texas for the Years 2000 Through 2060 Final Report*, prepared for the Texas Water Development Board by Representatives of Investor-Owned Utility Companies of Texas, January 2003.

(8) Espey, Padden and Freese and Nichols, Inc., “Memorandum to File, Workplan for Developing Naturalized Streamflows and Project Management Plan”, Trinity River Basin Water Availability Model, September 1999.

(9) Codified in Texas Health & Safety Code, Chapter 372, Environmental Performance Standards for Plumbing Fixtures, [Online], available URL: http://www.capitol.state.tx.us/statutes/hs.toc.htm, December 2005.

4C. Methodology for Evaluation and Selection of Water Management Strategies

Section 4B discusses the evaluation and selection of water conservation and reuse strategies to meet needs in Region C. This section describes the process to determine potentially feasible strategies for Region C and the methods used in evaluation of potentially feasible strategies and the selection of recommended strategies. The steps in the evaluation and selection of water management strategies for Region C include the following:

- Review of previous plans for water supply in Region C, including locally developed plans and the 2002 State Water Plan [(1)]
- Consideration of the types of water management strategies required by Senate Bill One regional planning guidelines [(2)]
- Development of evaluation criteria for management strategies
- Selection for evaluation of potentially feasible water management strategies that could meet needs in Region C
- Environmental evaluation of individual strategies
- Development of cost information for individual strategies
- Discussions with regional wholesale water providers
- Selection of recommended strategies for Region C.

Previous Planning Efforts

Appendix B is a list of previous water-related plans and reports for Region C. The region has a long history of successful local water supply planning and development. When the update to the Senate Bill One planning process began in 2003, pre-existing plans for future water supply in Region C included the following:

- Dallas Water Utilities planned to connect its currently unused supplies in Lake Fork Reservoir and Lake Palestine to its system.
- Tarrant Regional Water District was planning to divert return flows of treated wastewater from the Trinity River into Cedar Creek Reservoir and Richland-Chambers Reservoir to increase the yield of its system.
- Tarrant Regional Water District was planning to participate in Marvin Nichols Reservoir on the Sulphur River or develop Lake Tehuacana on Tehuacana Creek.
- North Texas Municipal Water District was planning to expand its existing reuse project and seek additional water supplies.

- Irving and Upper Trinity Regional Water District had obtained water supplies in Chapman Lake and were constructing water transmission facilities (completed in 2003) to deliver the supplies to Lewisville Lake.
- Several Region C water suppliers were considering the development of water supplies in the Sulphur River Basin to the east. Alternatives included George Parkhouse Lakes (North and South), Marvin Nichols Reservoir, and Marvin Nichols Lake (South).
- Other Region C suppliers were planning and developing smaller water supply projects to meet local needs, whether by connecting to regional water suppliers or developing independent resources.

While this regional water plan was being developed, planning and development efforts by local water suppliers have continued. Some examples include the following:

- Dallas Water Utilities is constructing transmission facilities to connect its Lake Fork Reservoir supplies to its system.
- Dallas Water Utilities has completed an update of its long-range water supply plan [3], including development and implementation of major water conservation and water reuse programs [4, 5].
- Tarrant Regional Water District has received a water right permit for its proposed Trinity River diversion reuse project.
- Tarrant Regional Water District is constructing improvements to increase the capacity of its transmission system from East Texas.
- Tarrant Regional Water District has begun design of the Eagle Mountain Connection to deliver East Texas water to Eagle Mountain Lake.
- North Texas Municipal Water District has applied for additional reuse in Lake Lavon, reuse from the East Fork of the Trinity River, and additional water rights from Lake Texoma.
- North Texas Municipal Water District has developed a new water conservation and drought contingency plan [6] and has developed model water conservation and drought contingency plans for its member cities and customers [7, 8].
- North Texas Municipal Water District and Upper Trinity Regional Water District have expanded their regional water treatment and treated water delivery systems.
- The Greater Texoma Utility Authority has begun to develop a pipeline to deliver water from the North Texas Municipal Water District to users in northern Collin and southern Grayson Counties.
- Gainesville has developed a surface water supply from Moss Lake.
- Weatherford has completed transmission facilities from Benbrook Lake.
- Terrell has contracted to obtain treated water from the North Texas Municipal Water District.
- Midlothian and Ennis are developing connections to obtain raw water from the Tarrant Regional Water District through the Trinity River Authority.

- Several Ellis County water suppliers have contracted with Dallas Water Utilities for treated water and are developing facilities to deliver it.
- Athens Municipal Water Authority has obtained a permit for indirect reuse through Lake Athens.
- Several steam electric power generating facilities have obtained water from existing raw water supplies or reuse of treated wastewater.
- Many Region C suppliers have developed updated water conservation and drought contingency plans.
- As discussed in Chapter 6, several Region C water suppliers have applied for permits to allow reuse of return flows of treated wastewater.

Most Recent State Water Plan

Plans for Region C in the most recent state water plan, *Water for Texas – 2002* (1), were based on the 2001 *Region C Water Plan* (9). Table 4C.1 lists water management strategies in the 2001 *Region C Water Plan* that provided 25,000 acre-feet of new supplies or more. The plan also included many smaller water management strategies.

4C.1 Types of Water Management Strategies and Potentially Feasible Strategies for Water Supply in Region C

Senate Bill One guidelines require that certain types of water management strategies be considered as means of developing additional water supplies. The types of strategies that must be considered include the following (2):

- Water conservation and drought response planning
- Reuse of wastewater
- Expanded use or acquisition of existing supplies, including system optimization and conjunctive use
- Reallocation of reservoir storage to new uses
- Voluntary redistribution of water resources
- Voluntary subordination of water rights
- Enhancement of yields of existing sources
- Control of naturally occurring chlorides
- Brush control, precipitation enhancement, and desalination

Table 4C.1
Recommended Water Management Strategies
Exceeding 25,000 Acre-Feet per Year in the 2001 *Region C Water Plan*

Strategy	Sponsor	Supply Available from Strategy in Acre-Feet per Year
Marvin Nichols I Reservoir North (Phases I and II)	Dallas County-Other, North Texas Municipal Water District, Dallas Water Utilities & Tarrant Regional Water District, Irving	495,300
Lake Fork Connection	Dallas Water Utilities	120,000
Reuse from Trinity River (Phases I and II)	Tarrant Regional Water District	115,500
Cedar Creek/Richland-Chambers pipeline expansion	Tarrant Regional Water District	110,000
Lake Palestine Connection	Dallas Water Utilities	109,600
East Fork Reuse Project	North Texas Municipal Water District	102,000
Lower Bois d'Arc Creek Lake	North Texas Municipal Water District	98,000
Reuse	Trinity River Authority (multiple strategies)	81,500
Indirect Reuse	Dallas Water Utilities	68,300
Oklahoma water	North Texas Municipal Water District & Tarrant Regional Water District	62,000
Chapman Lake	Irving & Upper Trinity Regional Water District	63,400
Return Flows above Lakes	Dallas Water Utilities	50,000
Additional indirect reuse	North Texas Municipal Water District	35,872

- Water right cancellation
- Aquifer storage and recovery
- New supply development
- Interbasin transfers
- Other measures.

The Region C Water Planning Group reviewed each of these types of water management strategies and determined whether there were potentially feasible strategies to develop water supply in Region C within each type. Water conservation and drought response planning and reuse strategies are discussed in Section 4B and Chapter 6. Other types of management strategies are discussed below, and a more detailed listing of potentially feasible water management strategies for Region C is included in Appendix S.

Reservoir System Operation

System operation is the coordinated use of multiple sources of supply, usually surface water reservoirs. System operation is widely used throughout Region C, and can be implemented for many purposes, including gaining yield, reducing pumping costs, or maintaining acceptable water quality. Most of the systems in Region C are operated primarily to reduce pumping costs. For the purpose of the Region C planning process, only system operation that results in increased yield will be considered as potentially feasible water management strategies. The following system operations were adopted as potentially feasible strategies to gain additional supplies for Region C:

- Dallas Water Utilities reservoirs
- Tarrant Regional Water District reservoirs
- System operation of Wright Patman Lake and Chapman Lake to gain additional yield.

Summary of Decision: System operation is widely used in Region C, primarily to reduce pumping costs. Potentially feasible system operation strategies to provide additional yield should be investigated.

Connecting Existing Supplies

The connection of existing supplies that are not yet being fully utilized was a major element of the 2001 *Region C Water Plan* [9]. There are several sources of water supply that have long been committed for use in Region C and could be connected to provide additional water supply. Region C water suppliers could also connect to currently uncommitted supplies in other regions, but these supplies are not necessarily available for use in Region C.

Table 4C.2 lists potentially feasible water management strategies for Region C based on the connection of existing sources that would supply over 25,000 acre-feet per year. In addition to the strategies listed in Table 4C.2, smaller potentially feasible strategies to connect existing supplies are listed in Appendix S. There are also several general categories of strategies to connect existing supplies that are considered to be potentially feasible in Region C:

- Connections to other water user groups or wholesale water providers
- Expansion and renovation of existing connections and transmission systems
- New, renewed, and increased contracts for water
- Water treatment plant expansions.

The development (or continued development) of regional water systems was also an important part of the 2001 *Region C Water Plan* [9]. The following regional systems were in the 2001 Plan and are potentially feasible strategies for this plan:

- North Texas Municipal Water District
- Upper Trinity Regional Water District
- Trinity River Authority Tarrant County Water Supply Project
- Trinity River Authority Ellis County Project
- Cooke County
- Grayson County
- East Parker County
- Fannin County
- Southeast Wise County (Walnut Creek SUD).

Summary of Decision: Include connection of existing supplies as a major component of the Region C plan. Evaluate specific potentially feasible strategies for connection of existing supplies.

Conjunctive Use of Groundwater and Surface Water

In Region C, only 5 percent of the water used comes from groundwater. Groundwater is sometimes used to meet peak demands in systems that have both groundwater and surface water supplies. This does not, however, increase total supply on a yearly basis. Therefore, conjunctive use should not be considered as a potentially feasible water management strategy to provide additional supplies for Region C.

Table 4C.2
Potentially Feasible Water Management Strategies for Connecting Existing Supplies Exceeding 25,000 Acre-Feet per Year

Strategy	Potential Sponsor(s) [a]	Maximum Supply Available to Region C from Strategy in Acre-Feet per Year	Included in 2001 Plan?
Toledo Bend Reservoir	SRA, NTMWD, TRWD, DWU, and UTRWD	600,000	No
Gulf of Mexico with Desalination	DWU, NTMWD, and TRWD	Unlimited [b]	No
Wright Patman Lake – System	DWU, NTMWD, and TRWD	390,000	No
Sam Rayburn Reservoir/B.A. Steinhagen	DWU, NTMWD, or TRWD	200,000	No
Lake Livingston	DWU, NTMWD, or TRWD	200,000	No
Wright Patman Lake – Raise Flood Pool	DWU, NTMWD, TRWD, or UTRWD	180,000	No
Oklahoma Water	DWU, NTMWD, TRWD, and UTRWD	165,000 or more	Yes
Lake Fork Reservoir	DWU	120,000	Yes
Lake Palestine	DWU	114,337	Yes
Lake Texoma - Blend	NTMWD	113,000	No (smaller project was in plan)
Lake Texoma Not Yet Authorized - Blend	DWU, NTMWD, TRWD, or UTRWD	about 220,000 (full use of Texas' share)	No
Lake Texoma - Desalination	NTMWD	105,000	No
Lake Texoma Not Yet Authorized - Desalination	DWU, NTMWD, or TRWD	about 220,000 (full use of Texas' share)	No
Wright Patman Lake – Texarkana	DWU, NTMWD, TRWD, or UTRWD	100,000	No
Carrizo-Wilcox Groundwater (Brazos County)	DWU or NTMWD	100,000	No
DWU Cypress River Basin Supplies (Lake O' the Pines)	DWU, NTMWD, or TRWD	89,600	No
GTUA Lake Texoma Already Authorized	GTUA	56,500	Yes

Table 4C.2, Continued

Strategy	Potential Sponsor(s)	Maximum Supply Available to Region C from Strategy in Acre-Feet per Year	Included in 2001 Plan?
Upper Sabine River Basin	NTMWD	50,000	No
Additional Lake Palestine	DWU	30,000	No
TRWD Purchase from Brazos River Authority	TRWD	28,000	No
NTMWD/GTUA Supply to North Collin and South Grayson Counties	Multiple	26,015	Yes
Ellis County Project	TRA / TRWD	26,582	Yes

Notes: a. Recommended and alternative strategies for wholesale water providers are discussed in Section 4E.

b. This strategy was evaluated for the transmission of 200,000 acre-feet per year of treated water to the Metroplex.

Summary of Decision: Do not include the conjunctive use of ground water and surface water as a source of additional supplies for Region C. Conjunctive use to meet peak needs is appropriate and should continue.

Reallocation of Reservoir Storage

There are two types of reallocation of existing reservoir storage. Reallocation among various water supply uses (municipal, industrial, irrigation, etc.) is a relatively simple matter. It is considered to be a minor water right amendment by Texas Commission on Environmental Quality (TCEQ). This type of reallocation should be allowed at the discretion of the owner of the water right and should be considered to be consistent with the Region C plan.

The more complex type of reallocation is to transfer water from other uses such as hydropower generation or flood control to water supply. There are three reservoirs that have the potential for this type of storage reallocation and might provide supplies for Region C:

- Wright Patman Lake in the Sulphur River Basin in Region D has storage allocated to flood control that could be reallocated for municipal use. This would require environmental studies by the Corps of Engineers and Congressional approval.

- In Lake Texoma in the Red River Basin, Congress recently approved the reallocation of 150,000 acre-feet of storage from hydropower to municipal use in Texas and 150,000 acre-feet of storage from hydropower to municipal use in Oklahoma. Actual reallocation will require environmental studies which are currently underway [10]. Additional reallocation from hydropower storage to conservation storage is possible in Lake Texoma, and this would require additional Congressional approval.
- The reallocation of flood storage to municipal storage in Bardwell Lake in Ellis County has also been considered.

Most other Region C reservoirs with flood control or hydropower storage already have sufficient conservation storage to develop their potential supplies. Therefore, the reallocation of storage in other reservoirs is not likely to provide significant additional supplies for the region.

Summary of Decision: Permit transfers among types of water use at the discretion of the water right holder. Evaluate reallocation to municipal use for Lake Texoma, Wright Patman Lake, and Bardwell Lake.

Voluntary Redistribution of Water Resources

In many cases, the connection of existing sources and the development of new sources require the voluntary redistribution of water resources by sale from the owner of the supply to the proposed user. (This would be true unless the proposed user is also the owner of the supply.) The water management strategies involving the voluntary redistribution of water resources are discussed under other categories.

Summary of Decision: Evaluate potentially feasible strategies involving the voluntary redistribution of water resources under other categories.

Voluntary Subordination of Water Rights

Voluntary subordination of water rights is most useful where senior water rights limit reservoir yields under the prior appropriations doctrine. Very little additional yield is available for existing reservoirs in Region C by voluntary subordination. This strategy is appropriate for new water supply sources that would have junior water rights. In Region C, subordination of water rights is necessary to obtain the permitted amount for Muenster Lake in Cooke County.

Summary of Decision: Include voluntary subordination of water rights as a source of water supply for Muenster Lake.

Enhancement of Yields of Existing Sources

Examples of ways to enhance the yield of existing sources might include the following:

- Artificial recharge of aquifers
- System operation of reservoirs
- Conjunctive use of surface water and groundwater

System operation of reservoirs and conjunctive use are discussed separately above. Artificial recharge of aquifers has not been implemented or studied in depth in Region C. If artificial recharge were to be implemented, it would probably be as part of an aquifer storage and recovery (ASR) program, which is discussed separately below.

Summary of Decision: Do not include enhancement of yields of existing sources as a source of water supply for Region C except as discussed under other categories.

Control of Naturally Occurring Chlorides

The Brazos and Red River Basins have chloride concentrations in excess of desirable levels for municipal use. Much of the chloride in these basins is naturally occurring. Chloride control has been studied in the Brazos and Red River Basins and partially implemented in the Red River Basin. Current plans call for additional chloride control in the Lake Kemp watershed in Region B. If that project is successful, additional chloride control in the Lake Texoma watershed is possible. However, it does not appear likely that chloride control will have a significant impact on chloride levels in Lake Texoma during the current planning horizon. Chloride control projects should continue to be monitored. The Texas Commission on Environmental Quality and the Texas Railroad Commission should continue efforts to control chloride resulting from man-made conditions.

Summary of Decision: Monitor chloride control projects. Do not include control of naturally occurring chlorides as a source of water supply for Region C.

Brush Control

Brush control is the process of removing non-native brush from the banks along rivers and streams and upland areas in order to reduce water consumption by vegetation and increase stream flows and groundwater availability. Studies and pilot projects on brush control in West Texas show promising results. The first large-scale projects are currently underway. Undertaking and maintaining brush control is expensive and requires landowner participation.

The Texas State Soil and Water Conservation Board published the *State Brush Control Plan* in 2002 [11]. This plan identifies areas that could potentially benefit from brush control programs. Two reservoirs in Region C, Lake Jacksboro and Lake Weatherford, were listed in the *State Brush Control Plan* as potential watersheds where brush control could enhance supplies. No formal studies have been conducted for either watershed. Given that there is no quantifiable evidence that brush control would increase water supply in either reservoir, brush control is not recommended as a potentially feasible water management strategy for any specific water user group (WUG) in Region C. However, brush control may be a management strategy for localized areas within the region, especially as a means to help meet localized livestock water supply needs.

Summary of Decision: Allow for studies and localized pilot projects to further investigate brush control. Do not consider brush control as a potentially feasible strategy for the development of additional water supplies.

Precipitation Enhancement

Precipitation enhancement involves seeding clouds with silver iodide to promote rainfall. Such programs are generally located within areas where the rainfall is lower than in Region C. Given that Region C has adequate rainfall, and that there are no studies showing what impact precipitation enhancement would have on streamflow and reservoirs in Region C, precipitation enhancement is not recommended as a potentially feasible water management strategy for Region C. However, there may be localized areas in Region C who might benefit from such a management strategy.

Summary of Decision: Do not include precipitation enhancement as a potentially feasible strategy for the development of additional water supplies. Allow for studies and localized pilot projects to further investigate precipitation enhancement.

Desalination

The salinity of water in Lake Texoma and the Red River is too high for municipal use, and the water must be desalinated or blended with higher quality water in order to meet drinking water standards. The cost of desalination has decreased in recent years, and the process is being used more frequently. Desalination is a potentially feasible strategy to use supplies from the following sources:

- Lake Texoma and the Red River
- Brackish groundwater
- Water from the Brazos River
- Water from the Gulf of Mexico
- Local projects from other sources, if pursued by water suppliers.

Summary of Decision: Include desalination as a potentially feasible management strategy in order to utilize supplies from the sources listed above.

Water Rights Cancellation

The Texas Commission on Environmental Quality has the power to cancel water rights after ten years of non-use, but this involuntary cancellation authority has seldom been used. The Water Availability Models showed that very little additional supply would be gained from water right cancellation in Region C [12, 13]. Therefore, water rights cancellation is not recommended as a potentially feasible water management strategy for Region C.

Summary of Decision: Do not consider water rights cancellation as a potentially feasible strategy for the development of additional water supplies.

Aquifer Storage and Recovery

Aquifer storage and recovery (ASR) involves storing excess water in aquifers and retrieving this water when needed. The water to be stored can be introduced through enhanced recharge or injected through a well into the aquifer. The excess water to be stored can be treated water or raw water with some pre-treatment.

ASR has the potential to store large volumes of water at lower costs than traditional surface storage. Other benefits of aquifer storage and recovery include elimination of evaporation losses, minimization of environmental impacts, and elimination of storage loss due to sedimentation. ASR requires suitable geological conditions for implementation and can cause contamination of groundwater. The water injected into the aquifer must be treated so that it will not cause damage to the existing groundwater system.

It is premature to determine the suitability of ASR as a source of supply for Region C at this time. Studies of ASR should continue, and pilot projects should be implemented if the strategy appears to be promising. The Colony and Addison are currently considering aquifer storage and recovery projects to reduce peak demands on surface water supplies. Neither project will provide additional water supplies on an annual basis, but they should be considered potentially feasible as management strategies to help meet peak needs.

Summary of Decision: Studies of ASR should continue, and pilot projects should be implemented if the strategy appears promising. ASR projects for The Colony and Addison are potentially feasible strategies to meet peak demands, with no additional supplies.

Development of New Surface Water Supplies

Over the years, many new reservoirs have been considered as sources of water supply for Region C. New reservoirs represent a large source of potential supply for Region C, but environmental impacts of reservoir development are a concern. Potential impacts of reservoir development include:

- Inundation of wetlands and other wildlife habitat, including bottomland hardwoods
- Changes to streamflows and streamflow patterns downstream
- Impacts on inflows to bays and estuaries
- Impacts on threatened and endangered species.

In the 2001 *Region C Water Plan*, the following reservoirs were selected for detailed analysis after a preliminary screening:

- Upper Bois d'Arc Creek Lake
- Lower Bois d'Arc Creek Reservoir
- Lake Tehuacana

- Muenster Lake
- Lake Ralph Hall
- George Parkhouse II Reservoir North (called George Parkhouse Lake (North) in this plan)
- George Parkhouse I Reservoir South (called George Parkhouse Lake (South) in this plan)
- Marvin Nichols I Reservoir North (called Marvin Nichols Reservoir in this plan)
- Marvin Nichol II Reservoir South (called Marvin Nichols Lake (South) in this plan).

Since the completion of the *2001 Region C Water Plan*, there have been several developments in planning for new surface water supply sources for Region C:

- The Sulphur River Basin Authority (SRBA) and several Region C water suppliers have conducted additional studies of Marvin Nichols Reservoir. SRBA is currently pursuing a basin-wide study of the Sulphur River Basin. The Marvin Nichols Reservoir site has been moved upstream to a new site to have fewer impacts on the bottomland hardwoods.
- The Upper Trinity Regional Water District has conducted additional studies of Lake Ralph Hall and has filed an application for a water right permit from the Texas Commission on Environmental Quality.
- Dallas Water Utilities is considering supplies from Fastrill Lake in the Neches River Basin.
- North Texas Municipal Water District is considering supplies from Lower Bois d'Arc Creek Reservoir.
- Tarrant Regional Water District is considering supplies from Lake Tehuacana.
- Construction of Muenster Lake is currently underway and should be completed in 2006.

Table 4C.3 shows the new reservoirs adopted as potentially feasible sources of additional water supply for Region C by the Region C Water Planning Group. Figure 4C.1 shows the location of these potentially feasible reservoir projects.

The Region C Water Planning Group also adopted the additional use of local surface water supplies as potentially feasible if needed and practical.

Summary of Decision: Evaluate Marvin Nichols Reservoir, Lower Bois d'Arc Creek Reservoir, Muenster Lake, Lake Ralph Hall, George Parkhouse Lake (North and South), Lake Columbia, and Lake Tehuacana as potentially feasible strategies.

Table 4C.3
Potentially Feasible Strategies for New Reservoirs

Strategy	Potential Sponsor(s)	Maximum Supply Available to Region C from Strategy in Acre-Feet per Year	Recommended in 2001 Plan?
Marvin Nichols Reservoir	DWU, NTMWD, TRWD, UTRWD, and Irving	495,300	Yes
Lower Bois d'Arc Creek Reservoir	NTMWD	123,000	Yes
George Parkhouse Lake (North)	DWU, NTMWD, or UTRWD	118,960	No
Lake Fastrill	DWU	112,100	No
Tehuacana Reservoir	TRWD	56,800	No (alternate)
Lake Columbia	DWU	35,800	No
Lake Ralph Hall	UTRWD	32,940	No (alternate)
George Parkhouse Lake (South)	NTMWD	135,600	No
Muenster Lake	Muenster	500	Yes

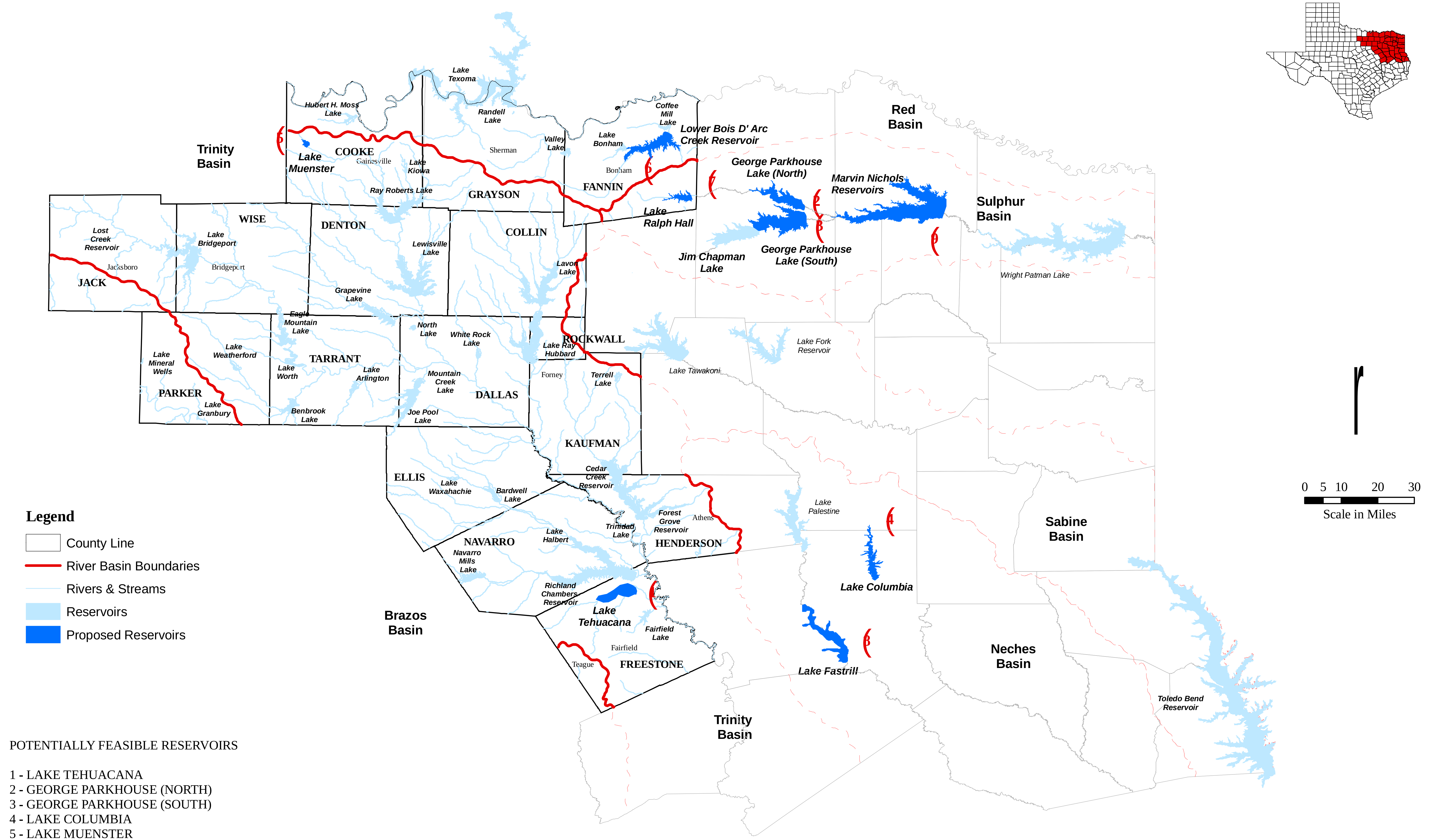
Development of New Groundwater Supplies

New groundwater supplies within Region C are limited, since the majority of the available supplies are already developed. The Region C Water Planning Group identified a large number of relatively small additional groundwater supplies as potentially feasible strategies, and these are listed in Appendix S. The planning group also authorized development of new wells as needed and as groundwater is available as a potentially feasible strategy.

Two major strategies for the importation of groundwater were also identified as potentially feasible:

- The importation of up to 200,000 acre-feet per year from the Ogallala aquifer in Roberts County (Region A)
- The importation of up to 100,000 acre-feet per year from the Carrizo-Wilcox aquifer in Brazos County and surrounding counties (Region G).

Summary of Decision: Evaluate the importation of groundwater from the Ogallala aquifer in Roberts County and the importation of groundwater from the Carrizo-Wilcox aquifer in Brazos County and surrounding counties. Evaluate specific potentially feasible groundwater supplies within Region C.



POTENTIALLY FEASIBLE RESERVOIRS

1 - LAKE TEHUACANA
2 - GEORGE PARKHOUSE (NORTH)
3 - GEORGE PARKHOUSE (SOUTH)
4 - LAKE COLUMBIA
5 - LAKE MUENSTER
6 - LOWER BOIS D' ARC CREEK RESERVOIR
7 - LAKE RALPH HALL
8 - LAKE FASTRILL
9 - MARVIN NICHOLS RESERVOIR

Figure 4C.1
Existing and Potentially Feasible Reservoirs

Interbasin Transfers

Table 4C.4 shows the potentially feasible strategies for Region C that would require interbasin transfer permits. (Under Texas law, interbasin transfer permits are required to transfer surface water from one river basin to another. They are not required for the transfer of groundwater.) Several of the strategies listed in Table 4C.4 have already been granted interbasin transfer permits, including Dallas' connections to Lake Fork Reservoir and Lake Palestine. Existing sources with the potential to provide supply to Region C that would require interbasin transfer permits include Lake Texoma, the Brazos River Authority system, Wright Patman Lake, Toledo Bend Reservoir, Lake Sam Rayburn/Lake B.A. Steinhagen, additional Lake Palestine water, Cypress River Basin water (Lake O' the Pines), Oklahoma reservoirs, and the Gulf of Mexico. Potential new surface water supplies that would need interbasin transfer permits include Marvin Nichols Reservoir, George Parkhouse North and South Lakes, Lower Bois d'Arc Creek Reservoir, Lake Fastrill, Lake Columbia, and Lake Ralph Hall. A comparison of total available supplies to projected demands for each basin of potential interest to Region C is presented in Table 4C.5. This table shows that the Trinity and Brazos River Basins are projected to have shortages over the planning period, while the other basins show supplies above the projected demands. Detailed studies of water needs in the receiving and the source basins will be required as part of the permitting process for new interbasin transfers. Development of adequate supplies for Region C and the other growing areas of Texas will require interbasin transfers.

Summary of Decision: Include interbasin transfers as part of the management strategies considered in the Region C plan.

Other Measures - Renewal of Contracts

Many of the water users in Region C purchase water from a regional wholesale water provider or from another water supplier through contractual arrangements. For this plan it was assumed that existing water supply contracts will be renewed unless either entity indicated they were not planning to continue the contract. Renewal of a contract was not treated as a specific management strategy. In most cases in Region C, both the seller and the purchaser plan to renew existing contracts, and their long-term plans are based on the renewal of contracts. Contract increases are potentially feasible with the agreement of both parties.

Summary of Decision: Assume that existing contracts are renewed upon their expiration and do not consider renewal to be a water management strategy. Assume an increase in the amount of the contracts to meet projected needs with the agreement of both parties.

Table 4C.4
Potentially Feasible Interbasin Transfers for 2006 Region C Plan

Source	Basin of Origin	Receiving Basin	Maximum Amount (Ac-Ft/Yr)	Comments
Lake Fork Reservoir	Sabine	Trinity	120,000	Already permitted, under construction
Lake Palestine	Neches	Trinity	114,337	Already permitted
Toledo Bend Reservoir	Sabine	Trinity	600,000	Connection of Existing Supply
Oklahoma Water	Red	Trinity	165,000 or more	Connection of Existing Supply
Wright Patman Lake	Sulphur	Trinity	184,000	Connection of Existing Supply, Reallocation
Wright Patman Lake – System Operation with Chapman Lake	Sulphur	Trinity	390,000	Connection of Existing Supply, Reallocation
NTMWD Upper Sabine River Basin Water	Sabine	Trinity	50,000	Connection of Existing Supply
Forest Grove Reservoir	Trinity	Neches	2,500	Connection of Existing Supply
Additional Lake Moss water	Red	Trinity	871	Connection of Existing Supply
Gulf of Mexico Desalination	Gulf of Mexico	Trinity	unlimited	Connection of Existing Supply, Desalination
Lake Texoma Already Authorized with or without desalination	Red	Trinity	113,000	Connection of Existing Supply, Reallocation, Desalination
GTUA Lake Texoma and Grayson County Project	Red	Trinity	56,500	Connection to Existing Supply, Desalination, Reallocation
Lake Texoma Not Yet Authorized with or without Desalination	Red	Trinity	220,000	Connection of Existing Supply, Reallocation, Desalination
Lake Texoma Not Yet Authorized – Blending with Elm Fork Reservoirs	Red	Trinity	20,000	Connection of Existing Supply, Reallocation
Cypress River Basin Supplies	Cypress	Trinity	89,600	Connection of Existing Supply
Sam Rayburn Reservoir/B.A. Steinhagen	Neches	Trinity	200,000	Connection of Existing Supply
Additional Lake Palestine	Neches	Trinity	30,000	Connection of Existing Supply
Purchase from BRA	Brazos	Trinity	28,000	Connection of Existing Supply
Interim GTUA Texoma Water	Red	Trinity	20,000	Connection of Existing Supply
Marvin Nichols Reservoir	Sulphur	Trinity	495,300	New Surface Water
Lower Bois d'Arc Creek Reservoir	Red	Trinity	123,000	New Surface Water
Lake Ralph Hall	Sulphur	Trinity	32,940	New Surface Water
Lake Fastrill	Neches	Trinity	112,100	New Surface Water
George Parkhouse North Lake	Sulphur	Trinity	118,960	New Surface Water
George Parkhouse South Lake	Sulphur	Trinity	135,600	New Surface Water
Lake Columbia	Neches	Trinity	35,800	New Surface Water

Table 4C.5
Difference in Total Available Supply and Total Demand by Basin
-Values in Acre-Feet per Year-

Basin	2010	2020	2030	2040	2050	2060
Brazos	425,963	52,112	(304,620)	(616,290)	(774,606)	(885,416)
Cypress	445,624	428,670	404,782	379,637	359,903	339,849
Neches	2,321,648	2,269,433	2,239,472	2,208,294	2,172,709	2,132,910
Red	704,752	529,407	417,453	362,291	366,869	349,498
Sabine	1,764,347	1,718,935	1,680,733	1,637,305	1,587,279	1,525,278
Sulfur	222,104	209,476	198,260	187,562	177,332	161,760
Trinity	1,065,986	722,172	451,588	177,387	(145,550)	(535,830)

Other Measures – Temporary Overdrafting

In several Region C counties, the current use of groundwater exceeds or is near the estimate of long-term reliable groundwater supply. In order to reduce the demand on overused groundwater resources, water suppliers will need to develop alternate sources of supply. However, the development of alternate sources will take some time. Temporary overdrafting of some groundwater supplies will continue in order to provide water in the interim. Temporary overdrafting of surface water reservoirs may also occur on a short-term basis while water suppliers are connecting to other supply sources.

Summary of Decision: Temporary overdrafting of groundwater resources and surface water reservoirs can be used as an interim measure while other water supplies are developed.

Other Measures – Groundwater Conservation Districts

Texas law allows for the establishment of groundwater conservation districts to help control the development and use of groundwater resources. Groundwater conservation districts can control well size and use, well spacing, and groundwater pumping. There are currently two groundwater conservation districts in Region C that oversee the Carrizo-Wilcox aquifer in Freestone and Henderson counties. There are no districts in the north and central part of Region C that overlie the Trinity and Woodbine aquifers. As shown on Table 4C.6, the Trinity aquifer is at or above the estimated long-term sustainable supply in seven counties. Groundwater conservation districts may be an appropriate way to share a limited resource in areas where groundwater use exceeds or approaches the long-term reliable supply. The formation of such districts is a local decision and should be considered by water suppliers and government officials in areas of heavy groundwater use.

Summary of Decision: Local water suppliers and government officials should consider the formation of groundwater conservation districts in areas of heavy groundwater use.

Table 4C.6
Counties with Trinity Aquifer Groundwater Use
Above or Near Long-Term Availability

County	Aquifer	Historical Use		Availability (Ac-Ft/Yr)
		1999	2000	
Collin	Trinity	1,335	2,058	2,100
Cooke	Trinity	6,478	6,373	6,400
Dallas	Trinity	4,783	5,158	4,400
Ellis	Trinity	4,356	4,707	4,000
Grayson	Trinity	9,507	9,397	9,400
Tarrant	Trinity	13,505	13,823	9,200
Wise	Trinity	4,775	4,366	4,400

Other Measures – Assumed Reallocation of Groundwater

As suppliers currently using groundwater convert to surface water supplies, which will happen in many parts of Region C, they may reduce their current use of groundwater. Although some suppliers will continue to use groundwater to meet a portion of their peak demand or to supply a part of their service area, many will eventually convert entirely to surface water supplies. The resulting decrease in groundwater use may make a portion of the limited groundwater supply available to other water suppliers. It should be emphasized that the water plan does not require a water supplier to change their use of groundwater supplies. Rather, the gradual decrease of groundwater use after a surface water supply is developed is a predicted result that is consistent with past experience in many cases.

Summary of Decision: In some cases, assume a gradual decrease in groundwater use as other supplies are made available and assume that groundwater supplies will become available to other water suppliers.

Other Measures – Supplemental Wells

Over time the efficiency of groundwater wells decreases due to siltation, declining water levels, and aging materials. Water providers with groundwater sources will periodically replace existing wells or add new wells to maintain the same level of supply currently produced from their systems. To ensure the continued availability of groundwater it was assumed that supplemental wells would be installed over the planning period.

Summary of Decision: Include supplemental wells for all groundwater users in Region C at a replacement rate of 20 percent per decade.

Other Measures – Sediment Control Structures

The accumulation of sediment in existing reservoirs can have a significant impact on the reliable supply from those reservoirs over time. For Region C reservoirs, there is a projected reduction in reservoir yield of 62,700 acre-feet per year over the 60-year period from 2000 to 2060.

Since the 1950s numerous dams and structures in Texas have been constructed to help reduce the amount of sediment carried downstream into water supply sources. Many of these structures are approaching the end of their useful life and will require rehabilitation or new structures. Studies conducted by the Tarrant Regional Water District in the Trinity River Basin estimate that existing Natural Resources Conservation Service (NRCS) control structures provide considerable reductions in sediment loading to downstream reservoirs. In the West Fork System watershed, the cost per acre-foot of sediment retained was estimated by the District at $435. Based on the projected sediment accumulation in the lakes and the corresponding reduction in yield, the cost of water saved would be about $200 per acre-foot. This indicates sediment control structures can be very cost effective in selected watersheds. The control of sediment by these NRCS structures can also have water quality benefits for downstream streams and reservoirs.

Summary of Decision: Recommend the state support both federal and state efforts to rehabilitate existing sediment control structures and encourage funding and support for the construction of new structures in watersheds that would have the greatest benefits.

Summary of Potentially Feasible Strategies

Appendix S includes a discussion of potentially feasible water management strategies for Region C and a list of the strategies. Table 4C.7 lists potentially feasible strategies that would supply over 25,000 acre-feet per year for Region C. As the table shows, Region C considered and evaluated a wide variety of potentially feasible water management strategies. The results of the evaluation and the recommended strategies for Region C are discussed in Sections 4D, 4E, and 4F, and summarized in Appendix T. The methodology for the evaluation is discussed below.

4C.2 Methodology for Evaluating Water Management Strategies

The TWDB guidelines set forth certain factors that are to be considered by the regional water planning groups in the evaluation of water management strategies (2):

- Evaluation of quantity, reliability, and cost of water delivered and treated
- Environmental factors including:
  - Environmental water needs
  - Wildlife habitat
  - Threatened and endangered species
  - Cultural resources
  - Bays and estuaries
- Impacts on other water resources
- Impacts on threats to agricultural and natural resources
- Other factors deemed relevant by the planning group
- Equitable comparison of all feasible strategies
- Consideration of interbasin transfer requirements in the Texas Water Code and other regulatory requirements
- Consideration of third party social and economic impacts of voluntary redistributions of water.

This subsection discusses the specific evaluation factors selected by the Region C Water Planning Group for the potentially feasible water management strategies, including the environmental evaluation of alternatives and the development of costs. Additional details on the environmental evaluations, the development of costs, and the evaluation of strategies are included in various appendices.

Table 4C.7
Potentially Feasible Water Management Strategies for Region C Supplying 25,000 Acre-Feet per Year or More

Strategy	Potential Sponsor(s)	Maximum Supply Available to Region C in Acre-Feet per Year	Recommended in 2001 Plan?
Conservation and Reuse (Including reuse projects listed below)	Multiple	1,180,067	Yes
Toledo Bend Reservoir	SRA, NTMWD, TRWD, DWU, and UTRWD	600,000	No
Gulf of Mexico with Desalination	DWU, NTMWD, and TRWD	Unlimited	No
Marvin Nichols Reservoir	DWU, NTMWD, TRWD, UTRWD, and Irving	489,840	Yes
Wright Patman Lake – System	DWU, NTMWD, and TRWD	390,000	No
Lake Texoma Not Yet Authorized - Blend	DWU, NTMWD, TRWD, or UTRWD	220,000	No
Lake Texoma - Desalination	NTMWD	207,000	No
Sam Rayburn Reservoir/B.A. Steinhagen	DWU, NTMWD, or TRWD	200,000	No
Lake Livingston	DWU, NTMWD, or TRWD	200,000	No
Ogallala Groundwater (Roberts County)	DWU, NTMWD, or TRWD	200,000	No
TRWD 3rd Pipeline and Reuse	TRWD	188,765	Yes
Wright Patman Lake – Raise Flood Pool	DWU, NTMWD, or TRWD	180,000	No
Oklahoma Water	DWU, NTMWD, TRWD, and UTRWD	165,000 or more	Yes
Lower Bois d'Arc Creek Reservoir	NTMWD	123,000	Yes
Lake Fork Reservoir	DWU	120,000	Yes
George Parkhouse Lake (North)	DWU, NTMWD, or UTRWD	118,960	No
Lake Palestine	DWU	114,337	Yes
Lake Texoma - Blend	NTMWD	113,000	No (Smaller project was in plan)
Lake Fastrill	DWU	112,100	No
George Parkhouse Lake (South)	NTMWD	108,480	No

Table 4C.7, Continued

Strategy	Potential Sponsor(s)	Maximum Supply Available to Region C in Acre-Feet per Year	Recommended in 2001 Plan?
Lake Texoma Not Yet Authorized - Desalination	DWU, NTMWD, TRWD	105,000	No
East Fork Reuse Project	NTMWD	102,000	Yes
Wright Patman Lake – Texarkana	DWU, NTMWD, TRWD, or UTRWD	100,000	No
Carrizo-Wilcox Groundwater (Brazos County)	DWU or NTMWD	100,000	No
DWU Cypress River Basin Supplies (Lake O' the Pines)	DWU, NTMWD, or TRWD	89,600	No
Return Flows above Lakes	DWU and UTRWD	79,605	Yes
DWU Southside (Lake Ray Hubbard) Reuse	DWU	67,253	Yes
DWU Lewisville Lake Reuse	DWU	67,253	No
Tehuacana Reservoir	TRWD	56,800	No (alternate)
GTUA Lake Texoma Already Authorized	GTUA	56,500	Yes
Carrizo-Wilcox Groundwater (Brazos County)	TRWD	50,000	No
Upper Sabine River Basin	NTMWD	50,000	No
TRA Ellis County Reuse	TRA	40,000	Yes
Additional Lake Lavon Reuse	NTMWD	35,941	Yes
Lake Columbia	DWU	35,800	No
Lake Ralph Hall	UTRWD	32,940	No (Alternate)
Additional Lake Palestine	DWU	30,000	No
TRA Contract with Irving for Reuse	TRA and Irving	28,000	No
TRWD Purchase from Brazos River Authority	TRWD	28,000	No
Ellis County Project	TRA/ TRWD	26,582	Yes
NTMWD/GTUA Supply to North Collin and South Grayson Counties	Multiple	26,015	Yes

Factors Considered in Evaluation

Table 4C.8 sets out the factors specifically considered by the Region C Water Planning Group in the evaluation of potential water management strategies. As required by Senate Bill Two, the evaluation of water management strategies includes the quantitative reporting of quantity, reliability, costs and environmental factors. While the quantitative reporting of water made available and the unit cost of delivered and treated water can readily be developed, data for the quantitative reporting of environmental factors are limited. The detailed quantitative assessment of environmental factors requires data from site-specific studies, which are often not conducted at the planning level. Available data for environmental factors are used in the evaluation. For factors that could not currently be quantified, the potential impacts are evaluated qualitatively, with a rating of low, medium, high, or positive.

Table 4C.8
Factors Used to Evaluate Water Management Strategies for Region C

Quantity of Water Made Available
Reliability of Supply
Unit Cost of Delivered and Treated Water
Environmental Factors
- Total Acres Impacted
- Wetland Acres
- Environmental Water Needs
- Wildlife Habitat
- Threatened and Endangered Species
- Cultural Resources
- Bay and Estuary Flows
- Water Quality
- Other
Impacts on Agricultural and Rural Areas
Impacts on Natural Resources
Impacts on Other Water Management Strategies and Possible Third Party Impacts
Impacts to Key Water Quality Parameters
Consistency with Plans of Region C Water Suppliers
Consistency with Other Regions

Consistency with plans of Region C water suppliers is an important factor in the evaluation of strategies. It has always been the intent of the Region C Water Planning Group to build the Region C Water Plan considering the existing plans of the water suppliers in the region, especially the regional wholesale water providers.

Equitable comparison of all feasible strategies is not included as an explicit evaluation factor because it describes the way that the entire evaluation was conducted. This factor was considered in the development of the methodology for evaluations. Interbasin transfer requirements in the Texas Water Code were considered in the development of strategies. Appendix T gives more details on the evaluation of potentially feasible water management strategies for Region C.

Environmental Evaluation

The environmental evaluation of potentially feasible management strategies is summarized in Appendix T. Factors reported quantitatively include the total acres impacted by the strategy and the number of threatened and endangered species listed in the counties of the proposed water source. For existing water sources, only the species that are water dependent are included in the count of threatened and endangered species. Other factors were assigned a high, moderate, or low rating based on existing data and the potential to avoid or mitigate each of the environmental categories listed in Table 4C.8. If a strategy would have a positive impact to the respective environmental factor, this was noted as "positive". These evaluations were summarized in an overall environmental evaluation for the strategy. Certain management strategies were evaluated as a category rather than individually because their environmental effects do not vary greatly. Examples of evaluation by category include purchasing water from another provider, development of new wells in aquifers with additional water available, and temporary overdrafting of aquifers.

Agricultural Resources and Other Natural Resources

The evaluation of impacts to agricultural resources and rural areas assesses the ability to continue current agricultural and livestock activities. Strategies that move considerable amounts of water from rural to urban areas were also considered under this category. The impacts of recommended strategies on these factors are discussed in more detail in Chapter 5.

Impacts to other natural resources include potential impacts to water resources that are not the direct source for the strategy and impacts to mineral resources, oil and gas, timber resources, and parks and public lands. (Impacts to the water resources that are the source for the strategy are included under environmental factors.) The considerations of the impacts to agricultural and natural resources are used to assess how the regional water plan is consistent with the protection of the state's resources. This discussion is summarized in Chapter 7 of the plan.

Costs of Water Management Strategies

Appendix U contains more detailed information on the development of cost estimates for individual water management strategies. Development of cost estimates followed guidelines provided by the Texas Water Development Board. The assumptions used for the cost estimates are outlined in Appendix U. For equitable comparison of the water management strategies, capital costs for all strategies were amortized over 30 years. The discounted present value of each potentially feasible strategy will be calculated by the Texas Water Development Board. The costs shown in Appendix U are the unit costs during and after amortization.

Recommended Water Management Strategies

Water management strategies are recommended based on the overall factors set forth in the strategy evaluations. As discussed above, consistency with the on-going water development plans of regional water providers is an important factor in the strategy selection. All factors listed in Table 4C.8 were considered in the selection process. The recommended strategies are based on the ability to supply the quantity of water needed at a reasonable cost, while providing long-term protection of the state's resources. Recommended strategies for Region C are discussed in the following Sections 4E and 4F.

SECTION 4C
LIST OF REFERENCES

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(12) R.J. Brandes Company, *Final Report – Water Availability Modeling for the Sulphur River Basin*, prepared for the Texas Water Development Board, Austin, June 1999.

(13) Espey Consultants, Inc., Brown and Root, Inc., Freese and Nichols, Inc. GSG, Inc., Crespo Consulting Services, Inc., *Final – Water Availability Models for the Trinity, Trinity-San Jacinto, and Neches Trinity Basins*, prepared for the Texas Water Development Board, Austin, March 2002.

4D. Evaluation of Major Water Management Strategies

This section of the report reviews the evaluation of major potentially feasible water management strategies. Major strategies are defined as those that would supply more than 60,000 acre-feet per year and those that involve the construction of a new reservoir supplying over 1,000 acre-feet per year. Table 4D.1 lists the major potentially feasible water management strategies for Region C, and Figure 4D.1 shows the location of the water supplies for the major strategies considered. In this round of planning, the Region C Water Planning Group investigated a large number of potentially feasible water management strategies that were not studied in the 2001 *Region C Water Plan* (1). In particular, the planning group looked at a number of existing projects that might have water available for Region C.

As discussed in Section 4C, potentially feasible water management strategies for Region C were evaluated on the basis of quantity, reliability, cost, environmental factors, impacts on agricultural and rural areas, impacts on natural resources, impacts on other water management strategies and third party impacts, impacts to key water quality parameters, consistency with plans of Region C water suppliers, and consistency with the plans of other regions. Table 4D.2 summarizes the evaluation of the potentially feasible strategies listed in Table 4D.1. Figure 4D.2 shows the comparative unit costs of the strategies. Appendix T gives more details on non-cost evaluations for the strategies, and Appendix U contains detailed cost estimates. The costs shown in Table 4D.2 and Figure 4D.2 should be used with caution. The costs for a given source can vary a great deal based on the amount used and where the water is delivered.

The remainder of this section discusses the evaluations of the specific potentially feasible major water management strategies for Region C. (Conservation strategies are discussed in Section 4B and Chapter 6.)

4D.1 Toledo Bend Reservoir

Toledo Bend Reservoir is an existing impoundment located in the Sabine River Basin on the border between Texas and Louisiana. It was built in the 1960s by the Sabine River Authority of Texas (SRA) and the Sabine River Authority of Louisiana. The yield of the project is split equally between the two states, and Texas' share of the yield is slightly over 1,000,000 acre-feet per year [2]. The SRA holds a Texas water right to divert 750,000 acre-feet per year from Toledo Bend and is seeking the right to divert an additional 293,300 acre-feet per year.

Table 4D.1
Major Potentially Feasible Water Management Strategies for Region C

Strategy	Maximum Supply Available to Region C in Acre-Feet per Year	Location Number in Figure 4D.1
Conservation and Reuse (Includes Projects Listed below)	1,068,627	N/A
Toledo Bend Reservoir	600,000	24
Gulf of Mexico with Desalination	Unlimited	18
Marvin Nichols Reservoir	489,840	20
Wright Patman Lake – System	390,000	22
Lake Texoma Not Yet Authorized - Blend	220,000	3
Lake Texoma Not Yet Authorized - Desalination	207,000	3
Sam Rayburn Reservoir/B.A. Steinhagen	200,000	23
Lake Livingston	200,000	17
Ogallala Groundwater (Roberts County)	200,000	1
TRWD Third Pipeline and Reuse	188,765	8
Wright Patman Lake - Raise Flood Pool	180,000	22
Oklahoma Water	165,000 or more	16
Lower Bois d'Arc Creek Reservoir	123,000	9
Lake Fork Reservoir	120,000	10
George Parkhouse Lake (North)	118,960	12
Lake Palestine	114,337	14
Lake Texoma - Blend	113,000	3
Lake Fastrill	112,100	15
George Parkhouse Lake (South)	108,480	13
Lake Texoma - Desalination	105,000	3
East Fork Reuse Project	102,000	5
Wright Patman Lake - Texarkana	100,000	22
Carrizo-Wilcox Groundwater (Brazos County)	100,000	6
Cypress Basin Supplies (Lake O' the Pines)	89,600	21
Return Flows above DWU Lakes	79,605	N/A
Southside (Lake Ray Hubbard) Reuse	67,253	4
Lewisville Lake Reuse	67,253	2
Tehuacana Reservoir	56,800	7
Lake Ralph Hall and Reuse	50,740	11
Lake Columbia	35,800	19

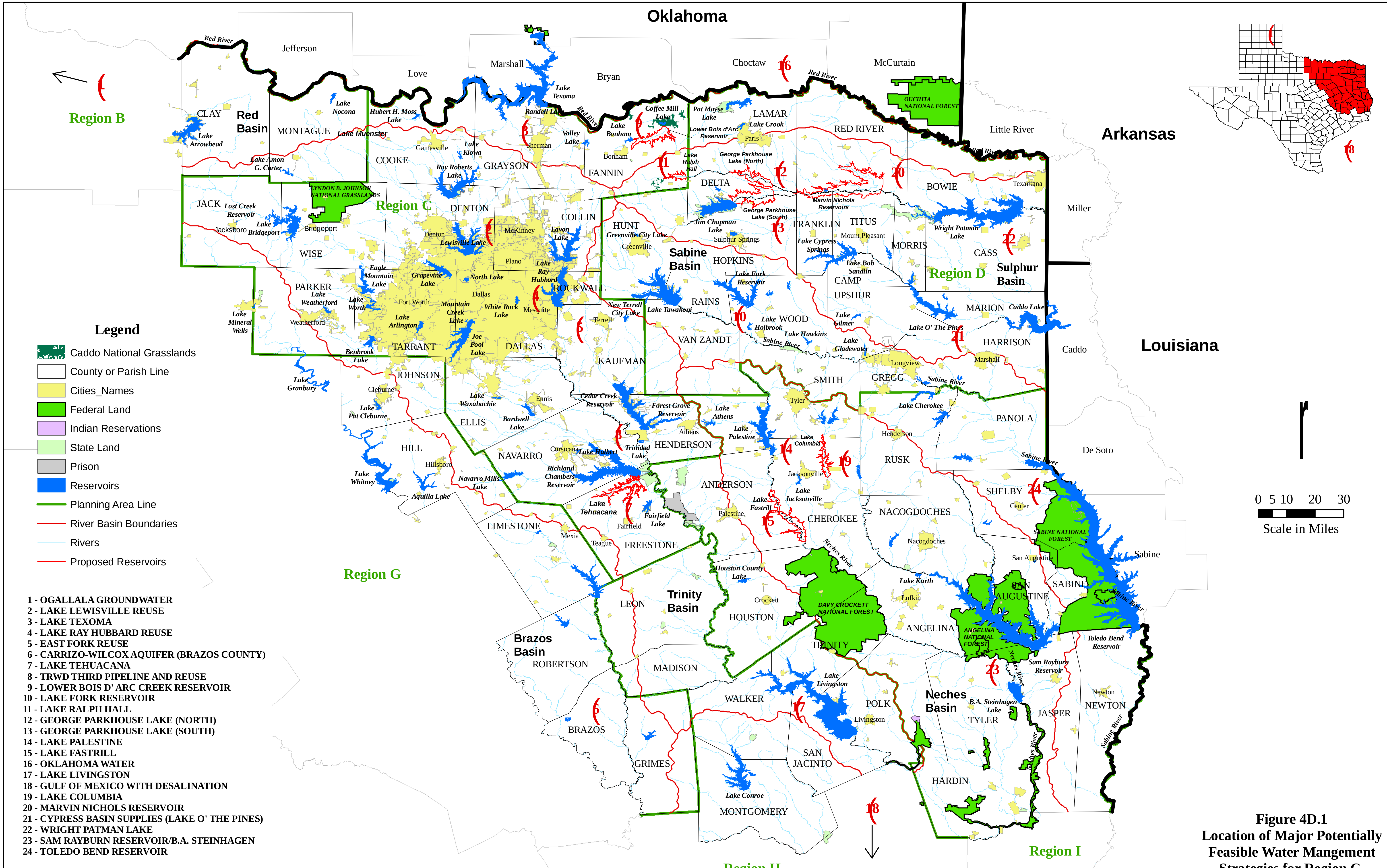


Figure 4D.1
Location of Major Potentially Feasible Water Mangement Strategies for Region C

Table 4D.2
Summary of Costs and Impacts of Major Potentially Feasible Strategies for Region C

Strategy	Potential Supplier(s)	Potential Region C Supply (Acre-Feet per Year)	Region C Share of Capital Cost	Unit Cost for Region C ($/kGal.)		Reliability	Environ-mental Factors	Agricultural/ Rural Impacts	Other Natural Resources	3rd Party Impacts	Key Water Quality Parameters	Consistency		Implement-ation Issues	Comments
				Pre-Amort.	Post-Amort.							Suppliers	Other Regions		
Toledo Bend Reservoir	DWU, NTMWD, SRA, TRWD & UTRWD	600,000	$2,428,789,000	$1.50	$0.60	High	Medium low	Low	Low	Medium Low	Low	Yes	Yes	Requires IBT and agreements with multiple users	Costs are weighted average for all four potential participants.
Gulf of Mexico	DWU, NTMWD, or TRWD	Unlimited (costs for 200,000 acre-feet per year)	$2,836,207,000	$5.57	$2.41	Medium	Medium	Low	Medium Low	Low	Low	No	N/A	Technology is still developing for this application at this scale. May require state water right permit and IBT.	Strategy was costed to central location. Capital Cost was based on one supplier. Supply is treated water.
Marvin Nichols Reservoir	DWU, Irving, NTMWD, TRWD and UTRWD	489,840	$2,092,720,000	$1.33	$0.37	High	High	High	Medium high	High	Medium	Yes	Not inconsistent	Requires new water rights permit and IBT. .	Costs are weighted average for all five potential participants.
Wright Patman - System	DWU, Irving, NTMWD, TRWD, and UTRWD	390,000	$1,891,022,000	$1.66	$0.58	High	Medium	Low	Medium	Medium	Medium Low	No (alternate)	Not inconsistent	Requires IBT, contract with USACE, contract with Texarkana, and new or amended water right permit.	Costs are based on 130,000 acre-feet per year for each potential participant.
Lake Texoma Not Yet Authorized (Blend)	DWU, TRWD, or UTRWD	220,000 (Costs for 113,000 acre-feet per year)	$182,588,000	$1.07	$0.25	High	Medium low	Low	Medium Low	Medium Low	Medium	No (alternate)	N/A	Requires IBT, state water right, Congressional authorization, and contract with USACE.	
Lake Texoma Not Yet Authorized (Desalinate)	DWU or TRWD	207,000 (Costs are for 105,000)	$621,448,000	$2.17	$0.85	High	Medium	Low	Medium	Medium Low	Medium	No (alternate)	N/A	Requires IBT, Congressional authorization, state water right, contract with USACE and brine discharge permit (or deep well injection).	Delivers treated water.

Table 4D.2, Continued

Strategy	Potential Supplier(s)	Potential Region C Supply (Acre-Feet per Year)	Region C Share of Capital Cost	Unit Cost for Region C ($/kGal.)		Reliability	Environ-mental Factors	Agricultural/ Rural Impacts	Other Natural Resources	3rd Party Impacts	Key Water Quality Parameters	Consistency		Implement-ation Issues	Comments
				Pre-Amort.	Post-Amort.							Suppliers	Other Regions		
Sam Rayburn Reservoir/Lake B.A. Steinhagen	DWU, NTMWD, or TRWD	200,000	$1,306,045,000 to $1,525,001,000	$2.04 to $2.42	$0.59 to $0.72	High	Low	Low	Low	Medium Low	Low	No (alternate)	Unknown	Requires IBT and contract with LNVA.	May be competing interest in supply in other region.
Lake Livingston	DWU, NTMWD, or TRWD	200,000	$1,142,917,000 to $1,299,183,000	$1.99 to $2.25	$0.72 to $0.83	High	Low	Low	Low	Medium Low	Low	No (alternate)	Unknown	Requires contract with TRA.	May be competing interest in supply in other region.
Ogallala Groundwater (Roberts County)	DWU, NTMWD, or TRWD	200,000	$1,650,619,000 to $1,994,699,000	$2.40 to $2.83	$0.55 to $0.61	High	Medium low	Medium	Medium	Medium Low	Medium	No (alternate)	Not inconsistent	Requires additional water rights.	Assumes 400,000 acres of water rights. Currently permitted or contracted for 150,000 acres.
TRWD 3rd Pipeline and Reuse	TRWD	188,765	$626,347,000	$1.05	$0.31	Low	Low	Low	Low	Low	Medium	Yes	N/A	Permit is in hand.	
Wright Patman - Raise Flood Pool	DWU, Irving, NTMWD, or TRWD	180,000	$825,088,000 to $1,038,329,000	$1.42 to $1.83	$0.37 to $0.54	High	Medium	Low	Medium Low	Medium Low	Medium Low	Yes	Not inconsistent	Requires IBT, contract with USACE and new or amended water right permit.	
Oklahoma Water	DWU, Irving NTMWD, TRWD, and/or UTRWD	165,000 or more (costs based on 115,000)	$477,214,000	$1.40	$0.47	High	Low	Low	Low	Medium Low	Medium Low	Yes	N/A	Oklahoma has moritorium for export of water out of state. May require an IBT.	
Lower Bois d'Arc Creek Reservoir	NTMWD	123,000	$399,190,000	$0.87	$0.14	High	Medium high	High	Medium	Medium	Low	Yes	N/A	Requires new water rights permit and IBT.	
Lake Fork Reservoir	DWU	120,000	$362,916,000	$0.84	$0.17	High	Low	Low	Low	Medium Low	Low	Yes	Yes	Project is underway,	
George Parkhouse Lake (North)	DWU, NTMWD, and/or UTRWD	118,960	$362,322,000 to $365,002,000	$0.91 to $1.00	$0.23 to $0.27	High	Medium high	Medium high	Medium	Medium	Low	No (alternate)	Not inconsistent	Requires new water rights permit and IBT.	Costs are for NTMWD and DWU.
Lake Palestine	DWU	111,460 [a]	$414,447,000	$1.08	$0.25	High	Low	Low	Low	Medium Low	Low	Yes	Yes	DWU has IBT permit.	

Table 4D.2, Continued

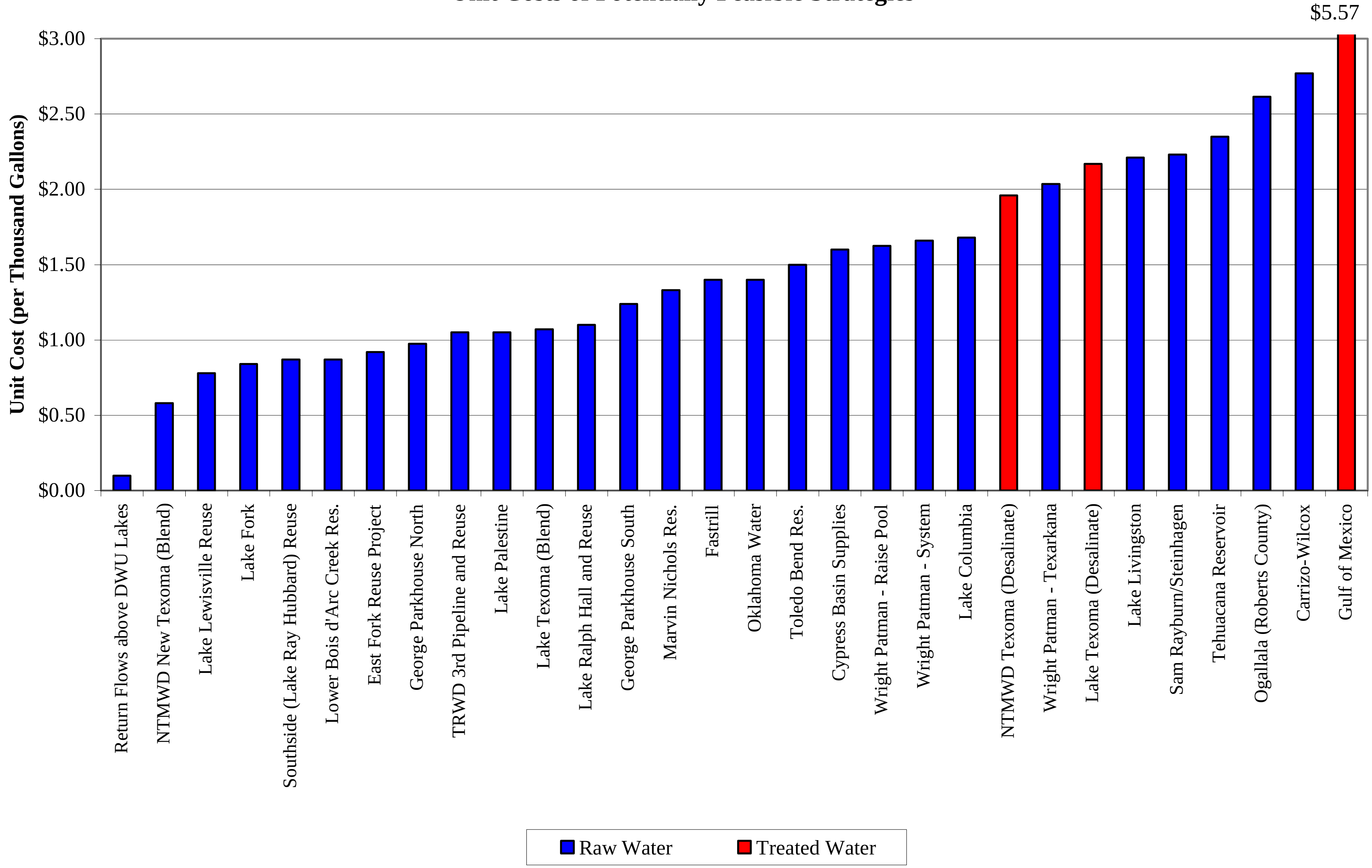
Strategy	Potential Supplier(s)	Potential Region C Supply (Acre-Feet per Year)	Region C Share of Capital Cost	Unit Cost for Region C ($/kGal.)		Reliability	Environ-mental Factors	Agricultural/ Rural Impacts	Other Natural Resources	3rd Party Impacts	Key Water Quality Parameters	Consistency		Implement-ation Issues	Comments
				Pre-Amort.	Post-Amort.							Suppliers	Other Regions		
New Lake Texoma (Blend)	NTMWD	113,000	$201,829,000	$0.58	$0.18	High	Medium low	Low	Medium Low	Medium Low	Medium	Yes	N/A	Requires IBT, state water right and contract with USACE.	NTMWD has applied for water right and is negotiating with USACE.
Lake Fastrill	DWU	112,100	$569,170,000	$1.40	$0.27	High	High	Medium	Medium high	Medium	Low	Yes	Unknown	Requires new water right permit and IBT.	
George Parkhouse Lake (South)	NTMWD and/or UTRWD	108,480	$480,099,000	$1.24	$0.25	High	Medium High	Medium High	Medium	Medium	Low	No (alternate)	Not inconsistent	Requires new water rights permit and IBT.	
Lake Texoma Desalinate	NTMWD	105,000	$538,635,000	$1.96	$0.82	High	Medium	Low	Medium	Medium Low	Medium	No (alternate)	N/A	Requires IBT, state water right, contract with USACE and brine discharge permit (or deep well injection).	Delivers treated water.
East Fork Reuse Project	NTMWD	102,000	$288,879,000	$0.92	$0.21	High	Low	Low	Low	Low	Medium	Yes	N/A	Requires water right permit.	
Wright Patman Lake – Texarkana	DWU, Irving, NTMWD, or TRWD	100,000	$429,176,000 to $670,735,000	$1.70 to $2.37	$0.65 to $0.87	High	Low	Low	Low	Medium Low	Medium Low	No (alternate)	Not inconsistent	Requires agreement with Texarkana and IBT.	
Carrizo-Wilcox Groundwater (Brazos County and vicinity)	DWU or NTMWD	100,000	$506,662,000 to $577,413,000	$2.65 to $2.89	$1.24 to $1.28	High	Medium	Medium	Medium High	Medium	Low	No (alternate)	No	Requires coordination with local groundwater districts. Competing uses for water.	
Cypress Basin Supplies (Lake O' the Pines)	DWU, NTMWD, or TRWD	89,600	$257,192,000 to $469,493,000	$1.25 to $1.97	$0.60 to $0.78	High	Low	Low	Low	Medium Low	Low to Medium Low	No (alternate)	Not inconsistent	Requires IBT, renegotiating existing contracts, and contract with NETMWD.	
Return Flows above DWU Lakes	DWU and UTRWD	79,605	$0	$0.10	$0.10	High	Low	Low	Medium Low	Low	Low	Yes	N/A	Requires contracts with wastewater dischargers.	
Southside (Lake Ray Hubbard) Reuse	DWU	67,253	$200,333,000	$0.87	$0.21	High	Low	Low	Medium Low	Low	Medium	Yes	N/A	Requires water right permit.	

Table 4D.2, Continued

Strategy	Potential Supplier(s)	Potential Region C Supply (Acre-Feet per Year)	Region C Share of Capital Cost	Unit Cost for Region C ($/kGal.)		Reliability	Environ-mental Factors	Agricultural/ Rural Impacts	Other Natural Resources	3rd Party Impacts	Key Water Quality Parameters	Consistency		Implement-ation Issues	Comments
				Pre-Amort.	Post-Amort.							Suppliers	Other Regions		
Lewisville Lake Reuse	DWU	67,253	$191,439,000	$0.78	$0.15	High	Low	Low	Medium Low	Low	Medium	Yes	N/A	May require water right permit.	
Tehuacana Reservoir	TRWD	56,800	$511,829,000	$2.35	$0.35	High	Medium High	Medium High	Medium	Medium	Low	No (alternate)	N/A	Requires new water rights permit.	
Lake Ralph Hall and Reuse	UTRWD	50,740	$211,153,000	$1.10	$0.17	High	Medium high	Medium	Medium	Medium	Medium	Yes	N/A	Requires new water right and IBT.	
Lake Columbia	DWU	35,800	$223,705,000	$1.68	$0.29	High	Medium high	Medium	Medium	Medium	Medium	No (alternate)	Yes	Requires contract with ANRA and IBT.	

Note: a. DWU has a contract for 114,337 acre-feet per year for water from Lake Palestine. Based on the firm yield of the reservoir, the estimated amount of supply available to DWU in 2020 is 111,460 acre-feet per year

Figure 4D.2
Unit Costs of Potentially Feasible Strategies



The SRA and Metroplex water suppliers have been investigating the possibility of developing substantial water supplies from Toledo Bend Reservoir, with up to 100,000 acre-feet per year delivered to SRA customers in the upper Sabine River Basin (Region D, the North East Texas Region) and up to 600,000 acre-feet per year delivered to Region C. (Toledo Bend Reservoir is located in Region I, the East Texas Region.) The development of this supply will require an agreement among the SRA and Metroplex suppliers, an interbasin transfer permit from the Sabine River Basin to the Trinity River Basin, and development of water transmission facilities. Because Toledo Bend Reservoir is so far from Region C (about 200 miles), this is a relatively expensive source of supply for the Region. However, it does offer a substantial water supply, and environmental impacts will be limited because it is an existing source.

As discussed in Section 4E, getting water from Toledo Bend Reservoir is a recommended strategy for the North Texas Municipal Water District (200,000 acre-feet per year) and the Tarrant Regional Water District (200,000 acre-feet per year). It is an alternative strategy for Dallas Water Utilities and the Upper Trinity Regional Water District. The recommended strategy involves the use of 500,000 acre-feet per year (100,000 for SRA customers in the upper Sabine River Basin and 400,000 for the Metroplex). The Region C capital cost of the recommended strategy is $1.92 billion. (This differs from the cost in Table 4D.2 because the recommended strategy develops less supply from Toledo Bend Reservoir than is potentially feasible.)

4D.2 Gulf of Mexico with Desalination

The cost of desalination has been decreasing in recent years, and some municipalities in Florida and California have been developing desalinated seawater as a supply source. The State of Texas has sponsored initial studies of potential seawater desalination projects [(3)], 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 Region C. However, seawater desalination has been mentioned through public input during the planning process, and it was evaluated in response to that input.

The supply from seawater desalination is essentially unlimited, but the cost is a great deal higher than the cost of other water management strategies for Region C. Developing water from the Gulf of Mexico with desalination is not a recommended or alternative strategy for any water supplier in Region C.

4D.3 Marvin Nichols Reservoir

The proposed Marvin Nichols Reservoir is located on the Sulphur River in the Sulphur River Basin in Senate Bill One Planning Region D, the North East Texas Region. The proposed reservoir is about 115 miles from the Metroplex. Development of Marvin Nichols Reservoir was a major strategy for Region C in the 2001 *Region C Water Plan* (1), called Marvin Nichols I Reservoir North in that plan Since 2001, the Sulphur River Basin Authority and Metroplex water suppliers have been studying the development of Marvin Nichols Reservoir. As a result of those studies, the proposed location for the reservoir has been moved upstream to reduce impacts to bottomland hardwoods. The Sulphur River Basin Authority and Metroplex water suppliers are currently pursuing a basin-wide study of the Sulphur River Basin in cooperation with the Fort Worth District of the Corps of Engineers to obtain additional information on potential water supplies from the basin, including Marvin Nichols Reservoir.

Using the Sulphur River Basin Water Availability Model (4) and assuming that the proposed Lake Ralph Hall is in place as a senior water right, the estimated yield of Marvin Nichols Reservoir is 612,300 acre-feet per year after allowing for downstream water rights and environmental releases as required by the Texas Water Development Board's environmental flow criteria. (The yield analysis assumes that the reservoir will be operated as a system with Wright Patman Lake, protecting Wright Patman Lake's senior water right while minimizing impacts on the yield of Marvin Nichols Reservoir. The cooperative operation assumed in this report will require negotiations between the operators of Marvin Nichols Reservoir and the City of Texarkana, which holds a Texas water right in Wright Patman Lake.)

The yield is slightly less than the 619,100 acre-feet per year estimated in the 2001 *Region C Water Plan* (1) because Lake Ralph Hall is assumed to be in place as a senior water right. (If Lake Ralph Hall were not developed, the yield of Marvin Nichols Reservoir would be 640,800 acre-feet per year operated as a system with Wright Patman Lake, based on the Sulphur River Basin WAM – somewhat higher than estimated in the 2001 *Region C Water Plan*.) Assuming that 20 percent of the yield is used to provide water in Region D and 80 percent is made available to Region C, Marvin Nichols Reservoir will provide 489,840 acre-feet per year of additional water supply for Region C.

As a major reservoir project, Marvin Nichols Reservoir will have significant environmental impacts. The reservoir would inundate about 68,000 acres. The 1984 U.S. Fish and Wildlife Service *Bottomland Hardwood Preservation Program* [(5)] classified some of the land that would be flooded as a Priority 1 bottomland hardwood site, which is "excellent quality bottomlands of high value to key waterfowl species." The proposed new location of the dam will reduce but not eliminate the impact on bottomland hardwoods and will slightly increase the acreage required for the reservoir. Permitting the project and developing appropriate mitigation for the unavoidable impacts will require years, and it is important that water suppliers start that process well in advance of the need for water from the project. Development of the Marvin Nichols Reservoir will require an interbasin transfer permit to bring the water from the Sulphur River Basin to the Trinity River Basin. The project will include a major water transmission system to bring the new supply to the Metroplex. The project will make a substantial water supply available to the Metroplex, and the unit cost is less than that of most other major water management strategies.

As discussed in Section 4E, the proposed Marvin Nichols Reservoir is a recommended strategy for the North Texas Municipal Water District (174,840 acre-feet per year), the Tarrant Regional Water District (280,000 acre-feet per year), and Upper Trinity Regional Water District (35,000 acre-feet per year). It is an alternative strategy for Dallas Water Utilities and the city of Irving. The Region C capital cost of the recommended strategy is $2.16 billion. (This differs from the value in Table 4D.2 because the delivery locations of the recommended strategy are different from the delivery locations assumed in Table 4D.2.)

4D.4 Wright Patman Lake

Wright Patman Lake is an existing reservoir on the Sulphur River in the Sulphur River Basin, about 150 miles from the Metroplex. It is located in Region D, the North East Texas Region, and owned and operated by the U.S. Army 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. (In order to obtain a reliable supply of 180,000 acre-feet per year from the lake, Texarkana would have to activate a contract with the Corps of Engineers to increase the conservation storage in the lake.)

There are three different ways in which water could be made available from Wright Patman Lake for water suppliers in Region C:

- 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 increased yield could be used in Region C.
- Wright Patman Lake could be operated as a system with Jim Chapman Lake (formerly Cooper Lake) upstream to further increase yield.

Each of these approaches to developing supplies from Wright Patman Lake is discussed below.

Purchase from Texarkana. The 180,000 acre-feet per year for which Texarkana currently has a water right is in excess of their projected demands. 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.

Conversion of Flood Storage to Conservation Storage. 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 [(6)]. It was assumed that 180,000 acre-feet per year of the additional supply developed could be made available to water suppliers in the Metroplex. The yield of Wright Patman Lake could be increased to much more than 364,000 acre-feet per year by converting additional flood storage to conservation storage and increasing the top of conservation storage. However, increases beyond elevation 228.64 feet msl will 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 [(6)].)

System Operation with Jim Chapman Lake (formerly Cooper Lake). 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 [(6)]. 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 for Region C from Wright Patman Lake.

As discussed in Section 4E, converting Wright Patman Lake flood storage to conservation storage is a recommended water management strategy for Dallas Water Utilities, providing 112,100 acre-feet per year. The capital cost of this recommended strategy is $572,036,000. Wright Patman Lake is an alternative water management strategy for Irving, North Texas Municipal Water District, Tarrant Regional Water District, and Upper Trinity Regional Water District. The basin-wide study of the Sulphur River Basin discussed in Section 4D.3 will provide additional information on the potential for developing supplies from Wright Patman Lake.

4D.5 Lake Texoma

Lake Texoma is an existing Corps of Engineers reservoir on the Red River on the border between Texas and Oklahoma. Under the terms of the Red River Compact, the yield of Lake Texoma is divided equally between Texas and Oklahoma. Lake Texoma is used for water supply, hydropower generation, flood control, and recreation. In Texas, the North Texas Municipal Water District, the Greater Texoma Utility Authority, the City of Denison, TXU, and the Red River Authority have contracts with the Corps of Engineers and Texas water rights allowing them to use water from Lake Texoma [7].

The U.S. Congress has passed a law allowing the Corps to reallocate an additional 300,000 acre-feet of storage in Lake Texoma from hydropower use to water supply, 150,000 acre-feet for Texas and 150,000 acre-feet for Oklahoma. The North Texas Municipal Water District is negotiating to purchase 100,000 of the 150,000 acre-feet of storage for Texas and has applied for a Texas water right to divert an additional 113,000 acre-feet per year from Lake Texoma. The remaining 50,000 acre-feet of storage was reserved by Congress for the Greater Texoma Utility Authority.

Further reallocation of hydropower storage to water supply in Lake Texoma would provide additional yield. According to the Corps of Engineers, the firm yield of Lake Texoma with all hydropower storage reallocated to water supply would be 1,088,500 acre-feet per year [8]. Texas' share would be 544,250 acre-feet per year, leaving about 220,000 acre-feet per year of additional supply available to Texas by the reallocation of more hydropower storage to municipal use (beyond the supplies already contracted for and the currently authorized reallocation). Further reallocation would require a new authorization by Congress.

Lake Texoma is only about 50 miles from the Metroplex. 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. Use for most Region C needs will require an interbasin transfer permit. Blending water from Lake Texoma with water from other sources provides an inexpensive supply for Region C. Desalination provides treated water but is a more expensive strategy and there are considerable uncertainties in the long-term costs.

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 this plan for a couple of 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. In addition, the method and cost 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.

As discussed in Section 4E, Lake Texoma is a recommended source of additional water supply for the North Texas Municipal Water District (113,000 acre-feet per year) and the Greater Texoma Utility Authority (56,500 acre-feet per year). It is an alternative source of supply for Dallas Water Utilities and the Upper Trinity Regional Water District.

4D.6 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 two reservoirs are located in Region I, the East Texas Region. The Lower Neches Valley Authority holds Texas water rights in the projects, 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 Region C, with raw water costing over $2.00 per thousand gallons until the debt service is paid on the initial construction. Because this is an existing supply, the environmental impacts of this water management strategy are relatively low. An interbasin transfer permit and a transmission system would be required to develop this water management strategy for Region C. Developing water from Sam Rayburn Reservoir/Lake B.A. Steinhagen is not a recommended strategy for any Region C supplier. It is an alternative strategy for Dallas Water Utilities and Tarrant Regional Water District.

4D.7 Lake Livingston

Lake Livingston is an existing reservoir on the Trinity River in Region H. 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. Region H may be considering other potential uses of the supply from Lake Livingston.

Lake Livingston is a relatively expensive source of supply for Region C, with raw water costing about $2.20 per thousand gallons until the debt service is paid on the initial construction. Because this is an existing supply, the environmental impacts of this water management strategy are relatively low. Since Lake Livingston is in the Trinity River Basin, no interbasin transfer permit would be needed for this water management strategy, but a transmission system would be required. Water from Lake Livingston is not a recommended strategy for any Region C supplier, but it is an alternative strategy for Dallas Water Utilities, the North Texas Municipal Water District, and the Tarrant Regional Water District.

4D.8 Ogallala Groundwater (Roberts County)

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 Region C, with raw water costing about $2.50 per thousand gallons until the debt service is paid on the initial construction. Since this is a groundwater supply, no interbasin transfer permit would be required. Ogallala groundwater from Roberts County is not a recommended strategy for any Region C supplier. It is an alternative strategy for Dallas Water Utilities and the North Texas Municipal Water District.

4D.9 Tarrant Regional Water District Third Pipeline and Reuse

The Tarrant Regional Water District recently received a water right permit from the Texas Commission on Environmental Quality allowing the diversion of return flows of treated wastewater from the Trinity River. The water will be pumped from the river into constructed wetlands for treatment and then pumped into Richland-Chambers Reservoir and Cedar Creek Reservoir. This project will increase the safe yield of the two lakes and also provide an additional 115,500 acre-feet per year of new supply. The total supply made available by the reuse project is 188,765 acre-feet per year in 2060. In order to deliver the currently available supplies and the supplies developed from the reuse project, TRWD will need to build a third pipeline from Richland-Chambers Reservoir and Cedar Creek Reservoir to Tarrant County. This strategy was included in the 2001 *Region C Water Plan* (1).

This is a relatively inexpensive source of new supply for the Tarrant Regional Water District, and the environmental impacts are low. It is a recommended strategy for the Tarrant Regional Water District, and the estimated capital cost is $626,347,000. The Richland-Chambers Reservoir reuse project will probably be built first, around 2010. The Cedar Creek Reservoir reuse project and the third pipeline will be needed around 2018.

4D.10 Water from Oklahoma

Metroplex water suppliers have been pursuing the purchase of water from existing sources in Oklahoma in recent years. Water from Oklahoma was a recommended strategy for North Texas Municipal Water District and Tarrant Regional Water District in the 2001 *Region C Water Plan*

[1]. At the present time, the Oklahoma Legislature has established a temporary moratorium on the export of water from the state. In the long run, Oklahoma remains a promising source of water supply for Region C.

Raw water from Oklahoma would cost about $1.40 per thousand gallons and would have relatively low environmental impacts because of the use of existing sources. Water from Oklahoma is a recommended strategy for the North Texas Municipal Water District (50,000 acre-feet per year), the Tarrant Regional Water District (50,000 acre-feet per year) and the Upper Trinity Regional Water District (15,000 acre-feet per year), with a capital cost of $477,214,000. It is an alternative strategy for Dallas Water Utilities and Irving.

4D.11 Lower Bois d'Arc Creek Reservoir

The proposed Lower Bois d'Arc Creek Reservoir was a recommended strategy for the North Texas Municipal Water District in the 2001 *Region C Water Plan* [1]. The project is located in Region C on Bois d'Arc Creek in Fannin County, upstream from the Caddo National Grasslands. It would yield 123,000 acre-feet per year and would provide an inexpensive source of supply for Region C. The project would inundate 16,358 acres. The 1984 Fish and Wildlife Service *Texas Bottomland Hardwood Preservation Program* [5] report classified the Bois d'Arc Creek bottoms in the reservoir area as Priority 4 bottomland hardwoods, which are "moderate quality bottomlands with minor waterfowl benefits." Development would require a water right permit and an interbasin transfer permit. Lower Bois d'Arc Creek Reservoir is a recommended water management strategy for the North Texas Municipal Water District and would have a capital cost of $399,190,000.

4D.12 Lake Fork Reservoir

Dallas Water Utilities has a contract with the Sabine River Authority for water from Lake Fork Reservoir and an interbasin transfer permit allowing the use of up to 120,000 acre-feet per year from the lake in the Trinity River Basin. Lake Fork Reservoir is located in Region D on Lake Fork Creek in the Sabine River Basin. Dallas Water Utilities has long planned to connect Lake Fork Reservoir to its water supply system and is in the process of constructing transmission facilities, which are scheduled for completion in 2007. Development of a supply from Lake Fork Reservoir provides water at a low cost and with a low environmental impact, and it is a recommended water management strategy for Dallas Water Utilities. The capital cost for the strategy is $362,916,000.

4D.13 George Parkhouse Lake (North)

George Parkhouse Lake (North) is a potential reservoir located in Region D 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 development of Lake Ralph Hall or Marvin Nichols Reservoir. George Parkhouse Lake (North) would provide an inexpensive source of supply for Region C. The project would inundate 12,250 acres. Ninety percent of the land impacted is cropland or pasture. There are no designated priority bottomland hardwoods located within or adjacent to the site. Development would require a water right permit and an interbasin transfer permit. George Parkhouse Lake (North) is not a recommended water management strategy for any Region C water supplier. It is an alternative strategy for the Dallas Water Utilities, North Texas Municipal Water District, the Tarrant Regional Water District, and the Upper Trinity Regional Water District.

4D.14 Lake Palestine

Dallas Water Utilities has a contract with the Upper Neches River Municipal Water Authority for 114,337 acre-feet per year of water from Lake Palestine and an interbasin transfer permit allowing the use of water from the lake in the Trinity River Basin. Lake Palestine is located in East Texas Region on the Neches River. Dallas Water Utilities plans to connect Lake Palestine to its water supply system around the year 2015. Development of a supply from Lake Palestine provides water at a low cost and with a low environmental impact, and it is a recommended water management strategy for Dallas Water Utilities. The capital cost for the strategy is $414,447,000.

4D.15 Lake Fastrill

The proposed Lake Fastrill is being investigated by the Upper Neches River Municipal Water Authority and Dallas Water Utilities as a potential water supply source. According to preliminary studies, the project would have a yield of 148,780 acre-feet per year [(9)]. It would inundate 24,950 acres, including a portion of a potential wildlife refuge currently being studied by the U.S. Fish and Wildlife Service. As a major reservoir project, it has the potential to have significant environmental impacts. The 1984 Fish and Wildlife Service *Texas Bottomland Hardwood Preservation Program* [5] classified some of the land that would be flooded by Lake Fastrill as a Priority 1 bottomland hardwood site, which is "excellent quality bottomlands of high value to key waterfowl species." The Texas State Railroad is located near the proposed reservoir site. As part of the permitting process for Lake Fastrill, this facility would be protected. The cost estimates for the lake include protection of the railroad. Development would require a water right permit and an interbasin transfer permit. Lake Fastrill is a recommended water management strategy to supply 112,100 acre-feet per year for Dallas Water Utilities. (The remainder of the supply would be available for use in East Texas Region.) The Region C share of Lake Fastrill would have a capital cost of $569,170,000.

4D.16 George Parkhouse Lake (South)

George Parkhouse Lake (South) is a potential reservoir located in Region D 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. There are no designated priority bottomland hardwoods located within or adjacent to the site. Development would require a water right permit and an interbasin transfer permit. George Parkhouse Lake (South) is not a recommended water management strategy for any Region C water supplier. It is an alternative strategy for the North Texas Municipal Water District and the Upper Trinity Regional Water District.

4D.17 East Fork Reuse Project

The North Texas Municipal Water District has applied for a water right to develop the East Fork Reuse Project. The project was added to the 2001 *Region C Water Plan* by amendment in January 2005. The project calls for diversion of return flows of treated wastewater from the East Fork of the Trinity River near Crandall into a constructed wetland for treatment. Water would then be pumped into Lake Lavon, diverted from the lake, and treated for municipal use. The project would supply 102,000 acre-feet per year. The project is a relatively inexpensive source of water, and the environmental impact is low. The East Fork Reuse Project is a recommended strategy for the North Texas Municipal Water District, and the capital cost is $288,879,000.

4D.18 Carrizo-Wilcox Aquifer Groundwater (Brazos County and Vicinity)

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. Metroplex water suppliers have been approached as possible customers for the water. (The supplies under discussion are located in Region G, called the Brazos G Region, and these supplies have 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 Region C, with delivered raw water costing about $2.75 per thousand gallons until the debt service is paid on the initial construction. Since this is a groundwater supply, no interbasin transfer permit would be required. Carrizo-Wilcox groundwater from Brazos County and vicinity is not a recommended strategy for any Region C supplier. It is an alternative strategy for the North Texas Municipal Water District.

4D.19 Cypress Basin Supplies (Lake O' the Pines)

Lake O' the Pines is an existing Corps of Engineers reservoir, with Texas water rights held by the Northeast Texas Municipal Water District. The lake is on Cypress Creek in the Cypress Basin in Senate Bill One water planning Region D, the North East Texas Region. Some Metroplex water suppliers have explored the possibility of purchasing supplies in excess of local needs from the Cypress Basin for use in the Metroplex. There could be as much as 89,600 acre-feet per year available for export from the basin. Development of this source would require contracts with the Northeast Texas Municipal Water District and other Cypress River Basin suppliers with excess supplies and an interbasin transfer permit. Since this water management strategy obtains water from an existing source, the environmental impacts would be low.

Lake O' the Pines is about 120 miles from the Metroplex, and the distance and limited supply make this a relatively expensive water management strategy. Obtaining water from the Cypress River Basin is not a recommended strategy for any Region C supplier. It is an alternative strategy for Dallas Water Utilities and the North Texas Municipal Water District.

4D.20 Return Flows above Dallas Water Utilities Lakes

There are significant discharges of wastewater return flows in the watersheds of many of the lakes used for water supply in Region C. Dallas Water Utilities has water rights in excess of the yields of many of its lakes, which means that return flows to the lakes can legally be diverted and used as they occur. In order to make this a reliable supply, Dallas Water Utilities plans to contract with wastewater dischargers in these watersheds to continue to discharge treated wastewater effluent, making the additional supplies available on a continuing basis [(10)]. The cost of this supply is assumed to be $0.10 per thousand gallons, and the 2060 supply is estimated to be 79,605 acre-feet per year [(10)]. This is a recommended water management strategy for Dallas Water Utilities and the Upper Trinity Regional Water District. There is no capital cost for this alternative, but it would require on-going payments for continued discharges.

4D.21 Southside (Lake Ray Hubbard) Reuse

The 2001 *Region C Water Plan* [(1)] included development of the Dallas Southside Reuse Plan as a recommended water management strategy for Dallas Water Utilities. This strategy was further analyzed in Dallas Water Utilities' recent recycled water implementation plan [(11)]. Water would be pumped from the Southside wastewater treatment plant to into a constructed wetland for treatment. After treatment, water would be pumped into Lake Ray Hubbard, diverted from the lake, and treated for municipal use. The strategy would provide 67,253 acre-feet per year. This water management strategy would provide a relatively inexpensive water supply with relatively low environmental impacts, and it is a recommended water management strategy for Dallas Water Utilities. The capital cost is $200,333,000.

4D.22 Lewisville Lake Reuse

Indirect reuse through Lewisville Lake was analyzed in Dallas Water Utilities' recent recycled water implementation plan [(11)]. The strategy would provide 67,253 acre-feet per year. Treated wastewater at the Central Wastewater Treatment Plant would receive further treatment for reuse. Water would then be pumped into Lewisville Lake, diverted from the lake, and treated for municipal use. This water management strategy would provide a relatively inexpensive water supply with relatively low environmental impacts, and it is a recommended water management strategy for Dallas Water Utilities. The capital cost is $191,439,000.

4D.23 Tehuacana Reservoir

Tehuacana Reservoir is a proposed reservoir on Tehuacana Creek in Freestone County in Region C. It was an alternative strategy for the Tarrant Regional Water District in the 2001

Region C Water Plan [1]. Tehuacana Reservoir would flood about 15,000 acres adjacent to Richland-Chambers Reservoir and would have a yield of 56,800 acre-feet per year. There are no priority bottomland hardwoods within the site. Development of this supply would require a new water right permit, construction of the reservoir, and up-sizing TRWD's third pipeline to deliver that water to Tarrant County. Tehuacana Reservoir is not a recommended water management strategy for any Region C supplier. It is an alternative strategy for the Tarrant Regional Water District.

4D.24 Lake Ralph Hall and Reuse

The Upper Trinity Regional Water District has applied for a water right permit for the proposed Lake Ralph Hall, located on the North Fork of the Sulphur River in Fannin County in Region C. The reservoir would flood 7,600 acres. The yield of the project would be 32,940 acre-feet per year, and Upper Trinity Regional Water District plans to apply for the right to reuse return flows from water originating from the project, providing an additional 17,800 acre-feet per year. Developing Lake Ralph Hall and the related reuse is a strategy for the Upper Trinity Regional Water District, and the capital cost is $211,153,000.

4D.25 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 in East Texas Region. The Authority is pursuing development of the reservoir and has applied for a Federal 404 permit from the Corps of Engineers. In its recent long-range planning effort, Dallas Water Utilities studied purchasing 35,800 acre-feet per year from Lake Columbia and delivering the water through Lake Palestine [10]. Lake Columbia would flood about 11,500 acres. Lake Columbia is not a recommended water management strategy for any Region C supplier. It is an alternative strategy for Dallas Water Utilities.

4D.26 Summary of Recommended Major Water Management Strategies

Table 4D.3 is a summary of the recommended major water management strategies for Region C. There are 15 recommended major strategies, supplying a total of 2.24 million acre-feet per year to Region C at a capital cost of $8.6 billion.

Table 4D.3
Recommended Major Water Management Strategies for Region C

Strategy	Supplier	Supply (Acre-Feet per Year)	Supplier Capital Cost	Supplier Unit Cost ($/kGal.)	
				Pre-Amort.	Post-Amort.
Toledo Bend Reservoir	NTMWD	200,000	$886,002,000	$1.56	$0.57
	TRWD	200,000	$1,035,188,000	$1.92	$0.77
Marvin Nichols Reservoir	NTMWD	174,840	$534,125,000	$0.94	$0.26
	TRWD	280,000	$1,482,167,000	$1.66	$0.48
	UTRWD	35,000	$142,761,000	$1.27	$0.36
TRWD 3rd Pipeline & Reuse	TRWD	188,765	$626,347,000	$1.05	$0.31
Lower Bois d'Arc Ck. Res.	NTMWD	123,000	$399,190,000	$0.87	$0.14
Lake Fork Reservoir	DWU	120,000	$362,916,000	$0.84	$0.17
Oklahoma Water	NTMWD	50,000	$128,898,000	$0.95	$0.37
	TRWD	50,000	$287,349,000	$1.86	$0.58
	UTRWD	15,000	$60,967,000	$1.36	$0.45
Lake Palestine	DWU	111,460	$414,447,000	$1.08	$0.25
New Lake Texoma (Blend)	NTMWD	113,000	$201,829,000	$0.58	$0.18
Lake Fastrill	DWU	112,100	$569,170,000	$1.40	$0.27
Wright Patman Lake - Flood Pool	DWU	112,100	$572,036,000	$1.50	$0.36
East Fork Reuse Project	NTMWD	102,000	$288,879,000	$0.92	$0.21
Return Flows above DWU Lakes	DWU and UTRWD	79,605	$0	$0.10	$0.10
Southside (Lake Ray Hubbard) Reuse	DWU	67,253	$200,333,000	$0.87	$0.21
Lewisville Lake Reuse	DWU	67,253	$191,439,000	$0.78	$0.15
Lake Ralph Hall and Reuse	UTRWD	50,740	$211,153,000	$1.10	$0.17
Region C Total		**2,252,116**	**$8,595,196,000**		

Note: The costs and unit costs in Table 4D.3 may be different from those in Table 4D.2 because the amounts and participants may be different.

SECTION 4D
LIST OF REFERENCES

(1) Freese and Nichols, Inc., Alan Plummer Associates, Inc., Chiang, Patel & Yerby, Inc., and Cooksey Communications, Inc.: *Region C Water Plan*, prepared for the Region C Water Planning Group, Fort Worth, January 2001.

(2) Brown and Root, Inc., *Yield Study Toledo Bend Reservoir*, prepared for the Sabine River Authority of Texas and the Sabine River Authority of Louisiana, Houston, July 1991.

(3) Texas Water Development Board, Large-Scale Demonstration Seawater Desalination in Texas, Report of Recommendations for the Office of Governor Rick Perry, Austin, [Online], Available URL: http://www.twdb.state.tx.us/Desalination/FINAL%2012-16-02.pdf, May 2005.

(4) R.J. Brandes Company, *Final Report – Water Availability Modeling for the Sulphur River Basin*, prepared for the Texas Water Development Board, Austin, June 1999.

(5) U.S. Fish and Wildlife Service: Department of the Interior Final Concept Plan, *Texas Bottomland Hardwood Preservation Program*, Albuquerque, 1984.

(6) Freese and Nichols, Inc., *System Operation Assessment of Lake Wright Patman and Lake Jim Chapman*, prepared for the U.S. Army Corps of Engineers, Fort Worth District, Fort Worth, January 2003.

(7) Freese and Nichols, Inc., *Report in Support of Amending Permit 5003*, prepared for the North Texas Municipal Water District, Fort Worth, February 2005.

(8) U.S. Army Corps of Engineers, Tulsa District, *Draft Environmental Assessment, Lake Texoma Storage Reallocation Study, Lake Texoma, Oklahoma and Texas*, Tulsa, January 2005.

(9) HDR Engineering, Inc.: "Fastrill Reservoir - Preliminary Technical Information for 2006 Region C Regional Water Plan," Austin, April 2005.

(10) Chiang, Patel and Yerby, Inc.: *Draft 2005 Update to the City of Dallas Long Range Water Supply Plan*, Dallas, February 2005, and related presentations to the City Council and Council Committees.

(11) Alan Plummer Associates, Inc.: *Draft Recycled Water Implementation Plan*, Dallas, August 2004.

4E. Recommended Water Management Strategies for Wholesale Water Providers

As discussed in earlier chapters, the Region C Water Planning Group has designated 35 wholesale water providers – 12 classified as regional wholesale water providers and 23 classified as local wholesale water providers. The majority of the water supplied in Region C is provided by the 12 regional wholesale water providers, nine of which are based in the region, with three located in other regions. Collectively, the nine regional wholesale water providers located in Region C (Dallas Water Utilities, Tarrant Regional Water District, North Texas Municipal Water District, Fort Worth, Upper Trinity Regional Water District, Greater Texoma Utility Authority, Trinity River Authority, Corsicana, and Dallas County Park Cities Municipal Utility District) provide over 90 percent of the total water needs in the region. These entities will continue to provide over 90 percent of the water supply for Region C through 2060, and they will also develop most of the new supply in that time period.

The three regional wholesale water providers located in other regions (Sabine River Authority, Sulphur River Water District, and Upper Neches River Municipal Water Authority) also play an important role in water supply for Region C. These providers own and/or operate major sources of current water supply for Region C. The Sabine River Authority and the Upper Neches River Municipal Water Authority are also cooperating with Region C suppliers to develop new strategies to meet water needs in Region C.

The 23 local wholesale water providers supply considerable quantities of water to local water users and are expected to continue meeting these local water needs. Several of the local wholesale providers obtain water exclusively from a regional wholesale provider. It is assumed that these entities will continue to purchase water from a regional provider. Other local water providers will develop new water management strategies to meet their shortages.

This section discusses the recommended water supply plans for each regional wholesale water provider (Section 4E.1) and local wholesale water provider (Section 4E.2). Evaluations of specific water management strategies are included in Appendix T, and detailed costs are shown in Appendix U. Cost estimates for conservation strategies were developed for individual water user groups and are discussed in Chapter 4B and shown in Appendix U. Detailed listings of demands by customer for each wholesale water providers and the projected water shortages are included in Appendix H.

4E.1 Recommended Strategies for Regional Wholesale Water Providers

The recommended strategies for the regional wholesale water providers include conservation, reuse, connections to existing sources already under contract, connection to other existing sources, and the development of new reservoirs. The total amount of supply from these strategies is 2.6 million acre-feet per year in 2060, bringing the total supply for the regional providers to 3.8 million acre-feet per year.

Strategies for Multiple Wholesale Water Providers

Marvin Nichols Reservoir. The Marvin Nichols Reservoir is a recommended strategy for the Tarrant Regional Water District (TRWD), the North Texas Municipal Water District (NTMWD) and the Upper Trinity Regional Water District (UTRWD). Marvin Nichols Reservoir was a recommended project in the 2001 *Region C Water Plan*. The project would provide a large source of additional supply for the Metroplex at a relatively low cost. Marvin Nichols Reservoir is an alternative source of supply for Dallas Water Utilities and the City of Irving. 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. The division of the 489,840 acre-feet per year assumed to be available to Region C from the reservoir in the recommended strategy is:

- 280,000 acre-feet per year for Tarrant Regional Water District
- 174,840 acre-feet per year for North Texas Municipal Water District
- 35,000 acre-feet per year for Upper Trinity Regional Water District.

The delivery system from Marvin Nichols Reservoir (which accounts for three-quarters of the total cost of the project) will 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 Tarrant Regional Water District and North Texas

Municipal Water District in Region C. Toledo Bend Reservoir is an alternative strategy for Dallas Water Utilities and Upper Trinity Regional Water District. With participation from the NTMWD and the TRWD in Region C, the project would include the delivery of 500,000 acre-feet per year of water:

- 100,000 acre-feet per year for the Sabine River Authority in the upper Sabine Basin (North East Texas Region)
- 200,000 acre-feet per year for Tarrant Regional Water District
- 200,000 acre-feet per year for North Texas Municipal Water District.

The facilities to deliver the water would be developed in phases, with Phase 1 planned for 2050 and Phase 2 planned after 2060.

Oklahoma. Several wholesale water providers in the Metroplex have been pursuing the purchase of water from Oklahoma. At the present time, the Oklahoma Legislature has established a temporary moratorium on the export of water from the state. For the long term, Oklahoma remains a promising source of water supply for Region C. At this time, water from Oklahoma is a recommended strategy for the North Texas Municipal Water District, the Tarrant Regional Water District, and the Upper Trinity Regional Water District. Water from Oklahoma is an alternative strategy for Dallas Water Utilities and Irving. 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.

Dallas Water Utilities

Dallas Water Utilities (DWU) serves nearly all of Dallas County and much of the surrounding counties. The projected water demands on DWU are projected to increase from 641,000 acre-feet per year in 2010 to 1.08 million acre-feet per year by 2060 [a]. The supply currently available to DWU is slightly more than 443,500 acre-feet per year, decreasing to 422,600 acre-feet per year by 2060. As a result, DWU will need to develop an additional 198,000 acre-feet per year of additional water supplies by 2010 to meet projected demands and an additional 653,000 acre-feet per year by 2060. Some of these needs will be met through connection of existing sources currently under contract and conservation and reuse. Twenty-five

[a] Dallas Water Utilities has independently developed long-range water supply demands, and these demands differ slightly from the Region C water demands.

potentially feasible water management strategies were identified and evaluated for DWU. Figure 4E.1 shows the unit cost for each strategy, and the full evaluations are summarized in Appendix T. Considering recent planning efforts by DWU [1, 2], the recommended water management strategies for DWU are as follows:

- Conservation
- Contract for Return Flows to DWU Lakes
- Connect Lake Fork Reservoir (2007)
- Direct Non-Potable Reuse (2010)
- Indirect Reuse through Lake Ray Hubbard (2012)
- Connect Lake Palestine (2015)
- Indirect Reuse through Lewisville Lake (2022)
- Wright Patman Lake – Flood Pool Reallocation (2035)
- Lake Fastrill (2045)
- Water Treatment Plant Expansions (2010, 2012, 2022, 2035).

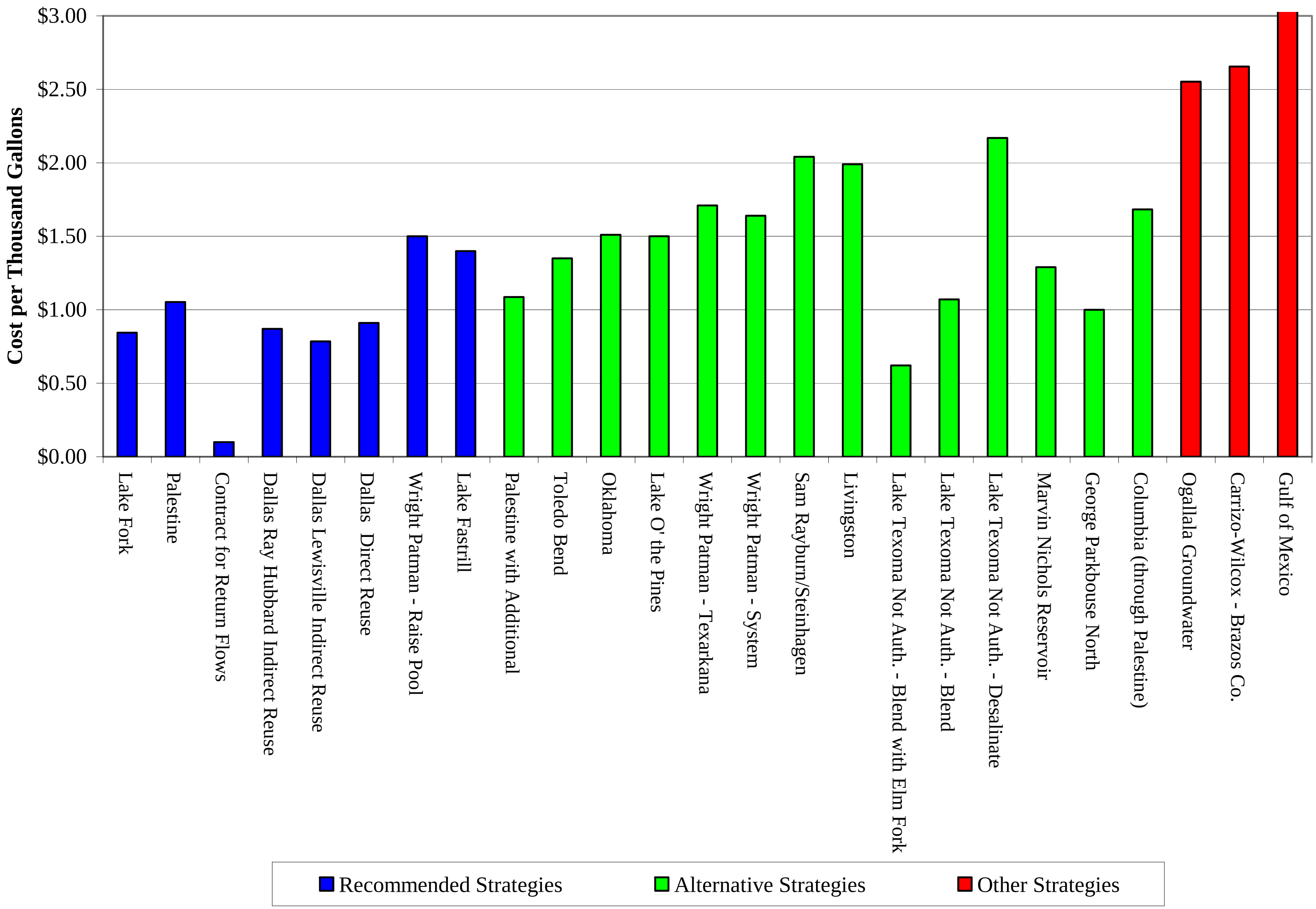
These strategies are discussed individually below.

DWU Conservation. The conservation savings for the DWU retail customers are based on DWU's recent conservation plan [3]. The savings for DWU's wholesale customers are based on the Region C recommended water conservation program. Not including savings from low-flow plumbing fixtures (which are built into the demand projections) and not including reuse, conservation by DWU retail and wholesale customers is projected to reach 105,299 acre-feet per year by 2060.

Additional Dry Year Supply. DWU's existing permits allow overdrafting of several of their lakes, which can be used to meet demands in the driest years. DWU plans to operate their existing system to provide additional dry year supply as needed.

Contract for Return Flows to DWU lakes. There are significant wastewater discharges in the watersheds of DWU's water supply lakes. DWU plans to contract with dischargers to continue to discharge, making additional reliable supplies available for DWU. The cost of this supply is assumed to be $0.10 per thousand gallons, and the 2060 supply is 79,613 acre-feet per year for DWU and Upper Trinity Regional Water District (UTRWD), a DWU customer [1].

Figure 4E.1
Potentially Feasible Strategies for DWU



UTRWD is expected to use slightly over 30,000 acre-feet per year of this supply. (It should be noted that reuse by UTRWD reduces the demand on the DWU system, since UTRWD is a DWU customer.)

Connect Lake Fork Reservoir. Construction is currently underway on facilities to connect Lake Fork Reservoir to DWU's East side water treatment plant. Construction is planned to be completed by 2007. DWU's share of the yield of Lake Fork Reservoir is 115,937 acre-feet per year as of 2060. This project was in the 2001 *Region C Water Plan* [4].

TXU Lake Fork Contract. TXU has an option agreement with DWU for 17,000 acre-feet per year of water from Lake Fork Reservoir for intended use at their Martin Lake facility. As part of this agreement TXU must exercise the option by September 1, 2009 or the water reverts back to DWU. According to the supply and demand analysis conducted by the East Texas Region, the projected shortage for steam electric power at the Martin Lake facility does not begin until 2040. For this plan, it is assumed that TXU will exercise the option for the Lake Fork water and negotiate with DWU to allow DWU to continue using Lake Fork water until it is needed by TXU. This supply is considered part of the Connect Lake Fork Reservoir strategy (discussed above).

Direct Non-Potable Reuse. DWU plans to develop a direct non-potable reuse system by 2010. The system will supply an additional 20,458 acre-feet per year of direct reuse for landscaping and industrial use by 2060 [1, 2, 5].

Indirect Reuse through Lake Ray Hubbard. The 2001 *Region C Water Plan* [4] included development of a 60 mgd indirect reuse project through Lake Ray Hubbard. This project is also in DWU's current plan [1, 2, 5], scheduled to be in service in 2012 with a supply of 67,253 acre-feet per year.

Connect Lake Palestine. DWU plans to develop facilities to connect Lake Palestine to its system by 2015 [1]. DWU has a contract for 114,337 acre-feet per year from Lake Palestine. Based on the firm yield of the reservoir, the available supply to DWU in 2020 is 111,460 acre-feet per year. This project was in the 2001 *Region C Water Plan* [4].

Indirect Reuse through Lewisville Lake. DWU plans to develop a 60 mgd indirect reuse project through Lewisville Lake by 2022 [1, 2, 5]. This project would provide a supply of 67,253 acre-feet per year.

Wright Patman Lake – Flood Pool Reallocation. By 2035, DWU plans to develop 100 mgd from raising the flood pool in Wright Patman Lake [1, 2]. This would require a transmission system back to Dallas and would supply 112,100 acre-feet per year.

Lake Fastrill. By 2045, DWU plans to develop 100 mgd by constructing the proposed Lake Fastrill [1, 2]. This would require a transmission system back to Dallas and would supply 112,100 acre-feet per year.

Water Treatment Plant Expansions. DWU's plan calls for water treatment plant expansions in 2010 and 2012 and construction of new plants in 2022 and 2035 [1, 2].

Table 4E.1 and Figure 4E.2 show the recommended plan by decade for DWU, and Table 4E.2 presents the costs associated with the infrastructure strategies.

Table 4E.1
Summary of Recommended Water Management Strategies for DWU
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies)						
Lake Ray Roberts/Lewisville System [a]	*191,729*	*189,705*	*187,681*	*185,657*	*183,633*	*181,609*
Lake Ray Hubbard	*60,367*	*60,033*	*59,700*	*59,367*	*59,033*	*58,700*
Lake Tawakoni	*183,619*	*182,251*	*180,882*	*179,515*	*178,146*	*176,777*
Grapevine Lake	*7,250*	*6,800*	*6,350*	*5,900*	*5,450*	*5,000*
Direct Reuse (Cedar Crest GC)	*561*	*561*	*561*	*561*	*561*	*561*
Total Available Supplies	***443,525***	***439,350***	***435,174***	***430,999***	***426,823***	***422,647***
Water Management Strategies						
Conservation (DWU Retail) [b]	17,600	24,998	31,724	38,675	45,737	53,135
Conservation (DWU Wholesale Customers)	7,186	17,330	23,312	31,084	39,955	52,164
Contract for Return Flows	34,370	44,750	53,147	60,646	69,861	79,613
Additional Dry Year Supply	20,000	0	0	0	0	0
Return Flows used by UTRWD [c]	(14,068)	(31,595)	(31,362)	(31,129)	(30,896)	(30,665)
Additional Direct Reuse	20,458	20,458	20,458	20,458	20,458	20,458
Connect Lake Fork Reservoir	120,000	119,312	118,468	117,624	116,781	115,937
Lake Ray Hubbard Indirect Reuse	0	67,253	67,253	67,253	67,253	67,253
Connect Lake Palestine	0	111,460	110,840	110,220	109,600	108,980

Table 4E.1, Continued

Source	2010	2020	2030	2040	2050	2060
Water Management Strategies, Continued						
Lewisville Lake Indirect Reuse	0	0	67,253	67,253	67,253	67,253
Wright Patman Lake	0	0	0	112,100	112,100	112,100
Lake Fastrill	0	0	0	0	112,100	112,100
Total Supplies from Strategies	**205,546**	**373,965**	**461,094**	**594,185**	**730,201**	**758,328**
Total Supplies	**649,071**	**813,315**	**896,267**	**1,025,184**	**1,157,024**	**1,180,975**
Total from Conservation & Reuse	66,106	143,754	232,346	254,801	280,181	309,772
Percent from Conservation & Reuse	**10.2%**	**17.7%**	**25.9%**	**24.9%**	**24.2%**	**26.2%**
Projected Demands	**641,065**	**709,097**	**755,366**	**819,287**	**929,052**	**1,075,359**
Surplus or (Shortage)	8,005	104,219	140,901	205,897	227,972	105,616

Notes: a. The yield of the Lake Ray Roberts/Lewisville System includes the water available from Dallas' water rights on the Elm Fork of the Trinity River.

b DWU retail conservation was provided by the City of Dallas.

c. The negative number for return flows used by UTRWD represents UTRWD reuse of return flows from UTRWD customers to Lewisville Lake. According to DWU's planning consultant, DWU's reuse number assumed that DWU would supply UTRWD demands. UTRWD reuse would decrease those demands. To avoid double counting this supply (as available to both entities), the DWU supply was reduced by the amount used by UTRWD.

Figure 4E.3 shows the distribution of DWU's 2060 supplies by type (current surface water, reuse, conservation, connecting existing supplies, and new reservoirs). By 2060, approximately 26 percent of the total supply provided to DWU is from reuse and conservation. The estimated capital cost for DWU's recommended water management strategies is approximately $2.8 billion, based on 2002 construction costs.

In addition, the following alternative water management strategies are designated for DWU in case water demand is higher than projected or one or more of DWU's recommended water management strategies is not developed in a timely manner:

- Additional water conservation
- Lake Texoma
- Toledo Bend Reservoir
- Lake O' the Pines
- Lake Livingston

Figure 4E.2
Recommended Water Management Strategies for Dallas Water Utilities

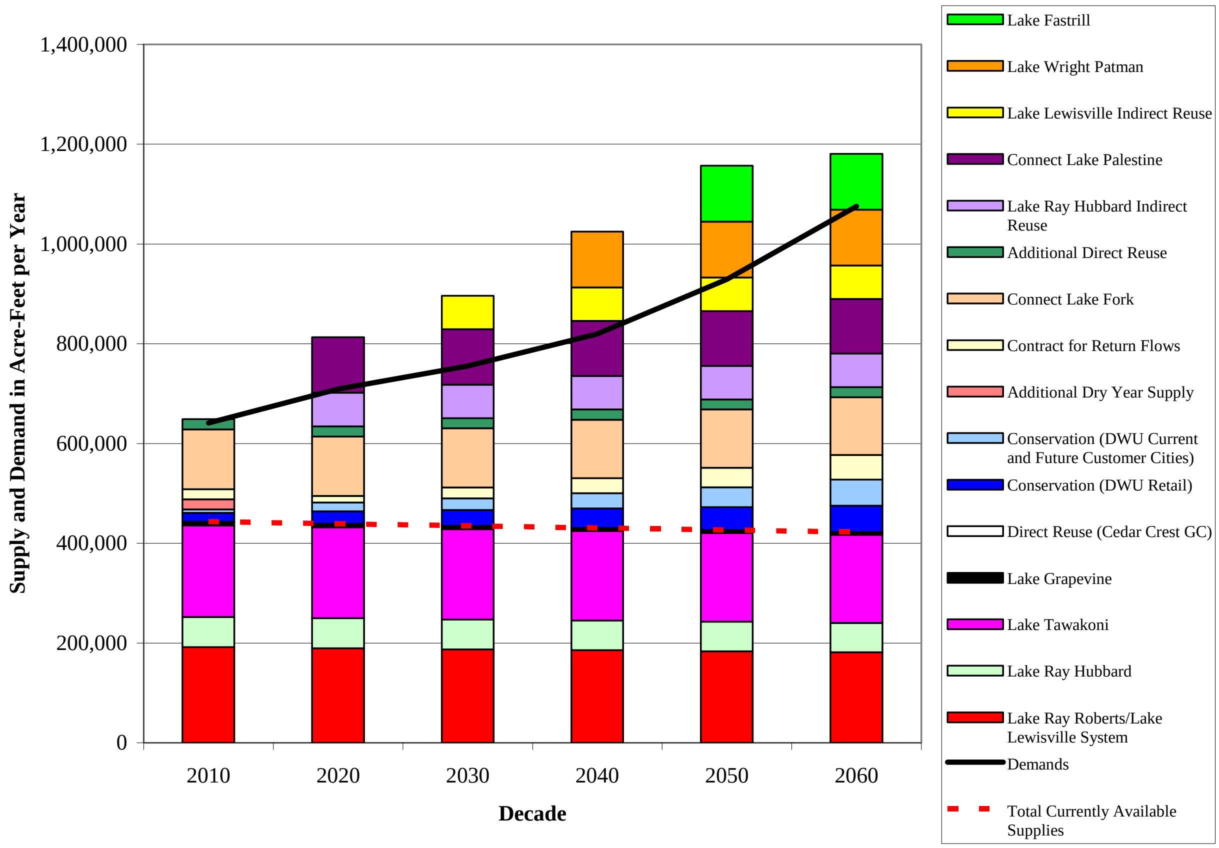
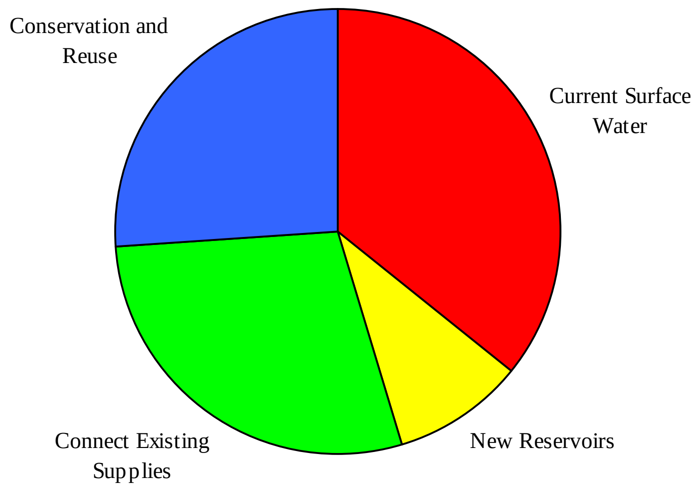


Table 4E.2
Summary of Costs for DWU Recommended Water Management Strategies

Strategy	Development Dates	Quantity for DWU (Ac-Ft/Yr)	DWU Share of Capital Cost	Unit Cost ($/kGal.)	
				Pre-Amort.	Post-Amort.
Water Treatment Plants	2005-2060	N/A	$382,441,000	N/A	N/A
Additional Dry Year Supply	2000	20,000	$0	N/A	N/A
Net Contract for Return Flows	2010	48,948	$0	$0.10	$0.10
Lake Fork Reservoir	2007	120,000	$362,916,000	$0.84	$0.17
Direct Reuse	2010	20,456	$63,110,000	$0.91	$0.22
Lake Ray Hubbard Indirect Reuse	2012	67,253	$200,333,000	$0.87	$0.21
Lake Palestine	2015	111,460	$414,447,000	$1.08	$0.25
Lewisville Lake Indirect Reuse	2022	67,253	$191,439,000	$0.78	$0.15
Wright Patman Lake	2035	112,100	$572,036,000	$1.50	$0.36
Lake Fastrill	2045	112,100	$569,170,000	$1.40	$0.27
Total Capital Costs			**$2,811,350,000**		

Note: No capital costs are associated with the recommended water conservation measures.

Figure 4E.3
Dallas Water Utilities' 2060 Supply by Type



- Lake Sam Rayburn/Lake B.A. Steinhagen
- Ogallala groundwater in Roberts County (Region A)
- Marvin Nichols Reservoir
- Lake Columbia
- George Parkhouse Reservoir (North)
- Oklahoma Water

Costs for the alternative strategies are shown in Table 4E.3.

Tarrant Regional Water District

Tarrant Regional Water District (TRWD) owns and operates several lakes and reservoirs in the Trinity River Basin. The TRWD system provides water either directly or indirectly to 104 water user groups and is expected to provide water to 13 additional water groups. The projected 2010 demand on TRWD is 429,000 acre-feet per year, increasing to 893,500 acre-feet per year by 2060. The total available supply from the TRWD system is 447,000 acre-feet per year in 2010, which is based on the operational safe yield analysis. The supply decreases to 394,000 acre-feet per year by 2060 due to sedimentation in the reservoirs. TRWD has enough currently available water supplies to meet projected demands through 2010. By 2020, TRWD has a

Table 4E.3
Summary of Costs of Alternative Strategies for DWU

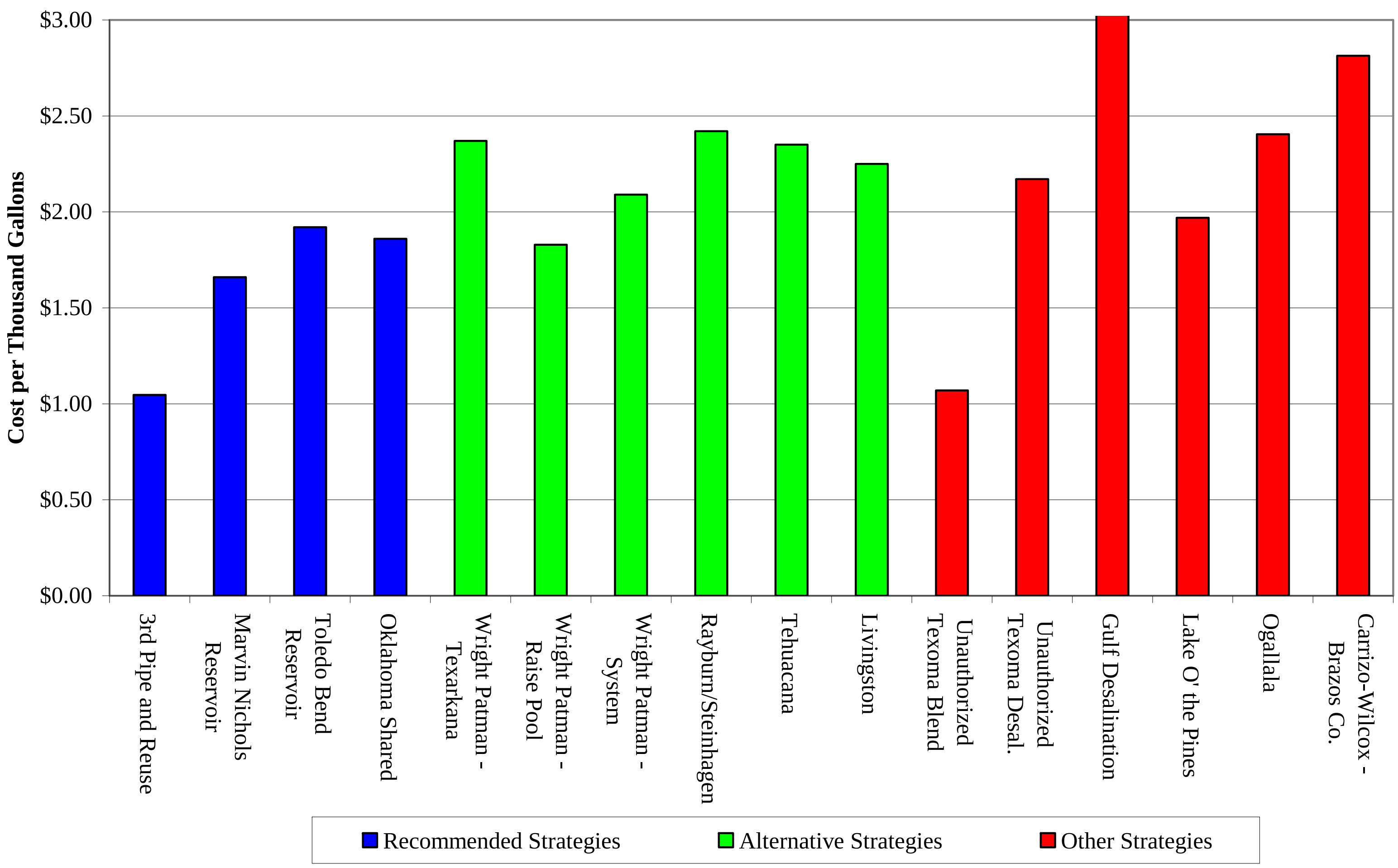
Strategy	Quantity for DWU (Ac-Ft/Yr)	DWU Share of Capital Cost	Unit Cost ($/kGal.)	
			Pre-Amort.	Post-Amort.
Additional Water Conservation	Unknown	Unknown	Varies	Varies
Lake Texoma - Elm Fork	20,000	$36,674,200	$0.62	$0.21
Lake Texoma - Blend	113,000	$182,587,700	$1.07	$0.25
Lake Texoma - Desalinate	105,000	$621,447,600	$2.17	$0.85
Toledo Bend Reservoir [a]	200,000	$749,289,400	$1.35	$0.51
Lake O' the Pines	89,600	$344,396,500	$1.50	$0.64
Lake Livingston	200,000	$1,142,917,000	$1.99	$0.72
Sam Rayburn/B.A. Steinhagen	200,000	$1,306,045,000	$2.04	$0.59
Roberts County Groundwater	200,000	$1,766,073,000	$2.55	$0.58
Marvin Nichols Reservoir	95,131	$400,248,000	$1.29	$0.36
Lake Columbia	35,800	$223,705,000	$1.68	$0.29
George Parkhouse Reservoir (North)	112,000	$365,002,000	$1.00	$0.27
Oklahoma Water	50,000	$233,715,000	$1.51	$0.47

Note: a. Costs are reported for the 700,000 acre-feet per year Toledo Bend Project, which includes DWU.

projected shortage of 82,660 acre-feet per year, increasing to nearly 500,000 acre-feet per year by 2060. TRWD is in the process of increasing the reliability of its supplies through system interconnections and developing its permitted reuse projects at Richland-Chambers Reservoir and Cedar Creek Reservoir. The TRWD will also need to develop additional new supplies over time. Sixteen infrastructure projects were evaluated for TRWD, and the unit costs for these are shown on Figure 4E.4. The full evaluations are summarized in Appendix T. The recommended water management strategies for TRWD are as follows:

- Conservation and Reuse
    - Water conservation by customers
    - Third pipeline and reuse project
- Eagle Mountain Connection
- Marvin Nichols Reservoir
- Toledo Bend Reservoir
- Oklahoma Water.

Figure 4E.4
Potentially Feasible Strategies for TRWD



The development of the Marvin Nichols Reservoir, connection to Toledo Bend Reservoir, and connection to Oklahoma water sources are multi-provider strategies and are discussed above. The other recommended strategies are discussed individually below.

Conservation and Reuse. Conservation for TRWD is the projected water savings from the Region C recommended water conservation program for TRWD's existing and potential customers. Not including savings from low-flow plumbing fixtures (which amount to about 5 percent of demand and are built into the demand projections) and not including reuse, conservation by TRWD customers is projected to reach 79,793 acre-feet per year by 2060.

TRWD recently received a permit from the Texas Commission on Environmental Quality allowing the diversion of return flows of treated wastewater from the Trinity River. The water will be pumped from the river into constructed wetlands for treatment and then pumped into Richland-Chambers Reservoir and Cedar Creek Reservoir. The wetlands project will increase the safe yield of the two lakes to the permitted amounts (increasing the total 2060 TRWD system safe yield by 73,265 acre-feet per year) and provide an additional 115,500 acre-feet per year of new supply. Thus, the total supply made available by the reuse project is 188,765 acre-feet per year in 2060. In order to deliver the currently available supplies and the supplies developed from the reuse project, the TRWD will need to build a third pipeline from Richland - Chambers Lake and Cedar Creek Reservoir to Tarrant County. The Richland-Chambers Reservoir reuse project has the river pump station on the Trinity River and a 15 mgd treatment train in operation. The pump station to move the water to Richland-Chambers Reservoir and a second 15 mgd treatment train are under design now and will be constructed in 2006. Final build-out for Richland-Chambers Reuse will be around 2010. The Cedar Creek Reservoir reuse project and the third pipeline will be needed around 2018.

The total projected 2060 supply from conservation and reuse for TRWD is 268,580 acre-feet per year. This does not include conservation from low-flow fixtures, which is built into TWDB demand projections.

Eagle Mountain Connection. The Eagle Mountain Connection consists of pipelines and pump stations to convey water delivered from TRWD's East Texas reservoirs (Cedar Creek Reservoir and Richland-Chambers Reservoir) to Eagle Mountain Lake on the West Fork of the Trinity River. The Eagle Mountain Connection will not increase the total amount of water supply available to TRWD. It will increase the amount that can be delivered to the rapidly-growing North Tarrant County area, greatly increase the reliability of the TRWD system, reduce the frequency of drought operation for TRWD's customers, and delay the construction of TRWD's third pipeline. The project is currently under design and is scheduled to be in operation by 2008.

Table 4E.4 and Figure 4E.5 show the recommended plan for TRWD by decade. Figure 4E.6 shows the distribution of TRWD's total supply in 2060 by strategy type. A considerable amount of new water supply provided through 2040 is from reuse and conservation, with approximately one fourth of the total 2060 supplies coming from conservation and reuse. A summary of costs for the infrastructure strategies is presented in Table 4E.5. TRWD's share of the total capital cost for the recommended plan is $3.6 billion.

The alternative water management strategies for TRWD are as follows:

- Toledo Bend Reservoir Phase 2 (accelerated to occur before 2060)]
- Wright Patman Lake
- Sam Rayburn/B.A. Steinhagen
- Lake Tehuacana
- Livingston
- System operation
- Paluxy groundwater wells near Eagle Mountain Lake.

Costs for the alternative strategies are presented in Table 4E.6

Table 4E.4
Recommended Water Management Strategies for Tarrant Regional Water District
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies (Safe Yield)						
West Fork System	*98,975*	*98,150*	*97,325*	*96,500*	*95,675*	*94,850*
Benbrook Lake	*6,834*	*6,834*	*6,834*	*6,834*	*6,834*	*6,834*
Cedar Creek	*152,783*	*150,067*	*147,350*	*144,633*	*141,917*	*139,200*
Richland-Chambers Reservoir	*188,444*	*181,388*	*174,332*	*167,276*	*160,220*	*153,165*
Total Available Supplies	***447,036***	***436,439***	***425,841***	***415,243***	***404,646***	***394,049***
Water Management Strategies						
Conservation	11,653	26,391	38,319	50,086	63,480	79,793
Third Pipeline and Reuse						
- Additional Richland-Chambers Yield	21,556	28,612	35,668	37,465	37,465	37,465
- Additional Cedar Creek Yield		24,933	27,650	30,367	33,083	35,800
- RC Reuse	63,000	63,000	63,000	63,000	63,000	63,000
- CC Reuse		52,500	52,500	52,500	52,500	52,500
Total, Third Pipeline and Reuse	**84,556**	**169,045**	**178,818**	**183,332**	**186,048**	**188,765**
Marvin Nichols Reservoir			140,000	140,000	280,000	280,000
Toledo Bend Reservoir					100,000	100,000
Oklahoma Water						50,000
Total Supplies from Strategies	**96,209**	**195,436**	**357,137**	**373,418**	**629,528**	**698,558**
Total Supplies	**543,245**	**631,875**	**782,978**	**788,661**	**1,034,174**	**1,092,607**
Total from Conservation & Reuse	96,209	195,436	217,137	233,418	249,528	268,558
Percent from Conservation & Reuse	17.7%	30.9%	27.7%	29.6%	24.1%	24.6%
Projected Demands	**428,966**	**518,976**	**595,992**	**678,304**	**779,509**	**893,510**
Surplus or (Shortage)	114,280	112,899	186,986	110,357	254,665	199,097

Figure 4E.5
Recommended Water Management Strategies for Tarrant Regional Water District

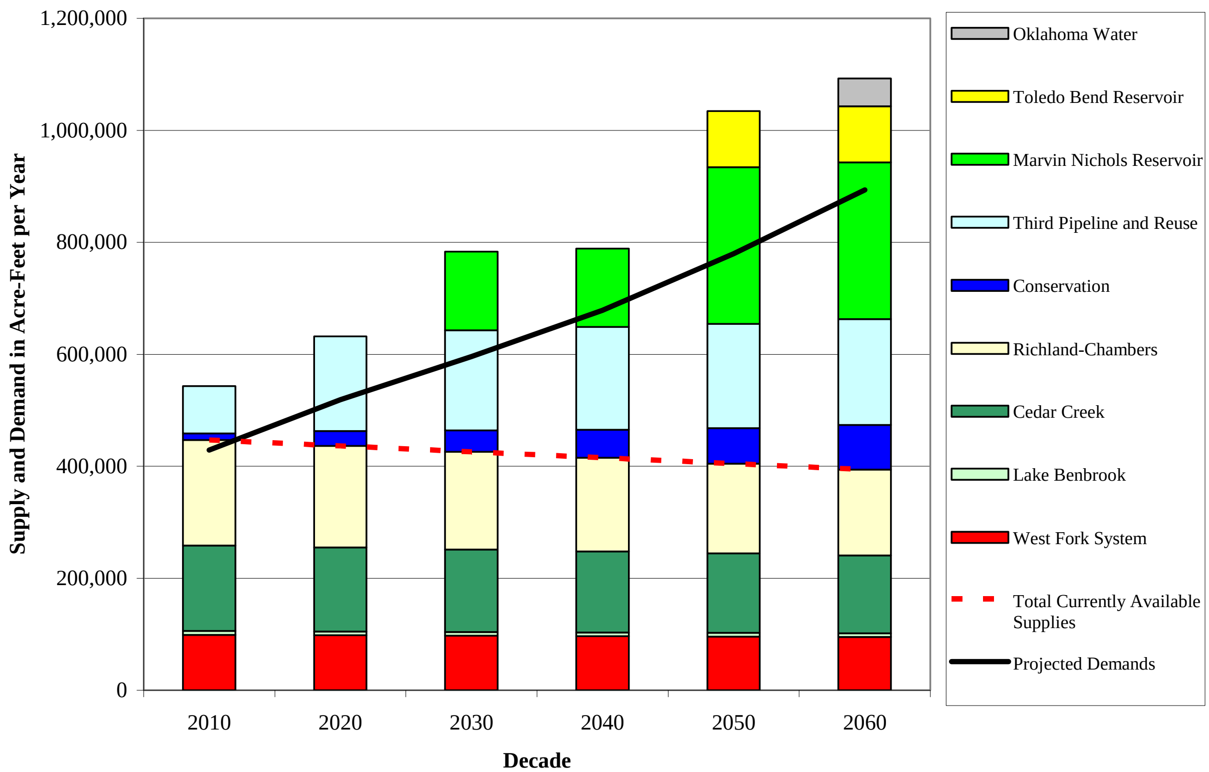


Figure 4E.6
TRWD's 2060 Supply by Type

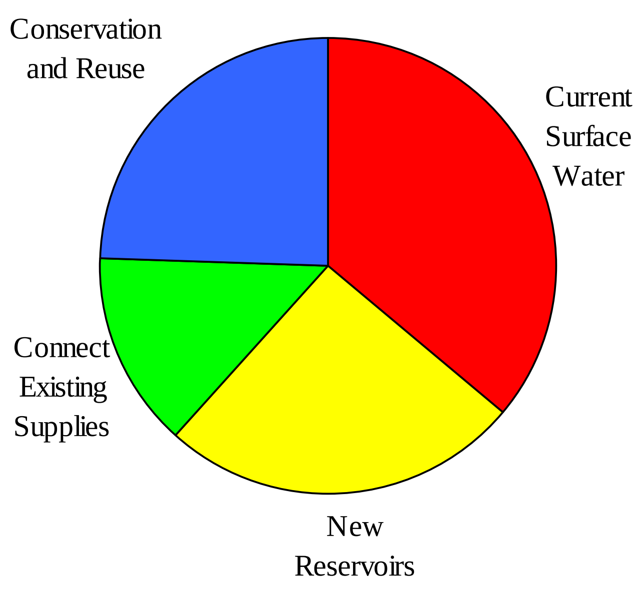


Table 4E.5
Summary of Costs for TRWD Recommended Water Management Strategies

Strategy	Development Dates	Quantity for TRWD (Ac-Ft/Yr)	TRWD Share of Capital Cost	Unit Cost ($/kGal.)	
				Pre-Amort.	Post-Amort.
Eagle Mountain Connection	2008	0	$130,595,000	N/A	N/A
Third East Texas Pipeline and Reuse	2010, 2018	188,765	$626,347,000	$1.05	$0.31
Marvin Nichols Reservoir	2030, 2050	280,000	$1,482,167,000	$1.66	$0.48
Toledo Bend Reservoir	2050, after 2060	200,000	$1,035,188,000	$1.92	$0.77
Oklahoma Water	2060	50,000	$287,349,000	$1.86	$0.58
Total Capital Costs			**$3,561,646,000**		

Note: No capital costs are associated with the recommended water conservation measures.

Table 4E.6
Costs for TRWD Alternative Strategies

Strategy	Quantity for TRWD (Ac-Ft/Yr)	TRWD Share of Capital Cost	Unit Cost ($/kGal.)	
			Pre-Amort.	Post-Amort.
Toledo Bend Reservoir - Phase 2	100,000	$398,737,000	$1.62	$0.74
Wright Patman Lake - Texarkana	100,000	$670,734,800	$2.37	$0.87
Wright Patman Lake - Raise Pool	180,000	$1,038,329,000	$1.83	$0.54
Wright Patman Lake - System	130,000	$791,832,000	$2.09	$0.73
Lakes Sam Rayburn/Steinhagen	200,000	$1,525,001,000	$2.42	$0.72
Lake Tehuacana	56,800	$511,829,000	$2.35	$0.35
Lake Livingston	200,000	$1,279,564,000	$2.25	$0.83

North Texas Municipal Water District

The North Texas Municipal Water District (NTMWD) serves much of the rapidly growing suburban area north and east of Dallas. Demands on the NTMWD are expected to more than double from 2010 to 2060. The projected water shortages for the NTMWD are nearly 113,300 acre-feet per year in 2010, increasing to 545,400 acre-feet per year by 2060. A considerable portion of this shortage will be met through conservation and reuse, as NTMWD fully utilizes its existing sources and their capacity for reuse. To meet the remaining shortages, NTMWD will need to develop new water supplies and utilize interim water sources as long-term strategies are developed. A listing of the potentially feasible strategies considered for NTMWD with the unit costs is shown on Figure 4E.7. The recommended water management strategies for NTMWD include:

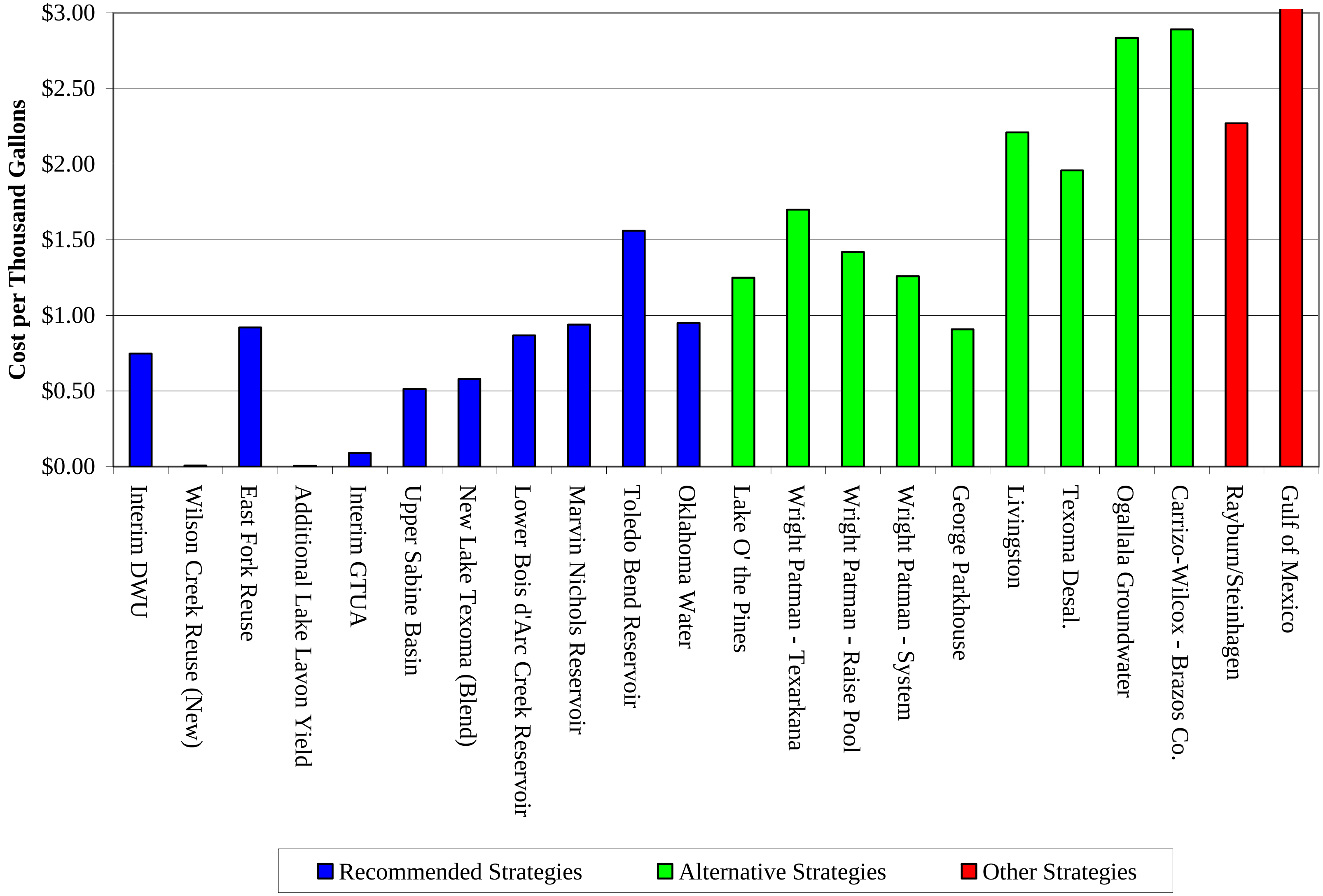
- Conservation
- Interim Treated Water Purchase from Dallas Water Utilities
- Additional Wilson Creek Reuse Project
- East Fork Reuse Project
- Additional Lake Lavon Yield
- Interim Purchase of Lake Texoma Water from GTUA/Sherman
- Upper Sabine Basin Supply
- New Supply from Lake Texoma
- Lower Bois d'Arc Creek Reservoir
- Fannin County Water Supply System
- Marvin Nichols Reservoir
- Toledo Bend Reservoir
- Oklahoma Water
- Water Treatment Plant and Distribution Improvements

The development of the Marvin Nichols Reservoir, connection to Toledo Bend Reservoir, and connection to Oklahoma water sources are multi-provider strategies and are discussed above. The other recommended strategies are discussed individually below.

NTMWD Conservation. Conservation is the projected conservation savings for NTMWD's existing and potential customers, based on the Region C recommended water conservation program. Not including savings from low-flow plumbing fixtures (which amount to about 5 percent of demand and are built into the demand projections) and not including reuse, conservation by NTMWD customers is projected to reach 86,114 acre-feet per year by 2060.

Figure 4E.7

Potentially Feasible Strategies for NTMWD



Interim Treated Water Purchase from Dallas Water Utilities. 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 by a connection between DWU's water distribution system and the NTMWD treated water distribution system, and a meter would be installed.

Additional Wilson Creek Reuse Project. NTMWD currently has a water right allowing the reuse of up to 35,941 acre-feet per year (32 mgd) of actual discharges from the Wilson Creek Wastewater Treatment Plant. The NTMWD has applied for a water right to reuse an additional 35,941 acre-feet per year of discharges from the plant. This was a recommended water management strategy in the 2001 *Region C Water Plan* [4].

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 with increasing wastewater flows to 102,000 acre-feet per year. This water management strategy was added to the 2001 *Region C Water Plan* by an amendment in 2005.

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 [6] 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.

Interim Purchase of Lake Texoma Water from GTUA/Sherman. NTMWD has reached an agreement with the City of Sherman and the Greater Texoma Utility Authority (GTUA) to purchase surplus 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. GTUA has applied for an interbasin transfer permit to allow the proposed sale and transfer.

Upper Sabine Basin Supply. NTMWD is negotiating 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. NTMWD would seek an interbasin transfer and would build a pump station and pipeline to deliver water from Lake Tawakoni or Lake Fork Reservoir to Lake Lavon.

New Supply from Lake Texoma. NTMWD has requested a contract for additional storage in Lake Texoma from the Tulsa District of the Corps of Engineers and has applied for a Texas water right to impound up to 100,000 acre-feet in Lake Texoma and divert up to 113,000 acre-feet per year from the lake. 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 per year reserved for the Greater Texoma Utility Authority (GTUA). The Corps has completed a draft reallocation study for the lake [(7)]. NTMWD would contract for the 100,000 acre-foot reallocation for municipal use not reserved for GTUA and would blend the water with higher quality supplies from other sources or develop a desalination plant. At this time, blending appears to be the more economical approach. It is assumed that NTMWD will use one part of Lake Texoma supply for four parts of other imported water. NTMWD would deliver the water directly from Lake Texoma and/or from the Red River downstream of the lake. (Downstream diversions would require a longer pipeline but offer the advantage of reduced levels of dissolved solids.)

Lower Bois d'Arc Creek Reservoir. Lower Bois d'Arc Creek Reservoir is a proposed reservoir on Bois d'Arc Creek in the Red River Basin. It was included in the 2001 *Region C Water Plan* [(4)] as a supply for NTMWD, and NTMWD has continued to study the project. Lower Bois d'Arc Creek Reservoir would provide up to 123,000 acre-feet per year for NTMWD and Fannin County. Lower Bois d'Arc Creek Reservoir would be developed by 2020.

Fannin County Water Supply System. NTMWD would cooperate with Fannin County entities to develop a treated water supply system for Fannin County water users after the Lower

Bois d'Arc Creek Reservoir is developed in 2020. The system would involve one or more water treatment plants and a treated water distribution system.

As shown on Table 4E.7 and Figure 4E.8, over 790,000 acre-feet per year of new supplies are recommended for NTMWD, leading to a total supply of 1.01 million acre-feet per year in 2060 (after accounting for treatment and distribution losses). Over 30 percent of the projected water supply through 2040 is from reuse and conservation. This percentage reduces to 26 percent as new supplies are developed in 2050. Figure 4E.9 shows the total supply to NTMWD in 2060 by the type of supply. A summary of costs for the infrastructure strategies is presented in Table 4E.8. NTMWD's share of the total capital cost for the recommended plan is $3.9 billion.

The following alternative water management strategies are recommended for NTMWD:

- Toledo Bend Reservoir Phase 2 (accelerated to occur before 2060)
- Lake O' the Pines
- Wright Patman Lake
- Lake Texoma with desalination rather than blending
- Ogallala groundwater in Roberts County (Region A)
- Carrizo-Wilcox groundwater in Brazos County Area (Region G)
- George Parkhouse Reservoir (North)
- Lake Livingston

Costs for the alternative strategies are shown in Table 4E.9.

City of Fort Worth

The City of Fort Worth obtains raw water from the Tarrant Regional Water District (TRWD) and treats and distributes treated water to 30 existing customers (including county-wide water user groups). Fort Worth is also expected to supply water to four new water user groups. The currently available supply to Fort Worth is limited by TRWD's raw water sources and transmission capacity. As the TRWD develops additional capacity and supplies, Fort Worth's available supply will also increase. To provide sufficient treated water to its customers, the Fort Worth will need to expand its water treatment facilities and improve the transmission system from existing sources. The city also plans to implement four direct reuse projects, which would be used for local irrigation and electric power generation. The total projected shortages for Fort

Table 4E.7
Recommended Water Management Strategies for North Texas Municipal Water District
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
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 Available Supplies	***257,854***	***257,069***	***256,245***	***254,769***	***255,160***	***254,020***
Water Management Strategies						
Conservation	12,638	33,936	47,866	60,800	72,991	86,114
Interim DWU Supply	11,210	11,210	0	0	0	0
Wilson Creek Reuse (new)	26,956	35,941	35,941	35,941	35,941	35,941
East Fork Reuse	81,400	96,400	102,000	102,000	102,000	102,000
Additional Lake Lavon	11,000	10,000	9,000	8,000	7,000	6,000
Interim GTUA Supply	20,000	0	0	0	0	0
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		123,000	121,000	119,000	117,000	115,000
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)	(17,240)	(21,623)	(20,823)	(32,362)	(35,312)
Total Supplies from Strategies	**213,204**	**378,737**	**480,332**	**477,266**	**720,232**	**792,355**
Total Supplies (Including Losses)	**461,030**	**618,566**	**714,954**	**711,212**	**943,030**	**1,011,063**
Total from Conservation & Reuse	156,935	202,218	221,748	234,682	246,873	259,996
Percent from Conservation & Reuse	34.0%	32.7%	31.0%	33.0%	26.2%	25.7%
Projected Demands	**371,170**	**482,856**	**567,856**	**650,027**	**722,158**	**799,386**
Surplus or (Shortage)	89,860	135,710	147,098	61,185	220,872	211,677

Figure 4E.8
Recommended Water Management Strategies for North Texas Municipal Water District

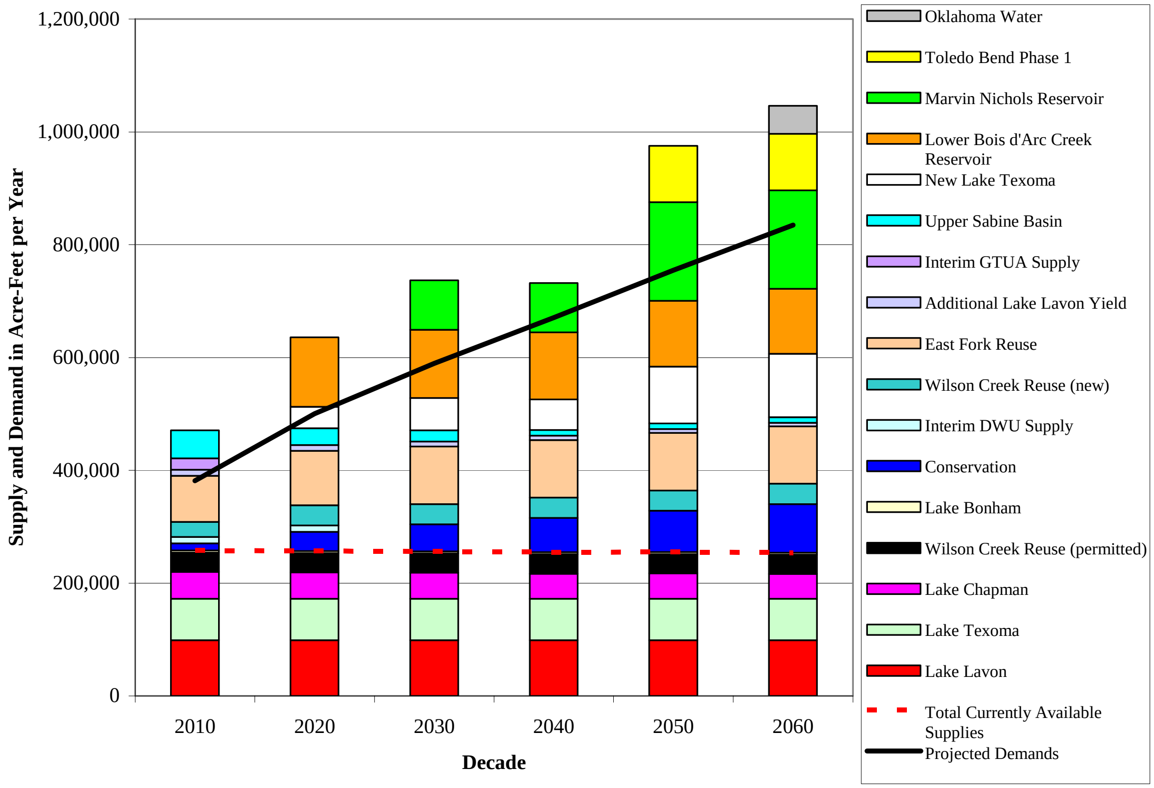


Figure 4E.9
NTMWD's 2060 Supply by Type

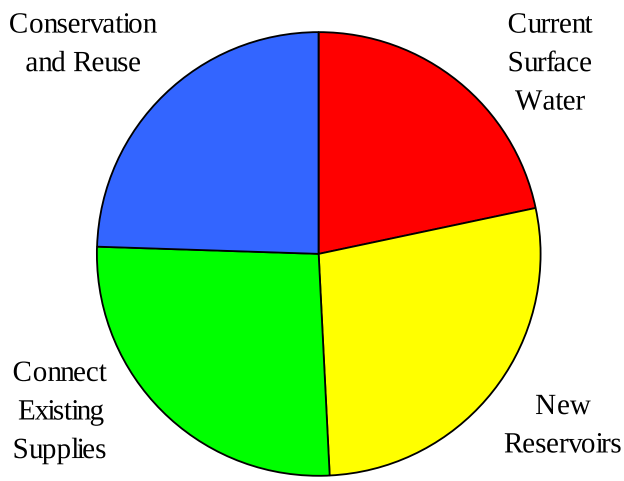


Table 4E.8
Summary of Costs for NTMWD Recommended Water Management Strategies

Strategy	Develop Dates	Quantity for NTMWD (Ac-Ft/Yr)	NTMWD Share of Capital Cost	Unit Cost ($/kGal.)	
				Pre-Amort.	Post-Amort.
Treatment and Distribution Improvements	2005-2060	N/A	$1,290,523,000	N/A	N/A
Interim DWU Supply	2006	11,210	$1,350,000	$0.75	$0.72
Wilson Creek Reuse	2005	35,941	$1,150,000	$0.0072	$0.00
East Fork Reuse	2010	102,000	$288,879,000	$0.92	$0.21
Additional Lake Lavon	2006	11,000	$270,000	$0.0056	$0.00
Interim GTUA Supply	2006	20,000	$104,000	$0.09	$0.09
Upper Sabine Basin	2010	50,000	$60,232,000	$0.52	$0.25
New Lake Texoma	2015	113,000	$201,829,000	$0.58	$0.18
Lower Bois d'Arc Creek	2020	123,000	$399,190,000	$0.87	$0.14
Fannin County Water Supply System	2020	0	$55,458,000	$1.96	$0.52
Marvin Nichols Reservoir	2030, 2050	174,840	$534,125,000	$0.94	$0.26
Toledo Bend Reservoir	2050, after 2060	200,000	$886,002,000	$1.56	$0.57
Oklahoma Water	2060	50,000	$128,898,000	$0.95	$0.37
Total Capital Costs			**$3,848,010,000**		

Note: No capital costs are associated with the recommended water conservation measures.

Worth are approximately 39,700 acre-feet per year by 2020, increasing to nearly 307,000 acre-feet per year by 2060.

The recommended water management strategies for the city of Fort Worth are:

- Conservation
- Expansion of water treatment plants
- Expansion of transmission pipelines
- New water treatment plants
- Additional supply from Tarrant Regional Water District
- Direct reuse for steam electric power
- Direct reuse for irrigation.

These strategies are discussed individually below.

Table 4E.9
Costs for NTMWD Alternative Strategies

Strategy	Quantity for NTMWD (Ac-Ft/Yr)	NTMWD Share of Capital Cost	Unit Cost ($/kGal.)	
			Pre-Amort.	Post-Amort.
Accelerated Phase 2 - Toledo Bend Reservoir	100,000	$425,995,000	$1.52	$0.57
Lake O' the Pines	87,900	$257,192,000	$1.25	$0.60
Wright Patman Lake - Texarkana	100,000	$429,176,000	$1.70	$0.74
Wright Patman Lake – Raise Pool	180,000	$825,088,000	$1.42	$0.39
Wright Patman Lake - System	130,000	$473,434,000	$1.26	$0.45
Lake Texoma Authorized with Desalination	105,000	$538,635,300	$1.96	$0.82
Roberts County Groundwater	200,000	$1,994,699,000	$2.83	$0.61
Carrizo-Wilcox - Brazos Co.	100,000	$577,413,000	$2.89	$1.28
George Parkhouse Reservoir (North)	118,960	$362,322,000	$0.91	$0.23
George Parkhouse Reservoir (South)	108,480	$480,099,000	$1.24	$0.25
Lake Livingston	200,000	$1,299,183,000	$2.21	$0.77

Conservation. Conservation is the projected conservation savings for Fort Worth and its existing and potential customers, based on the Region C recommended water conservation program. Not including savings from low-flow plumbing fixtures (which are built into the demand projections), conservation by Fort Worth and its customers is projected to reach 49,405 acre-feet per year by 2060.

Expansions of Water Treatment Plants. The City of Fort Worth has four water treatment plants: North Holly, South Holly, Rolling Hills, and Eagle Mountain. The current combined capacity of the existing water treatment plants is 400 mgd. In order to meet the projected demands, Fort Worth will need to expand their water treatment plant capacity to treat a total of 935 mgd by 2060.

Expansion of Transmission Pipelines. The City of Fort Worth plans to expand portions of the current transmission system. Fort Worth plans to install a parallel pipeline connecting the Eagle Mountain Water Treatment Plant to Eagle Mountain Lake by the year 2010. A pipeline connecting the proposed new Southwest Water Treatment Plant to the TRWD's pipeline will also be needed when the treatment plant is developed. The pipeline that will connect the Northwest Water Treatment Plant to the TRWD's system is included in the Tarrant Regional Water District system upgrades. The City of Fort Worth plans to assist some of their customers in developing additional pipelines. Projects that are not part of Fort Worth's internal distribution system improvements will be included as strategies for the customer cities involved.

New Water Treatment Plant. The City of Fort Worth plans to construct two more water treatment plants that will be known as the Northwest Water Treatment Plant and the Southwest Water Treatment Plant. The Northwest plant will be designed to treat 35 mgd initially, with room for expansions. The Southwest treatment plant will be designed to treat 25 mgd initially with room for expansions.

Additional Supply from Tarrant Regional Water District. As the Tarrant Regional Water District develops new supplies and increases transmission capacity, Fort Worth's allocation of supply from the District will increase proportionally to their projected demands.

Direct Reuse. Fort Worth plans to implement four direct reuse projects.

1. Mary's Creek Direct Reuse: A satellite wastewater treatment plant and conveyance facilities would be constructed to provide a supply for non-potable water needs for the Walsh Ranch development and other nearby areas.
2. Central Business District Reuse: A satellite wastewater treatment plant and conveyance facilities would be constructed to provide supply for non-potable water needs in the Central Business District.
3. Village Creek Direct Reuse: Effluent from the Village Creek Wastewater Treatment Plant would be used to meet non-potable water needs in the general vicinity of the wastewater treatment plant. Conveyance facilities would be constructed to transport the water to user delivery points.
4. Alliance Corridor Direct Reuse: A satellite wastewater treatment plant and conveyance facilities would be constructed to provide supply for non-potable water needs in the Alliance Corridor area.

Table 4E.10 and Figure 4E.10 show the recommended plan by decade for the city, and Table 4E.11 presents the costs associated with the infrastructure strategies. The estimated capital cost for Fort Worth's recommended water management strategies are approximately $783 million, based on 2002 construction costs.

Table 4E.10
Recommended Water Management Strategies for the City of Fort Worth
- Values in Acre-Feet per Year -

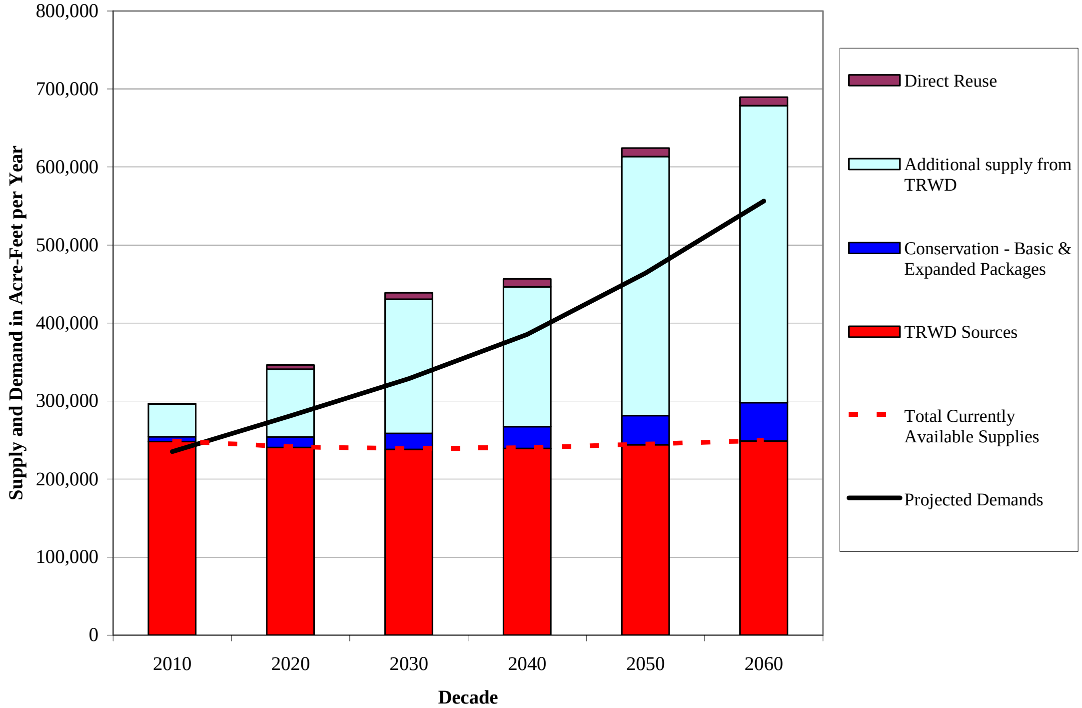
Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
TRWD Sources	*248,015*	*240,472*	*237,978*	*239,241*	*243,894*	*248,586*
Direct Reuse	*897*	*897*	*897*	*897*	*897*	*897*
Total Available Supplies	***248,912***	***241,369***	***238,875***	***240,138***	***244,791***	***249,483***
Water Management Strategies						
Conservation - Basic & Expanded Packages	6,257	13,639	20,569	28,056	37,405	49,405
Additional supply from TRWD (limited by WTP capacity)	41,995	86,909	172,003	178,991	332,118	380,582
Mary's Creek Direct Reuse	0	1,240	1,570	1,570	1,570	1,570
Central Business District Direct Reuse	0	2,240	3,360	3,360	3,360	3,360
Village Creek Direct Reuse	500	500	1,100	2,000	2,600	2,600
Alliance Corridor Direct Reuse	0	1,120	2,240	3,360	3,360	3,360
Total Supplies from Strategies	**48,252**	**100,548**	**192,572**	**207,047**	**369,523**	**429,987**
Total Supplies	**297,164**	**341,917**	**431,447**	**447,185**	**614,314**	**679,470**
Total from TRWD	**290,010**	**327,381**	**409,981**	**418,232**	**576,012**	**629,168**
TRWD Supply from Reuse	39,210	83,241	89,674	91,874	101,225	102,450
Total from Conservation & Reuse	46,864	102,877	119,410	131,117	150,417	163,642
Percent from Conservation & Reuse	15.8%	30.1%	27.7%	29.3%	24.5%	24.1%
Projected Demands	**235,183**	**281,032**	**328,722**	**385,458**	**463,960**	**556,258**
Surplus or (Shortage)	61,981	60,885	102,725	61,727	150,354	123,212

Table 4E.11
Summary of Costs for Fort Worth's Recommended Water Management Strategies

Strategy	Develop Dates	2060 Quantity (Ac-Ft/Yr)	Fort Worth Capital Cost	Unit Cost ($/kGal.)	
				Pre-Amor	Post-Amor
Additional supply from TRWD	2010	380,582	$0	N/A	N/A
Eagle Mountain WTP Exp. of 35 mgd (total of 105 mgd)	2010	0	$44,464,680	N/A	N/A
Parallel pipeline from Eagle Mountain Lake to WTP and Raw Water Pump Station Expansion	2010	0	$20,114,820	N/A	N/A
Rolling Hills WTP Exp. of 40 mgd (total of 200 mgd)	2010	0	$16,288,800	N/A	N/A
Holly WTP Exp. of 40 mgd (total of 200 mgd)	2010	0	$25,833,600	N/A	N/A
Village Creek Direct Reuse	2010	2,600	$4,123,000	$0.47	$0.11
Mary's Creek Direct Reuse	2020	1,570	$14,612,000	$2.65	$0.57
Central Business District Direct Reuse	2020	3,360	$28,970,000	$2.40	$0.48
Alliance Corridor Direct Reuse	2020	3,360	$25,425,000	$2.20	$0.52
Eagle Mountain WTP Exp. of 35 mgd (total of 140 mgd)	2020	0	$56,160,000	N/A	N/A
Rolling Hills WTP Exp. of 50 mgd (total of 250 mgd)	2020	0	$73,850,400	N/A	N/A
New Northwest WTP 35 mgd	2020	0	$57,915,000	N/A	N/A
New Southwest WTP 25 mgd	2020	0	$42,702,000	N/A	N/A
Pipeline to New Southwest WTP	2020	0	$17,032,000	N/A	N/A
New Northwest WTP Exp. of 35 mgd (total of 70 mgd)	2030	0	$51,246,000	N/A	N/A
Eagle Mountain WTP Exp. of 70 mgd (total of 210 mgd)	2030	0	$109,512,000	N/A	N/A
New Northwest WTP Exp. of 35 mgd (total of 105 mgd)	2050	0	$39,918,000	N/A	N/A
New Southwest WTP Exp. of 25 mgd (total of 50 mgd)	2050	0	$30,421,000	N/A	N/A
New Northwest WTP Exp. of 70 mgd (total of 175 mgd)	2060	0	$71,124,000	N/A	N/A
New Southwest WTP Exp. of 50 mgd (total of 100 mgd)	2060	0	$53,557,000	N/A	N/A
Total Capital Costs			**$783,269,300**		

Note: No capital costs are associated with the recommended water conservation measures.

Figure 4E.10
Recommended Water Management Strategies for the City of Fort Worth



Trinity River Authority

The Trinity River Authority (TRA) currently provides water to Region C users from its own water rights in four different lakes (Lakes Bardwell, Navarro Mills, Joe Pool, and Livingston) and supplies water to Tarrant County entities by purchases from the Tarrant Regional Water District (TRWD). TRA also provides raw water for steam electric power in Freestone County and reuse water to entities in Dallas and Ellis Counties. TRA has contracts with the TRWD and Ellis County user groups to supply water in Ellis County through the Ellis County Water Supply Project. The Authority also owns and operates several wastewater treatment plants, and has plans to develop a number of direct and indirect reuse projects in the region. Considering current demands and projected future demands for reuse water, the following water management strategies are recommended for TRA:

- Conservation
- Expansions to the Tarrant County Water Supply System
- Development of the Ellis County Water Supply Project

- Additional steam electric supply in Freestone County through existing facilities
- Obtaining a water right allowing reuse of wastewater discharged from TRA wastewater treatment plants
- Expansion of the existing Las Colinas reuse project in Dallas County with additional transmission facilities
- Development of reuse for steam electric power generation in Dallas County
- Development of reuse for steam electric power generation in Ellis County
- Development of reuse for steam electric power generation in Freestone County
- Development of reuse for steam electric power generation in Kaufman County
- Development of a reuse project from the Denton Creek WWTP for irrigation in Denton and Tarrant Counties and municipal use in Tarrant County
- Development of a reuse project for Johnson County SUD in Johnson County
- Development of an indirect reuse project to Joe Pool Lake
- Development of a reuse project for irrigation in Dallas and Ellis Counties
- Contracting with Irving to allow reuse of wastewater discharged from TRA's Central Wastewater Treatment Plant.

These projects are discussed below.

Conservation. Conservation is the projected conservation savings for existing and potential customers of the TRA, based on the Region C recommended water conservation program. Not including savings from low-flow plumbing fixtures (which are built into the demand projections) and not including reuse, conservation by TRA customers is projected to reach 9,758 acre-feet per year by 2060.

Expansions to the Tarrant County Water Supply System. The Tarrant County water supply project water treatment plant can be expanded two more times, from a current capacity of 87 mgd to a fully developed capacity of 117 mgd. These expansions are currently planned for 2008 and 2017. Raw water for the project will be provided by the Tarrant Regional Water District.

Development of the Ellis County Water Supply Project. The Ellis County Water Supply Project will deliver raw water from the Tarrant Regional Water District (TRWD) pipelines to water suppliers in Ellis County. Raw water will be diverted from the TRWD pipelines and treated at regional facilities, probably operated by Ennis, Waxahachie and Midlothian. Current plans call for development of this project to begin by 2010. The proposed supply from the Ellis County Water Supply Project by 2060 is 27,424 acre-feet per year.

Additional Steam Electric Supply in Freestone County through Existing Facilities. The Trinity River Authority currently has a contract with TRWD to divert water from Richland-Chambers Reservoir to be used for steam electric power generation in Freestone County. The current contract is for 6,726 acre-feet per year, and the proposed water management strategy would supply 1,000 acre-feet per year of additional water through existing facilities.

Obtaining a Permit Allowing Reuse of Wastewater Discharged from TRA Wastewater Treatment Plants. TRA has applied for a water right permit to reuse wastewater discharged from its wastewater treatment plants. This authorization would be used to develop many of the reuse projects discussed below.

Expansion of the Existing Las Colinas Reuse Project in Dallas County with Additional Transmission Facilities. The Trinity River Authority currently supplies treated wastewater to Las Colinas in Irving for golf course irrigation, landscape irrigation, and lake level maintenance. This project would allow expansion of that supply by 7,000 acre-feet per year. It is assumed to be developed by 2015.

Development of Reuse for Steam Electric Power Generation in Dallas County. Dallas County Steam Electric Power has a need for about 6,000 acre-feet per year of additional water supply by 2060. It is assumed that TRA will supply reuse water for 3,000 acre-feet per year for part of that need. The project cost is based on delivery of the water from the TRA Central Wastewater Treatment Plant to Mountain Creek Lake using a portion of the delivery capacity for the Johnson County SUD Reuse project. It is assumed that the project will be developed by 2020. (TRA reuse projects may be located elsewhere in Dallas County, depending on the development of steam electric power generation facilities and/or the occurrence of other opportunities to meet water needs with reuse water. If that were to occur, then costs for the project may differ.)

Development of Reuse for Steam Electric Power Generation in Ellis County. Ellis County Steam Electric Power has a need for about 40,000 acre-feet per year of additional water supply by 2060. It is assumed that TRA will supply 40,000 acre-feet per year of direct and indirect reuse water for that need. The project cost is based on four 10,000 acre-foot per year phases, each delivering water about 20 miles. (A similar, though smaller, reuse project for Ellis County was included in the 2001 *Region C Water Plan* [4].) (TRA reuse projects may be located elsewhere in Ellis County, depending on the development of steam electric power generation facilities and/or the occurrence of other opportunities to meet water needs with reuse water. If that were to occur, then costs for the project may differ.)

Development of Reuse for Steam Electric Power Generation in Freestone County. Freestone County Steam Electric Power has a need for about 20,000 acre-feet per year of additional water supply by 2060 (beyond the planned supply of 6,602 acre-feet per year from Richland-Chambers Reservoir and other existing supplies). It is assumed that TRA will supply 20,000 acre-feet per year of indirect reuse water for that need. The project cost is based on two 10,000 acre-foot per year phases, each diverting TRA treated return flows from the Trinity River and delivering the water about 15 miles. (TRA reuse projects may be located elsewhere in Freestone County, depending on the development of steam electric power generation facilities and/or the occurrence of other opportunities to meet water needs with reuse water. If that were to occur, then costs for the project may differ.)

Development of Reuse for Steam Electric Power Generation in Kaufman County. Kaufman County Steam Electric Power has a need for about 20,000 acre-feet per year of additional water supply by 2060. It is assumed that TRA will supply 15,000 acre-feet per year of indirect reuse water for that need (with the remainder coming from North Texas Municipal Water District). The project cost is based on two 7,500 acre-foot per year phases, each diverting TRA treated return flows from the Trinity River and delivering the water about 15 miles. (TRA reuse projects may be located elsewhere in Kaufman County, depending on the development of steam electric power generation facilities and/or the occurrence of other opportunities to meet water needs with reuse water. If that were to occur, then costs for the project may differ.)

Development of Reuse Projects from the Denton Creek WWTP for Irrigation and Municipal Use in Denton and Tarrant Counties. The Trinity River Authority has been in discussions with potential water users regarding the development of up to 15,000 acre-feet per year of reuse water from TRA's Denton Creek WWTP for irrigation and municipal use in Denton and Tarrant Counties. Costs for this strategy are based on 7,500 acre-feet per year direct reuse for irrigation and 7,500 acre-feet per year as indirect reuse through Grapevine Lake. This is similar to two management strategies in the 2001 *Region C Water Plan* [4].

Development of a Reuse Project for Johnson County SUD in Johnson County. The Trinity River Authority has been in discussions with representatives of Johnson County SUD regarding the development of a project to supply up to 20,000 acre-feet per year of indirect reuse water through Joe Pool Lake for use in Johnson County. This project is assumed to be developed by 2020 in conjunction with the Dallas County Reuse Project for steam electric power. It is assumed that Johnson County SUD will develop transmission and treatment facilities to use the water from Joe Pool Lake.

Development of a Reuse Project for Joe Pool Lake. The Trinity River Authority has applied for a reuse permit for 3.9 mgd from a new wastewater treatment plant in the watershed of Joe Pool Lake. Water would be discharged upstream of the lake for subsequent use from Joe Pool Lake. This project is assumed to be developed by 2020.

Development of a Reuse Project from the Ten Mile Creek WWTP for Irrigation in Dallas and Ellis Counties. The Trinity River Authority has a contract to supply 250 acre-feet per year of treated reuse water from TRA's Ten Mile Creek WWTP for irrigation use in Dallas and Ellis Counties. Facilities to implement this project are assumed to be developed by 2010.

Contracting with Irving to allow reuse of wastewater discharged from TRA's Central Wastewater Treatment Plant. TRA and Irving have entered into a contract to allow Irving to reuse wastewater discharged from TRA's Central Wastewater Treatment Plant. Irving will develop facilities to implement this strategy.

Figure 4E.11 and Table 4E.12 provide information on the recommended management strategies for TRA. Of the 11 recommended strategies, nine are conservation and reuse projects. Over 50 percent of the total amount of supply to TRA is attributed to conservation and reuse. Figure 4E.12 shows the 2060 supply to TRA (Region C) by supply type. A summary of the capital and unit cost for the strategies are shown in Table 4E.13. The estimated cost for TRA's recommended water management strategies is $340 million, based on 2002 construction costs.

Figure 4E.11
Recommended Water Management Strategies for the Trinity River Authority in Region C

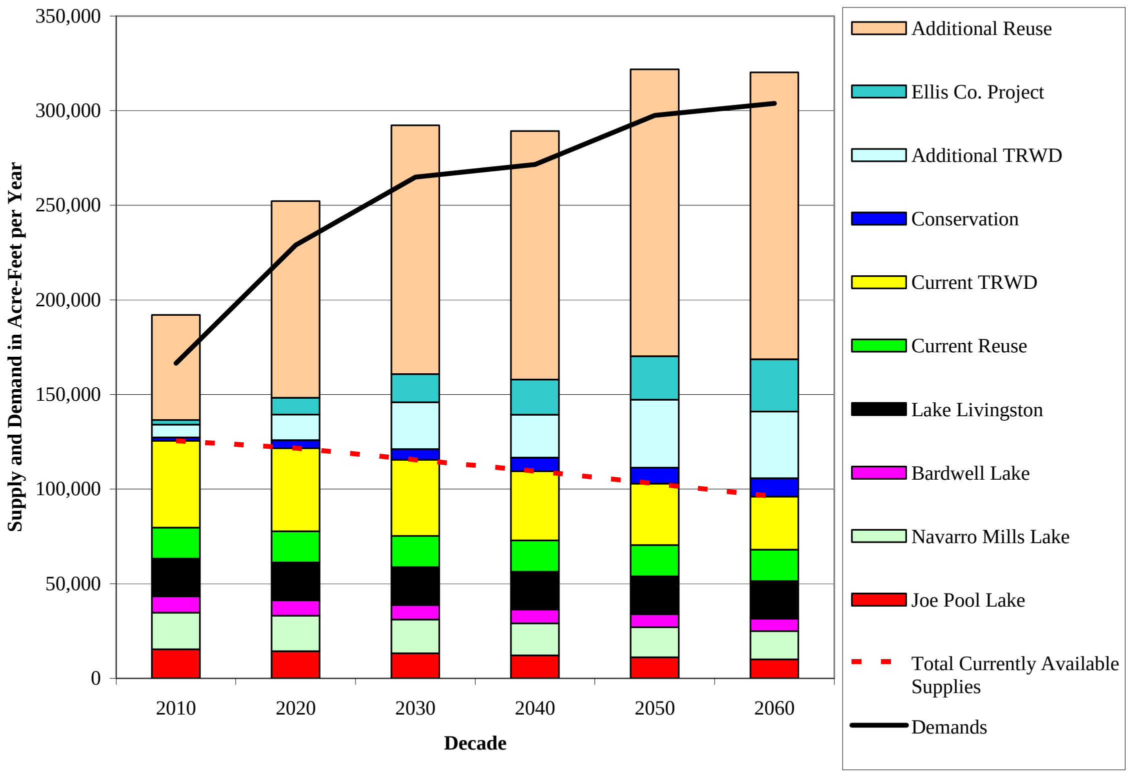


Figure 4E.12
Trinity River Authority Management Strategies by Type

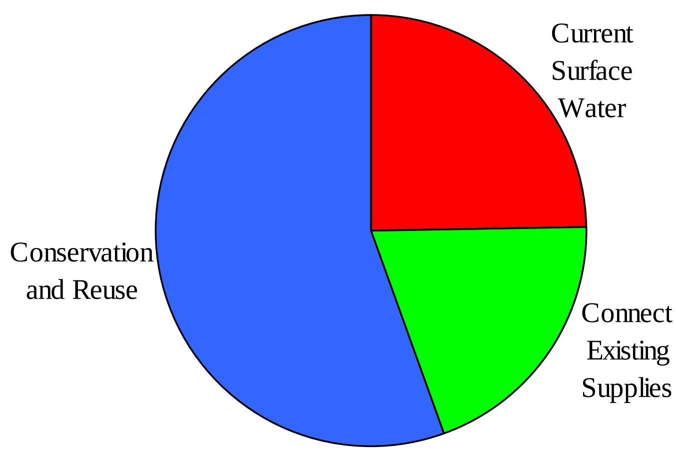


Table 4E.12
Recommended Water Management Strategies for the Trinity River Authority
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies (Safe Yield)						
Joe Pool Lake	*15,333*	*14,267*	*13,200*	*12,133*	*11,067*	*10,000*
Navarro Mills Lake	*19,400*	*18,800*	*17,850*	*16,900*	*15,950*	*15,000*
Bardwell Lake	*8,567*	*8,153*	*7,740*	*7,327*	*6,913*	*6,500*
Lake Livingston	*20,000*	*20,000*	*20,000*	*20,000*	*20,000*	*20,000*
Current Reuse	*16,361*	*16,492*	*16,492*	*16,492*	*16,492*	*16,492*
Current TRWD	*45,900*	*44,006*	*40,230*	*36,694*	*32,508*	*28,068*
Total Currently Available Supplies	***125,561***	***121,718***	***115,512***	***109,546***	***102,930***	***96,060***
Water Management Strategies						
Conservation	1,737	4,106	5,606	7,068	8,366	9,758
Tarrant Co. System (TRWD)	6,779	13,621	24,752	22,657	36,044	35,144
Ellis Co. Project	2,466	8,637	14,825	18,314	22,884	27,424
Freestone Co. Raw Water	0	0	0	1,000	1,000	1,000
Additional Las Colinas		7,000	7,000	7,000	7,000	7,000
Dallas County SEP Reuse	0	3,000	3,000	3,000	3,000	3,000
Ellis County SEP Reuse	20,000	20,000	30,000	30,000	40,000	40,000
Freestone County SEP Reuse	0	0	10,000	10,000	20,000	20,000
Kaufman County SEP Reuse	0	7,500	15,000	15,000	15,000	15,000
Tarrant/Denton County Reuse	7,500	15,000	15,000	15,000	15,000	15,000
Johnson County SUD Reuse	0	20,000	20,000	20,000	20,000	20,000
Joe Pool Lake Reuse	0	3,500	3,500	3,500	3,500	3,500
Ten Mile WWTP Reuse	250	250	250	250	250	250
Reuse for Irving	28,000	28,000	28,000	28,000	28,000	28,000
Total Supplies from Strategies	**66,732**	**130,614**	**176,933**	**180,789**	**220,044**	**225,076**
Total Supplies	**192,293**	**252,332**	**292,445**	**290,335**	**322,974**	**321,136**
Total from Conservation & Reuse	75,327	131,080	163,346	165,553	187,804	189,888
Percent from Conservation & Reuse	39.2%	51.9%	55.9%	57.0%	58.1%	59.1%
Projected Demands	**166,141**	**228,644**	**264,679**	**271,339**	**297,194**	**302,644**
Surplus or (Shortage)	26,152	23,688	27,766	18,996	25,780	18,492

Table 4E.13
Summary of Costs for TRA's Recommended Water Management Strategies

Strategy	Development Dates	Quantity (Ac-Ft/Yr)	Capital Cost	Unit Cost ($/kGal.)	
				Pre-Amort.	Post-Amort.
Tarrant County Water Supply Project Plant Expansion 1	2008	7,473	$20,328,000	$1.64	$1.03
Tarrant County Water Supply Project Plant Expansion 2	2017	7,473	$20,328,000	$1.64	$1.03
Ellis County Water Supply Project (Mid-County Section)	2015	9,940	$59,945,000	$2.57	$1.21
Ellis County Water Supply Project (Midlothian Section)	2007	12,213	$35,242,000	$1.74	$1.10
Ellis County Water Supply Project (Ennis Section)	2015	4,446	$19,356,000	$2.03	$1.06
Additional Supply to Steam Electric Power in Freestone County	2040	1,000	$1,729,000	$1.16	$0.77
Las Colinas Reuse	2015	7,000	$9,222,000	$0.65	$0.36
Ellis County Steam Electric Reuse - Phase 1	2008	10,000	$21,554,000	$0.84	$0.36
Ellis County Steam Electric Reuse - Phase 2	2010	10,000	$21,554,000	$0.84	$0.36
Ellis County Steam Electric Reuse - Phase 3	2030	10,000	$21,554,000	$0.84	$0.36
Ellis County Steam Electric Reuse - Phase 4	2050	10,000	$21,554,000	$0.84	$0.36
Freestone County Steam Electric Reuse - Phase 1	2030	10,000	$15,789,000	$0.69	$0.34
Freestone County Steam Electric Reuse - Phase 2	2050	10,000	$15,789,000	$0.69	$0.34
Kaufman County Steam Electric Reuse - Phase 1	2015	7,500	$12,473,000	$0.54	$0.26
Kaufman County Steam Electric Reuse - Phase 2	2030	7,500	$12,473,000	$0.54	$0.26
Tarrant and Denton County Irrigation	2010	7,500	$6,090,000	$0.53	$0.35
Tarrant County Municipal Reuse	2020	7,500	$0	$0.25	$0.25
Mountain Creek Lake Reuse, using delivery infrastructure for Joe Pool Lake Reuse	2020	3,000	$1,459,600	$0.43	$0.32
Joe Pool Lake Reuse from Central WWTP for Johnson County SUD	2020	20,000	$20,321,400	$0.56	$0.34

Table 4E.13, Continued

Strategy	Development Dates	Quantity (Ac-Ft/Yr)	Capital Cost	Unit Cost ($/kGal.)	
				Pre-Amort.	Post-Amort.
Joe Pool Lake Reuse from New WWTP	2020	3,500	$0	$0.25	$0.25
Contract with Irving	2005	28,000	N/A	N/A	N/A
Dallas and Ellis County Irrigation	2010	250	$290,000	$0.59	$0.33
Total Capital Costs			**$340,179,200**		

Note: No capital costs are associated with the recommended water conservation measures.

Upper Trinity Regional Water District

The Upper Trinity Regional Water District (UTRWD) currently supplies treated water to users in Denton County with a small amount to Collin County. The UTRWD also provides direct reuse for irrigation in Denton County. The currently available supplies for UTRWD include water from Lake Chapman, purchased raw water from Dallas Water Utilities (DWU) and reuse, and range between 25,200 and 42,200 acre-feet per year from 2010 to 2060. (The changes in supply over time are due primarily to changes in water availability from DWU.) Considering losses associated with treatment and distribution, UTRWD needs to develop an additional 7,000 acre-feet per year of raw water supplies by 2010 to meet projected demands and an additional 122,000 acre-feet per year by 2060. UTRWD will also need to develop additional treatment and distribution capacity to serve the growing demands of its current and future customers. The recommended water management strategies for UTRWD include the following:

- Conservation
- Additional supplies from DWU under current contract
- Lake Chapman indirect reuse
- Additional supplies from DWU linked to Lake Chapman reuse
- Lake Ralph Hall
- Indirect reuse of return flows from Lake Ralph Hall
- Marvin Nichols Reservoir
- Additional DWU supplies
- Oklahoma water
- Water treatment plant and distribution system improvements.

Marvin Nichols Reservoir and water from Oklahoma are multi-provider strategies and are discussed in the beginning of Section 4E.1. The other strategies identified for UTRWD are discussed individually below:

Conservation. Conservation is the projected conservation savings for UTRWD's existing and potential customers, based on the Region C recommended water conservation program. Not including savings from low-flow plumbing fixtures and not including reuse, conservation by UTRWD customers is projected to reach 11,762 acre-feet per year by 2060.

Additional Supplies from DWU under Current Contract. UTRWD's current contract with DWU indicates that DWU will supply water needed for several specific water suppliers in Denton County plus an additional 10 mgd. Based on the entities UTRWD is currently supplying, the contract would provide up to 54,865 acre-feet per year in 2060. UTRWD is currently using less than the amount in this contract but plans to eventually use the full contracted amount.

Lake Chapman Indirect Reuse. UTRWD is seeking a permit for indirect reuse of return flows originating from water supplied from Lake Chapman. UTRWD, DWU, and Denton have agreed that UTRWD would be able to reuse up to 60 percent of the Lake Chapman supply. This is part of the DWU return flows above DWU lakes that are used by UTRWD (see Table 4E.1).

Additional Supplies from DWU Linked to Lake Chapman Reuse. As part of the agreement on indirect reuse of Lake Chapman water, DWU has agreed to sell up to 40 percent of the amount imported from Lake Chapman to UTRWD at the DWU raw water rate. This is in addition to the supplies from the current contract between UTRWD and DWU described above.

Lake Ralph Hall. UTRWD has applied for a water right permit to develop the proposed Lake Ralph Hall on the North Sulphur River in Fannin County. The project would yield 32,940 acre-feet per year. Water would be pumped from the lake to the existing balancing reservoir on the pipeline from Lake Chapman to UTRWD's Harpool Water Treatment Plant and Lewisville Lake. From there, it would be delivered through existing facilities to the Harpool plant and the lake. (The existing facilities have sufficient capacity for the supply.)

Indirect Reuse of Return Flows from Lake Ralph Hall. UTRWD plans to apply for the right to reuse return flows from the Lake Ralph Hall project, which are assumed to be 60 percent of the supply from the project, or 17,800 acre-feet per year.

Additional Water from Dallas Water Utilities. In addition to the water supplied by DWU under the existing contract between UTRWD and DWU and the additional DWU supplies associated with Lake Chapman reuse, UTRWD plans to obtain additional surface water supplies from DWU. This supply is expected to amount to 6,000 acre-feet per year by 2060.

Water Treatment and Distribution Improvements. UTRWD will need to make improvements to its water treatment and distribution system to meet the demands of its customers. UTRWD has developed a capital improvement plan with specific projects through 2022, and estimated costs for improvements after 2022 are also included.

Table 4E.14 and Figure 4E.13 show the recommended plan for water supply development for UTRWD. Based on the recommended plan, 27 percent of the projected 2060 supply for UTRWD will be from conservation and reuse. Figure 4E.14 shows the 2060 supply to UTRWD by supply type. Table 4E.15 gives information on the capital and unit costs for the recommended water management strategies.

Table 4E.14
Recommended Water Management Strategies for Upper Trinity Regional Water District
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Current Supplies						
Lake Chapman	*14,068*	*13,835*	*13,602*	*13,369*	*13,136*	*12,905*
DWU	*10,317*	*11,041*	*14,458*	*19,867*	*28,184*	*27,463*
Direct Reuse	*897*	*897*	*897*	*897*	*897*	*897*
Total Existing	***25,282***	***25,773***	***28,957***	***34,133***	***42,217***	***41,265***
Water Management Strategies						
Conservation	850	3,070	4,933	7,196	9,643	11,762
Additional Supplies from DWU (Under Current Contract)	1,000	1,000	1,000	1,000	23,295	27,386
Lake Chapman Indirect Reuse	8,441	8,301	8,161	8,021	7,882	7,743
Additional DWU Supplies (Reuse)	5,627	5,534	5,441	5,348	5,254	5,162
Lake Ralph Hall		29,600	29,600	29,600	29,600	29,600
Additional Indirect Reuse		17,760	17,760	17,760	17,760	17,760
Marvin Nichols Reservoir			17,500	35,000	35,000	35,000
Additional DWU Supplies					2,200	6,000
Oklahoma Water						15,000
Total Supplies of Strategies	**15,918**	**65,265**	**84,395**	**103,925**	**130,634**	**155,413**

Table 4E.14, Continued

Source	2010	2020	2030	2040	2050	2060
Total Supplies	**41,200**	**91,039**	**113,351**	**138,058**	**172,851**	**196,678**
Portion of DWU Supply from Reuse	5,627	5,534	5,441	5,348	12,690	15,266
Total from Conservation & Reuse	15,815	35,562	37,192	39,222	48,872	53,428
Percent from Conservation & Reuse	38.4%	39.1%	32.8%	28.4%	28.3%	27.2%
Projected Demands	**31,769**	**56,353**	**80,904**	**109,456**	**136,932**	**155,831**
Losses in Treatment and Transmission	1,588	2,818	4,045	5,473	6,847	7,792
Surplus or (Shortage)	7,843	31,868	28,402	23,128	29,072	33,055

Figure 4E.13
Recommended Water Management Strategies for UTRWD

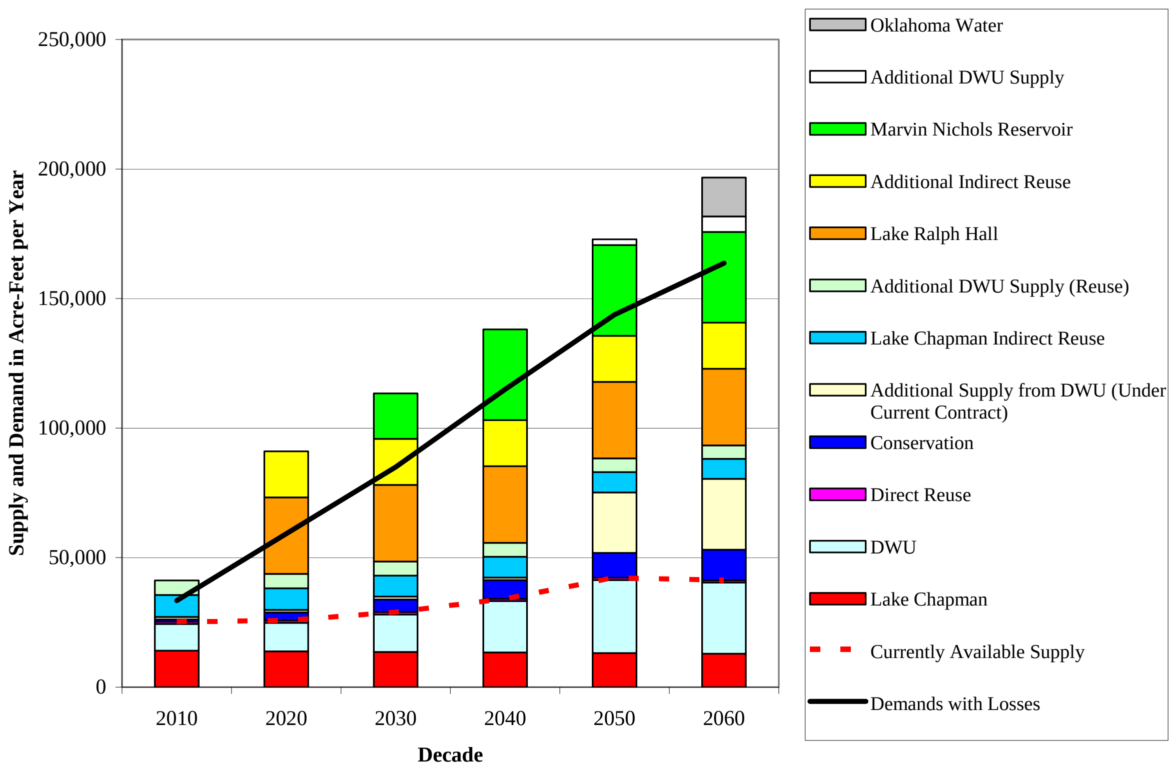


Figure 4E.14
UTRWD's 2060 Supply by Type

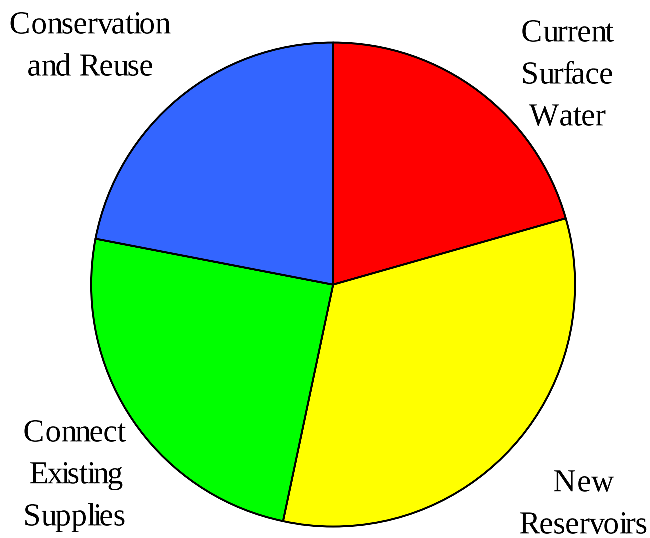


Table 4E.15
Summary of Costs for UTRWD Recommended Water Management Strategies

Strategy	Develop Dates	2060 Quantity (Ac-Ft/Yr)	Capital Cost	Unit Cost ($/kGal.)	
				Pre-Amort.	Post-Amort.
Additional DWU Supply under Current Contract	2010	33,386	$0	$0.40	$0.40
Lake Chapman Indirect Reuse	2007	7,743	$0	$0.00	$0.00
Additional DWU Purchase Linked to Lake Chapman Reuse	2007	5,162	$0	$0.40	$0.40
Lake Ralph Hall	2020	29,600	$211,153,000	$1.10	$0.17
Indirect Reuse (Ralph Hall)	2020	17,760	$0	$0.00	$0.00
Marvin Nichols Reservoir	2030	35,000	$142,761,000	$1.27	$0.36
Additional DWU Purchase	2050	6,000	$0	$0.40	$0.40
Oklahoma Water	2060	15,000	$60,967,000	$1.36	$0.45
Water Treatment and Distribution Improvements	2010-2060	N/A	$442,818,000	N/A	N/A
Total Capital Costs			**$857,699,000**		

If any of the projects identified in the recommended plan are not implemented, the UTRWD may wish to pursue alternative strategies. The following alternative water management strategies are recommended for UTRWD:

- Toledo Bend Reservoir
- Wright Patman Lake
- George Parkhouse Reservoir (North)
- George Parkhouse Reservoir (South)
- Lake Texoma
- Additional reuse.

Information on the alternative strategies is shown on Table 4E.16.

Table 4E.16
Costs for Alternate Strategies for UTRWD

Strategy	Develop Dates	2060 Quantity (Ac-Ft/Yr)	Capital Cost	Unit Cost ($/kGal.)	
				Pre-Amort.	Post-Amort.
Toledo Bend Reservoir	2050	48,000	$212,640,000	$1.66	$0.67
Wright Patman Lake	2035	38,000	$182,913,000	$1.64	$0.57
Lake Texoma	Unknown	25,000	$40,396,000	$0.47	$0.11
George Parkhouse Reservoir (North)	Unknown	35,000	$106,601,000	$1.01	$0.33
George Parkhouse Reservoir (South)	Unknown	35,000	$154,899,000	$1.34	$0.36
Additional Reuse	Unknown	15,000	$1,000,000	$0.01	$0.00

Greater Texoma Utility Authority

The Greater Texoma Utility Authority (GTUA) provides water to Sherman and manufacturing in Grayson County. The GTUA will participate in the Grayson County Water Supply Project and the Collin-Grayson Municipal Alliance Pipeline, and is expected to provide water to 19 water user groups in Grayson and Collin Counties from these projects. In addition, GTUA and NTMWD have reached an agreement for GTUA to provide up to 25,000 acre-feet per year of raw water to NTMWD on an interim basis (planning for 20,000 acre-feet per year).

The GTUA has an existing water right for 25,000 acre-feet per year from Lake Texoma. Of this amount, 11,210 acre-feet per year (limited by the Sherman water treatment plant capacity) is available to existing customers as potable water, and the remainder, 13,790 acre-feet per year, is available as raw water in Lake Texoma.

Considering existing and future demand, the GTUA will need to develop 6,000 acre-feet per year of new supply by 2010 and 43,000 acre-feet per year of supplies by 2060. To meet these needs, the following strategies are recommended:

- Conservation
- Change permitted Lake Texoma use to municipal or industrial
- Additional Lake Texoma (interim NTMWD supply)
- Collin-Grayson Municipal Alliance Pipeline Project
- Grayson County Water Supply Project

These strategies are discussed individually below.

Conservation. Conservation is the projected conservation savings for the GTUA's existing and potential customers, based on the recommended Region C water conservation program. Water savings by the GTUA and customers is projected to reach 5,843 acre-feet per year by 2060.

Change Permitted Lake Texoma Use to Municipal or Industrial. The GTUA has an existing water right that authorizes diversion from Lake Texoma of 15,000 acre-feet per year for municipal/domestic purposes and 10,000 acre-feet per year for industrial purposes. Under this strategy, the GTUA0 would seek an amendment to the water right that would allow the diversion from Lake Texoma of 25,000 acre-feet per year for municipal or industrial purposes. The GTUA has submitted an application for an amendment to the Texas Commission on Environmental Quality. The application is administratively complete, and a public meeting has been held at which there was no opposition to the amendment. This amendment will also make water available for sale to the NTMWD as an interim supply (discussed next).

Additional Lake Texoma (Interim NTMWD Supply). The GTUA has a contract with the NTMWD to provide an interim supply of up to 25,000 acre-feet per year of raw water. By 2010, it is expected that the GTUA will provide approximately 20,000 acre-feet per year of raw water from Lake Texoma to the North Texas Municipal Water District (NTMWD) on an interim basis. This strategy would require an interbasin transfer authorization, and GTUA has applied for this authorization. In addition, given that some of the water diverted from Lake Texoma by GTUA is committed to Sherman and its customers, a new water right to divert water from Lake Texoma (with interbasin transfer authorization) will be necessary to provide the interim demand. The U.S. Army Corps of Engineers is conducting a reallocation study of the storage in Lake Texoma [(7)]. After completion of this study, the GTUA will contract with the Corps of Engineers for storage in Lake Texoma (approximately 50,000 acre-feet) and apply to the TCEQ for a new water right in Lake Texoma (approximately 56,500 acre-feet per year). The new water right would also support the Grayson County Water Supply Project described below.

Collin-Grayson Municipal Alliance Pipeline Project. By 2006, the GTUA will purchase water from NTMWD for supply to customers of the Collin-Grayson Municipal Alliance Pipeline Project. This project would be constructed in two phases. Phase 1 would require a transmission system from McKinney to the customer cities and would require compensation to McKinney for use of their pumping facilities. Phase 2 would require additional capacity to move water from McKinney to the cities of Melissa, Anna and Weston. The Phase 1 transmission system is currently under design and will be limited to an annual demand of approximately 15 million gallons per day, or 16,813 acre-feet per year. Phase 2 is expected to provide an additional 24,166 acre-feet per year, with most of the additional supply used to meet growing demands in Anna and Weston.

Grayson County Water Supply Project. By 2020, due to limited groundwater availability in Grayson County, the GTUA will provide treated surface water from Lake Texoma to Grayson County customers. Phase 1, including a 25 million gallon per day water treatment plant expansion, a new 1 mgd water treatment plant in northwestern Grayson County, and a water transmission system, would be constructed by 2020. Phase 2, including a 20 mgd water treatment plant expansion, would be constructed by 2040. This strategy would use all water currently permitted under the GTUA's existing water right in Lake Texoma and would require that the GTUA obtain an additional water right (with interbasin transfer authorization) in Lake Texoma, as discussed above.

Table 4E.17 and Figure 4E.15 show the recommended plan for water supply development for the GTUA. Approximately 18 percent of the projected 2060 supply will be from conservation and reuse. Table 4E.18 presents the capital and unit costs for the recommended water management strategies. The opinion of probable capital cost for the recommended water management strategies is approximately $283.6 million, based on 2002 construction costs.

Table 4E.17
Recommended Water Management Strategies for GTUA
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
Lake Texoma (Potable)	*11,210*	*11,210*	*11,210*	*11,210*	*11,210*	*11,210*
Total Currently Available Supplies	***11,210***	***11,210***	***11,210***	***11,210***	***11,210***	***11,210***
Water Management Strategies						
Customer Water Conservation	629	1,724	2,670	3,567	4,558	5,843
Change Permitted Lake Texoma Use to Municipal or Industrial	0	0	0	0	0	0
Additional Lake Texoma (Interim NTMWD Supply)	20,000	0	0	0	0	0
Collin-Grayson Municipal Alliance Pipeline Project	3,481	9,672	14,544	17,886	29,453	40,979
Additional Lake Texoma - Grayson County Water Supply Project (Phase 1)	0	14,572	14,572	14,572	14,572	14,572
Additional Lake Texoma - Grayson County Water Supply Project (Phase 2)	0	0	0	11,557	11,557	11,557
Total Supplies from Strategies	**24,110**	**25,968**	**31,786**	**47,582**	**60,140**	**72,951**
Total Supplies	**35,320**	**37,178**	**42,996**	**58,792**	**71,350**	**84,161**
Total from Conservation & Reuse	3,567	6,084	7,642	9,760	11,159	14,801
Percent from Conservation & Reuse	10.1%	16.4%	17.8%	16.6%	15.6%	17.6%
Projected Demands	**31,544**	**23,780**	**31,977**	**42,957**	**55,757**	**72,956**
Surplus or (Shortage)	3,776	13,398	11,019	15,835	15,593	11,205

Figure 4E.15
Recommended Water Management Strategies for GTUA

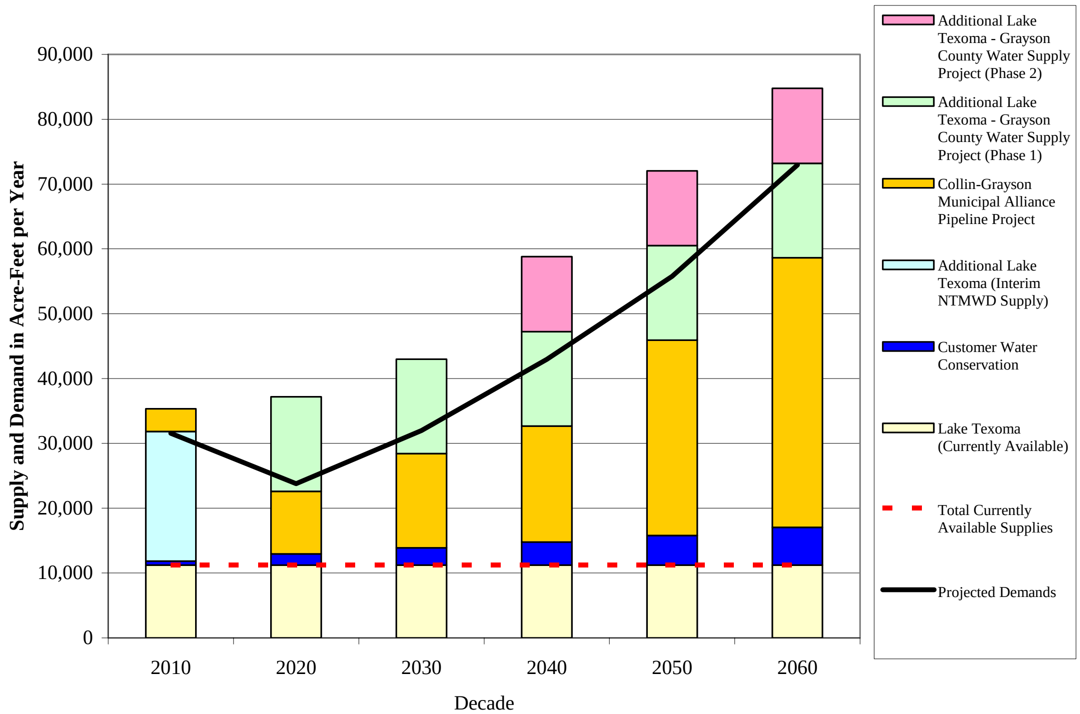


Table 4E.18
Summary of Costs for GTUA Recommended Water Management Strategies

Strategy	Develop Dates	2060 Quantity (Ac-Ft/Yr)	Capital Cost	Unit Cost ($/kGal.)	
				Pre-Amort.	Post-Amort.
Change Permitted Lake Texoma Use to Municipal or Industrial	2005	0	$50,000	N/A	N/A
Additional Lake Texoma (Interim NTMWD Raw Water Supply)	2006	20,000 (in 2010)	$15,729,000	$0.18	$0.00
Collin-Grayson Municipal Alliance Pipeline Project – Phase 1	2006	16,813	$15,342,000	$1.48	$1.28
Collin-Grayson Municipal Alliance Pipeline Project – Phase 2	2038	24,200	$36,112,400	$1.46	$1.13
Grayson County Water Supply Project - Phase 1	2020	14,572	$168,787,000	$4.55	$1.96
Grayson County Water Supply Project - Phase 2	2040	11,557	$46,578,000	$2.40	$1.50
Total Capital Costs			**$282,598,669**		

Dallas County Park Cities Municipal Utility District

The current supply for the Dallas County Park Cities Municipal Utility District (MUD) is Grapevine Lake. The MUD supplies water to Highland Park and University Park and plans to continue doing so through the planning period. No shortages are expected to occur during the planning period. The proposed strategy is to implement water conservation measures by the respective water customers. The water savings and costs for conservation were determined by water user group and are shown for Highland Park and University Park in Appendix U.

City of Corsicana

The City of Corsicana provides municipal and manufacturing water to much of Navarro County. The city's current water sources include Lake Halbert and Navarro Mills Lake. The city also has a water right for 13,650 acre-feet per year in Richland-Chambers Reservoir, but the infrastructure is not in place to use the water. The supply currently available to Corsicana is limited to 11,210 acre-feet per year because of the existing water treatment plant capacity. To meet the projected water demands, the city will need to develop 475 acre-feet per year of treated water by 2020 and 5,200 acre-feet per year of treated water by 2060. The recommended strategies to meet these needs include:

- Conservation
- Expansion of the Navarro Mills Water Treatment Plant by 5 mgd
- Expansion of Lake Halbert Water Treatment Plant by 10 mgd
- Connection to Richland-Chambers Reservoir (to use existing water right).

These strategies are discussed individually below.

Conservation. Conservation is the projected conservation savings for the City of Corsicana, as well as its existing and potential customers, based on the Region C recommended water conservation program. Not including savings from low-flow plumbing fixtures (which are built into the demand projections), conservation by Corsicana and its customers is projected to reach 1,165 acre-feet per year by 2060.

Expansion of Navarro Mills Water Treatment Plant by 5 mgd. The current capacity of the Navarro Mills Water Treatment Plant is 20 mgd. The 5 mgd expansion is expected to occur in the 2010-2020 time frame. The expansion would allow additional water already committed to

Corsicana in Navarro Mills Lake to be used. The resulting treatment capacity of 25 mgd will fully develop this site.

Expansion of Lake Halbert Water Treatment Plant by 10 mgd. The current capacity of the water treatment plant at Lake Halbert is 3 mgd. Corsicana plans to expand this plant by 10 mgd in order to treat water from the Richland-Chambers Reservoir for use by the city and its customers. Corsicana plans to expand this water treatment plant expansion in the 2050-2060 time frame.

Connection to Richland-Chambers Reservoir. Corsicana has a water right for 13,650 acre-feet per year in the Richland-Chambers Reservoir. The infrastructure is not currently in place to transport this water to the city. Corsicana plans to pipe this raw water to the Lake Halbert Water Treatment Plant. The city also plans to expand the water treatment plant to accommodate this supply.

Table 4E.19 and Figure 4E.16 show the recommended water management strategies for Corsicana. Table 4E.20 provides the capital and unit costs for the recommended infrastructure strategies. The estimated cost for Corsicana's recommended water management strategies is approximately $38.1 million, based on 2002 construction costs.

Sabine River Authority

The Sabine River Authority (SRA) is based in Regions D and I. The SRA currently provides water from its Upper Basin reservoirs (Lake Tawakoni and Lake Fork Reservoir) to water users in Region C. These sources are fully contracted and SRA has requests for additional water in the Upper Basin. The SRA plans to participate in the Toledo Bend Reservoir project that would transport water to the Upper Basin area and Region C. The Sabine River Authority is also seeking an amendment to its existing water right in Toledo Bend Reservoir for an additional 293,300 acre-feet per year of water supply. This amendment has been submitted to the Texas Commission on Environmental Quality and declared administratively complete. Regions D and I will develop management strategies for the Sabine River Authority.

Sulphur River Water District

The Sulphur River Water District is located primarily in Region D. The Sulphur River Water District does not have any shortages during the planning period. Region D will develop any water management strategies needed for the Sulphur River Water District.

Table 4E.19
Recommended Water Management Strategies for Corsicana
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
Lake Halbert [a]	*0*	*0*	*0*	*0*	*0*	*0*
Richland-Chambers Reservoir [b]	*0*	*0*	*0*	*0*	*0*	*0*
Navarro Mills Lake (limited by WTP)	*11,210*	*11,210*	*11,210*	*11,210*	*11,210*	*11,210*
Total Currently Available Supplies	***11,210***	***11,210***	***11,210***	***11,210***	***11,210***	***11,210***
Water Management Strategies						
Conservation - Basic & Expanded Packages	104	364	452	741	977	1,165
Navarro Mills WTP Expansion (5 mgd)	0	2,803	2,803	2,803	2,803	2,290
Connection to Richland-Chambers Reservoir & Lake Halbert WTP Exp. (10 mgd) [c]	0	0	0	0	5,605	5,605
Total Supplies from Strategies	**104**	**3,167**	**3,255**	**3,544**	**9,385**	**9,060**
Total Supplies	**11,314**	**14,377**	**14,465**	**14,754**	**20,595**	**20,270**
Total from Conservation & Reuse	104	364	452	741	977	1,165
Percent from Conservation & Reuse	0.9%	2.5%	3.1%	5.0%	4.7%	5.7%
Projected Demands	**10,690**	**11,685**	**12,571**	**13,501**	**14,739**	**16,338**
Surplus or (Shortage)	624	2,692	1,894	1,253	5,856	3,931

Notes: a. The yield of Lake Halbert is zero based on the Trinity River Water Availability Model.
b. Water right to divert 13,650 acre-feet per year, but infrastructure is not in place.
c. Supply from Richland-Chambers Reservoir is limited by the water treatment plant capacity. Total supply from Richland Chambers Reservoir is 13,650 acre-feet per year.

Upper Neches River Municipal Water Authority

The Upper Neches River Municipal Water Authority (UNRMWA) is located in the East Texas Region. The UNRMWA does not have any shortages during the planning period. The UNRMWA plans to sponsor the proposed Lake Fastrill and sell water to DWU. The East Texas

Region will be responsible for developing any water management strategies needed for the UNRMWA. Development of Lake Fastrill is discussed under the recommended plan for DWU.

Figure 4E.16
Recommended Water Management Strategies for Corsicana

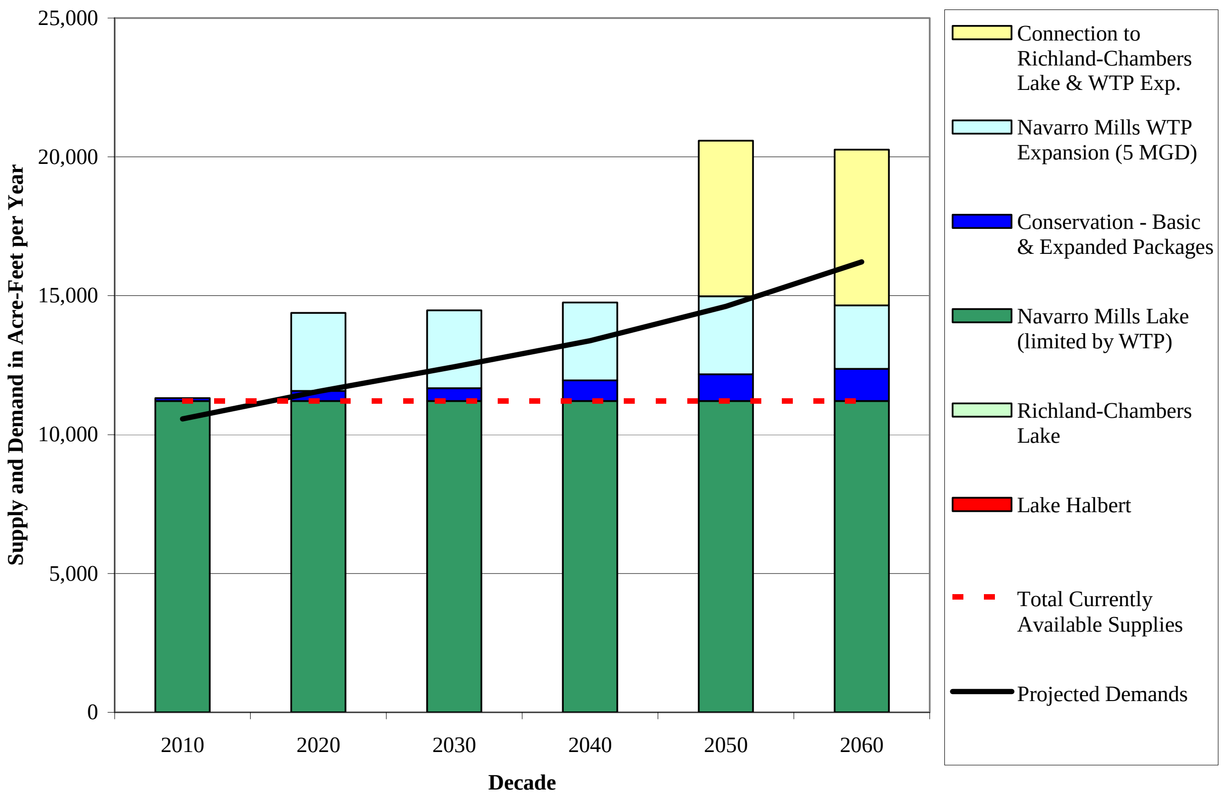


Table 4E.20
Summary of Costs for Corsicana's Recommended Water Management Strategies

Strategy	Development Dates	2060 Quantity (Ac-Ft/Yr)	Capital Cost	Unit Cost ($/kGal.)	
				Pre-Amort.	Post-Amort.
Navarro Mills WTP Expansion (5 mgd)	2020	2,290	$9,882,000	$1.14	$0.35
Lake Halbert WTP Expansion (10 mgd)	2050	0	$15,528,000	$0.97	$0.35
Connection to Richland-Chambers Reservoir	2050	13,650	$12,643,000	$0.27	$0.06
Total Capital Costs			**$38,053,000**		

4E.2 Recommended Strategies for Local Wholesale Water Providers

Athens Municipal Water Authority

Athens Municipal Water Authority (AMWA) currently provides water to the city of Athens, which is located in both Regions C and I. The AMWA obtains all its water from Lake Athens in East Texas Region. The Athens Fish Hatchery that is located at Lake Athens has a contract for 3,023 acre-feet per year from the lake. Operational constraints of the hatchery's intake structure do not allow the lake level to go below 431 ft msl. As a result the operational yield of the lake is 2,900 acre-feet per year. Total demands on the lake (including the fish hatchery) are 5,607 acre-feet per year in 2010, and are projected to increase to 9,492 acre-feet per year by 2060. The projected need for additional supply for AMWA is 2,707 acre-feet per year in 2010, increasing to 6,592 acre-feet per year in 2060. The recommended strategies to meet the demands on AMWA and Lake Athens include:

- Conservation
- Temporary pumping facilities for Athens Fish Hatchery
- Indirect Reuse to Lake Athens from the City of Athens
- Raw water from Forest Grove Reservoir to Lake Athens
- Expansion of existing water treatment facilities at Lake Athens by 1.5 mgd
- Construction of a new 3.5 mgd water treatment facility at Forest Grove Reservoir near the City of Athens.

These strategies are discussed individually below. The temporary pumping strategy identified for the Athens Fish Hatchery is also discussed.

Conservation. Conservation is the projected conservation savings for the City of Athens and a portion of savings projected for Henderson County manufacturing. These savings are based on the Region C recommended water conservation program for the entire city of Athens, including the portion in East Texas Region. Not including savings from low-flow plumbing fixtures (already built into the projected demands) conservation by AMWA is projected to reach 811 acre-feet per year by 2060.

Indirect Reuse. This strategy would include the infrastructure to move treated wastewater effluent from the City of Athens wastewater treatment plants to an outfall location upstream of

Lake Athens. This would supplement existing supplies in Lake Athens and would be available for rediversion by AMWA. The total amount of this supply would be 2,677 acre-feet per year.

Temporary Pumping Facility for the Fish Hatchery to Utilize Water below 431 ft msl. The safe yield of Lake Athens in year 2000 is 5,260 acre-feet per year. It is estimated that an additional 1,500 acre-feet per year is available from Lake Athens with temporary pumping for the hatchery and still allow the AMWA to use water from the lake. It is proposed that this strategy be used during drought for the first decade until a more permanent strategy can be implemented. This strategy is discussed in the East Texas Regional Water Plan [(8)].

Forest Grove Reservoir (Split to Lake Athens and City of Athens). This strategy assumes that a total of 4,500 acre-feet per year would be diverted from Forest Grove Reservoir. Of this amount, 2,500 acre-feet would be transported to Lake Athens and 2,000 acre-feet would be pumped to a new water treatment facility near the City of Athens. This strategy would be staged such that about 2,000 acre-feet per year of raw water would be pumped to Lake Athens by 2020, increasing to 2,500 acre-feet per year by 2030. By 2050, AMWA would construct the pipeline to the city for the additional 2,000 acre-feet per year of treated water. This strategy requires a change in permitted use and an agreement with TXU.

Expansion of Athens MWA Water Treatment Capacity. The current capacity of the Lake Athens Water Treatment Plant is 6 mgd. The total treatment capacity needed for the MWA over the planning period is 11 mgd. The treated water pipeline from the current facility to the city has a capacity of 7.5 mgd. It is proposed to expand the Lake Athens facility by 1.5 mgd to allow full utilization of the existing infrastructure and available supply in Lake Athens. This strategy would also require expanding the lake intake structure by 1.5 mgd. In addition, a new 3.5 mgd facility would be constructed near the City of Athens by 2050 to treat water from Forest Grove Reservoir.

Table 4E.21 shows the recommended plan for AMWA and users of Lake Athens. Table 4E.22 gives a summary of costs for the recommended strategies.

Table 4E.21
Recommended Water Management Strategies for Athens MWA and Lake Athens
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Existing Supplies						
Lake Athens	2,900	2,900	2,900	2,900	2,900	2,900
Water Management Strategies						
Conservation	25	196	359	483	627	811
Reuse	1,662	1,966	2,325	2,677	2,677	2,677
Temporary pump	1,500					
Forest Grove raw water	0	2,000	1,660	1,660	1,660	1,660
Forest Grove w/ Add. Trmt at Lake Athens			840	840	840	840
Forest Grove w/ New WTP at City					2,000	2,000
Total Supplies from Strategies	**3,187**	**4,162**	**5,184**	**5,660**	**7,804**	**7,988**
Total Supplies	**6,087**	**7,062**	**8,084**	**8,560**	**10,704**	**10,888**
Total from Conservation and Reuse	1,687	2,162	2,684	3,160	3,304	3,488
Percent of Supplies from Conservation and Reuse	27.7%	30.6%	33.2%	36.9%	30.9%	32.0%
Projected Demand	**5,607**	**6,125**	**6,743**	**7,444**	**8,360**	**9,492**
Surplus or (Shortage)	480	938	1,341	1,116	2,344	1,396

Table 4E.22
Summary of Costs for Athens MWA's Recommended Water Management Strategies

Strategy	2060 Quantity (Ac-Ft/Yr)	Capital Cost	Raw Water $/1,000 gal	Treated $/1,000 gal
Reuse	2,677	$3,601,700	$0.48	
Forest Grove (split to Lake and City)	4,500	$5,696,900	$0.38	
1.5 mgd Expansion at Lake	840	$4,150,100		$1.50
3.5 mgd New WTP at City	1,960	$11,423,800		$1.65
Total		**$24,872,500**		

City of Cedar Hill

The current water supply for the City of Cedar Hill includes groundwater from the Trinity and Woodbine aquifers and surface water purchased from Dallas Water Utilities (DWU). Cedar Hill has a contract with the Trinity River Authority to purchase water from Joe Pool Lake, but the infrastructure to use that water is not in place. Cedar Hill currently provides water to the City of Ovilla. This water sale is expected to terminate after Ovilla's direct connection to Dallas Water Utilities is complete. The shortages for Cedar Hill are 2,300 acre-feet per year in 2010, increasing to 9,000 acre-feet per year by 2060. These shortages are due to limited supplies from DWU. As DWU develops new supplies, Cedar Hill should have sufficient supply. The recommended strategies for Cedar Hill are to implement water conservation measures, drill supplemental wells in both aquifers, and continue purchasing water from DWU. A summary of the recommended water plan for Cedar Hill is shown on Table 4E.23. The total capital costs are $2,143,500, which are associated with the installation of supplemental wells.

Table 4E.23
Recommended Water Management Strategies for the City of Cedar Hill
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
Trinity aquifer	*275*	*275*	*275*	*275*	*275*	*275*
DWU	*6,484*	*6,457*	*6,985*	*7,120*	*6,857*	*6,345*
Total Existing	***6,759***	***6,732***	***7,260***	***7,395***	***7,132***	***6,620***
Water Management Strategies						
Conservation	793	2,440	2,986	3,447	3,901	4,317
Supplemental Wells	0	0	0	0	0	0
Purchase Water from DWU	2,265	4,476	6,218	8,273	9,908	9,380
Total Supplies from Strategies	**3,058**	**6,916**	**9,204**	**11,720**	**13,809**	**13,697**
Total Supplies	**9,817**	**13,648**	**16,464**	**19,115**	**20,941**	**20,317**
Projected Demands	**9,089**	**10,083**	**11,839**	**13,192**	**14,460**	**15,519**
Surplus or (Shortage)	728	3,565	4,625	5,923	6,481	4,798

City of Denton

The City of Denton currently provides treated water to its retail customers and manufacturing in Denton County. The city also provides treated wastewater effluent to steam electric power and irrigation users in Denton County. The projected demands on Denton are expected to more than triple between 2010 and 2060. The current sources of water supply include Ray Roberts Lake, Lewisville Lake, direct and indirect reuse, and water purchased from Dallas Water Utilities (DWU). The available supply in Ray Roberts Lake and Lewisville Lake is Denton's share of the firm yield of the reservoirs. The yield of each reservoir decreases over time due to sedimentation. Denton will need to develop 9,400 acre-feet per year of treated water supplies by 2020 and 70,000 acre-feet per year of treated water by 2060. The proposed future strategies for Denton are to implement water conservation measures, expand water treatment plant capacity, and purchase additional water from DWU. A summary of the recommended water plan for Denton is shown on Table 4E.24. The total capital costs are $175.4 million, which are associated with the construction of additional water treatment plant capacity.

Table 4E.24
Recommended Water Management Strategies for the City of Denton
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
Lewisville Lake	*7,702*	*7,507*	*7,313*	*7,119*	*6,924*	*6,730*
Ray Roberts Lake	*20,445*	*19,882*	*19,319*	*18,756*	*18,193*	*17,630*
Indirect Reuse	*1,682*	*2,130*	*2,915*	*3,475*	*4,372*	*5,381*
Direct Reuse	*1,233*	*2,242*	*2,690*	*3,251*	*3,924*	*4,708*
Existing DWU Supply with WTP expansions	*1,931*	*8,117*	*12,434*	*15,474*	*19,549*	*27,025*
Total Currently Available Supplies	***32,993***	***39,878***	***44,671***	***48,075***	***52,962***	***61,474***

water management strategies include implementing water conservation measures, increasing the contract and purchasing additional water from TRWD, and increasing water treatment capacity. A summary of the recommended water plan for East Cedar Creek FWSD is shown on Table 4E.25. The total capital costs are $31,550,000, which are associated with the construction of additional water treatment plant capacity.

Table 4E.25
Recommended Water Management Strategies for East Cedar Creek FWSD
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
TRWD Sources	*1,157*	*1,157*	*1,157*	*1,157*	*1,157*	*1,157*
Total Existing	***1,157***	***1,157***	***1,157***	***1,157***	***1,157***	***1,157***
Water Management Strategies						
Conservation	117	279	374	480	615	793
Additional water from TRWD with expanded WTP capacity	3,477	4,074	5,371	5,340	7,467	8,087
Total Supplies from Strategies	**3,594**	**4,353**	**5,745**	**5,820**	**8,082**	**8,880**
Total Supplies	**4,751**	**5,510**	**6,902**	**6,977**	**9,239**	**10,037**
Projected Demands	**3,741**	**4,479**	**5,221**	**5,963**	**6,923**	**8,152**
Surplus or (Shortage)	1,010	1,031	1,681	1,014	2,316	1,885

City of Ennis

The current water supply for the City of Ennis is water purchased from the Trinity River Authority (Bardwell Lake). Ennis sells reclaimed water in Ellis County for steam electric power purposes. By 2006, Ennis plans to complete the necessary infrastructure connecting to Tarrant Regional Water District (TRWD) pipelines to purchase water from the Trinity River Authority (TRA), which will purchase it from TRWD. This project is considered part of the Ellis County Water Supply Project, which is regional strategy to provide treated water to municipal and manufacturing water users in the county. Ennis sells water to Community Water Company in Ellis County, East Garrett WSC (Ellis County-Other), Rice WSC, and Ellis County Manufacturing. Ennis expects to continue providing water supplies up to the contract amounts to these customers throughout the planning period. Ennis will need to develop an additional 1,600 acre-feet per year by 2010 and 12,000 acre-feet per year by 2060. The recommended water management strategies for Ennis include implementing water conservation measures, developing indirect reuse from Bardwell Lake, and purchasing water from the TRA through the Ellis County Water Supply Project.

A summary of the recommended water plan for Ennis is shown on Table 4E.26. The total capital costs for infrastructure projects are $46,483,000.

Table 4E.26
Recommended Water Management Strategies for the City of Ennis
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
Bardwell Lake (TRA)	*4,712*	*4,484*	*4,257*	*4,030*	*3,802*	*3,575*
Direct Reuse	*2,098*	*2,615*	*3,302*	*3,363*	*3,363*	*3,363*
Total Existing	***6,810***	***7,099***	***7,559***	***7,393***	***7,165***	***6,938***
Water Management Strategies						
Conservation	140	369	583	826	1,130	1,544
Indirect Reuse from Bardwell Lake	0	70	135	1,037	2,269	3,696
Ellis County Water Supply Project (TRA/TRWD)	341	710	2,131	3,845	4,139	4,446
Total Supplies from Strategies	**481**	**1,149**	**2,848**	**5,708**	**7,538**	**9,686**
Total Supplies	**7,291**	**8,249**	**10,408**	**13,101**	**14,703**	**16,624**
Projected Demands	**6,336**	**7,810**	**9,690**	**11,239**	**13,167**	**15,625**
Surplus or (Shortage)	955	438	718	1,862	1,536	999

City of Forney

The City of Forney currently purchases water from the North Texas Municipal Water District (NTMWD). Forney also purchases reuse water from Garland, which it then sells to Kaufman County Steam Electric Power. Forney currently supplies water to High Point WSC and Talty WSC. Demands on Forney are expected to more than double between 2010 and 2060, creating shortages of 7,200 acre-feet per year in 2010 and increasing to 21,500 acre-feet per year by 2060. Part of this need is due to infrastructure constraints for the reuse supply from the city of Garland. Forney will need to expand this infrastructure to fully utilize the existing contract. In addition, NTMWD plans to continue providing water to Forney and its retail customers. As NTMWD develops new projects, Forney should have sufficient supplies. The recommended water management strategies for Forney include implementing water conservation measures, expanding infrastructure for its reuse supply, and purchasing additional water from NTMWD.

A summary of the recommended water plan for Forney is shown on Table 4E.27. The capital costs for infrastructure projects total $6,303,000.

Table 4E.27
Recommended Water Management Strategies for the City of Forney
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
NTMWD	*2,691*	*3,630*	*3,861*	*4,043*	*4,268*	*4,491*
Reuse from Garland (SEP only)	*3,000*	*3,000*	*3,000*	*3,000*	*3,000*	*3,000*
Total Existing	***5,691***	***6,630***	***6,861***	***7,043***	***7,268***	***7,491***
Water Management Strategies						
Conservation	106	375	562	754	961	1,207
Additional Reuse from Garland	5,979	12,600	12,600	12,600	12,600	12,600
Additional Water from NTMWD	2,102	4,638	6,084	6,069	9,715	10,996
Total Supplies from Strategies	**8,187**	**17,613**	**19,246**	**19,423**	**23,276**	**24,803**
Total Supplies	**13,877**	**24,243**	**26,108**	**26,466**	**30,544**	**32,294**
Projected Demands	**12,934**	**22,407**	**24,035**	**25,590**	**27,188**	**28,984**
Surplus or (Shortage)	943	1,836	2,073	876	3,356	3,310

City of Gainesville

The City of Gainesville currently provides treated water to its retail customers and manufacturing in Cooke County. The city also provides a small amount of direct reuse for irrigation. Gainesville is expected to be a sponsor of the Cooke County Project, which will serve seven other water user groups in Cooke County. Gainesville currently obtains water from the Trinity aquifer and Moss Lake. Water supplies from Moss Lake are limited by treatment capacity, such that the total available supplies for the city are 3,238 acre-feet per year. Due to declining well yields, the city also plans to limit its dependence on groundwater further reducing the available supply. The city needs to develop an additional 600 acre-feet per year of treated water supplies to meet projected demands through 2010 and an additional 5,730 acre-feet per year of supplies by 2060. The recommended water management strategies to meet these needs include:

- Conservation
- Water treatment plant expansion
- Cooke County Water Supply Project
- Indirect reuse – Moss Lake
- Divert Red River water to Moss Lake
- Supplemental wells
- Obtain bed and banks authorization.

These strategies are discussed individually below.

Conservation. Conservation is the projected conservation savings for Gainesville's existing and potential customers, based on the recommended Region C water conservation program. Not including savings from low-flow plumbing fixtures (already built into the projected demands) conservation by Gainesville and its customers is projected to reach 654 acre-feet per year by 2060.

Water Treatment Plant Expansion. By 2010, Gainesville would expand the water treatment plant capacity by 2 mgd and begin using additional water from Moss Lake. This strategy would use existing pipeline and pumping facilities and would result in an additional supply of 560 acre-feet per year from Moss Lake.

Cooke County Water Supply Project. By 2020, due to limited groundwater availability and declining aquifer levels in Cooke County, Gainesville would develop the Cooke County Water Supply Project (Project). The Project would provide surface water from Moss Lake to the city and to several Cooke County customers, including Bolivar WSC, Cooke County-Other, Cooke County Irrigation, Kiowa Homeowners WSC, Lindsay, Valley View, and Woodbine WSC. This project would require new infrastructure: a new pipeline from Moss Lake, a water transmission system, and a total of 7 mgd in water treatment plant expansions during the planning period. This strategy would provide an additional 3,840 acre-feet per year from Moss Lake. This strategy would use all water currently permitted under the city's existing water right in Moss Lake and would require that the city obtain an additional water right in Moss Lake. Gainesville has filed an application with the TCEQ for an additional water right in Moss Lake.

Indirect Reuse – Moss Lake. By 2020, Gainesville would contract with GTUA to transport treated wastewater effluent from the city's wastewater treatment plant to Moss Lake for blending, storage, and indirect potable reuse. New infrastructure for this project would include advanced treatment facilities at the city's wastewater treatment plant, a reclaimed water transmission pipeline, and a 1 mgd expansion to the city's water treatment plant. After blending and storage, water would be diverted from Moss Lake and transported to the city's water treatment plant using facilities constructed as part of the Cooke County Water Supply Project. This strategy would require a permit to discharge reclaimed water to Moss Lake, and would likely be permitted by the new water right that the city would obtain during implementation of the Cooke County Water Supply Project. However, development of Gainesville's full potential reclaimed water supply may require another new water right to divert water from Moss Lake.

Divert Red River Water to Moss Lake. By 2060, Gainesville would divert approximately 1 mgd from the Red River to Moss Lake to supplement its yield. To enable this strategy, the GTUA would apply for an appropriate diversion point on the Red River and an interbasin transfer authorization as part of its water right application for additional diversions from Lake Texoma.

Supplemental Wells. During the planning period, Gainesville would drill supplemental wells as necessary to maintain the city's groundwater supply.

Bed and Banks Authorization. Gainesvillewould obtain a bed and banks authorization from the TCEQ to transport raw and reclaimed water in the Elm Fork of the Trinity River to a downstream diversion point for diversion and use by downstream entities.

Table 4E.28 shows the recommended water management strategies for the City of Gainesville. Table 4E.29 gives information on the capital and unit costs for the recommended water management strategies. The opinion of probable capital cost for the recommended water management strategies is approximately $54.6 million, based on 2002 construction costs.

Table 4E.28
Recommended Water Plan for the City of Gainesville
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
Trinity aquifer	*2,108*	*1,615*	*1,121*	*1,121*	*1,121*	*1,121*
Moss Lake	*1,121*	*1,121*	*1,121*	*1,121*	*1,121*	*1,121*
Direct Reuse	*9*	*9*	*9*	*9*	*9*	*9*
Total Currently Available Supplies	***3,238***	***2,745***	***2,251***	***2,251***	***2,251***	***2,251***
Water Management Strategies						
Water Conservation	114	274	351	435	536	654
Water Treatment Plant Expansion	560	560	560	560	560	560
Cooke County Water Supply Project	0	2,202	2,202	3,840	3,840	3,840
Indirect Reuse - Moss Lake	0	561	561	561	561	561
Divert Red River Water to Moss Lake	0	0	0	0	0	1,121
Supplemental Wells	0	0	0	0	0	0
Bed and Banks Authorization	0	0	0	0	0	0
Total Supplies from Strategies	**674**	**3,597**	**3,674**	**5,396**	**5,497**	**6,736**
Total Supplies	**3,912**	**6,341**	**5,925**	**7,647**	**7,748**	**8,987**
Projected Demands	**3,808**	**4,938**	**5,601**	**6,797**	**7,342**	**7,980**
Surplus or (Shortage)	104	1,403	324	850	406	1,007

Table 4E.28
Summary of Costs for Gainesville's Recommended Water Management Strategies

Strategy	Develop Dates	2060 Quantity	Capital Cost	Unit Cost $/kGal.)	
				Pre-Amort.	Post-Amort.
Water Treatment Plant Expansion	2007	561	$4,941,000	$2.39	$0.42
Cooke County Supply Project	2020	3,689	$35,933,000	$3.74	$1.05
Indirect Reuse - Moss Lake	2020	561	$8,564,000	$4.71	$1.31
Divert Red River Water to Moss Lake	2060	1,121	$1,982,000	$1.09	$0.70
Supplemental Wells	Various	0	$3,148,000	N/A	N/A
Bed and Banks Authorization	TBD	0	$50,000	N/A	N/A
Total Capital Costs			**$54,618,000**		

City of Garland

The City of Garland currently purchases water from the North Texas Municipal Water District (NTMWD). The City of Garland sells some of its treated effluent to Forney for use for Kaufman County Steam Electric Power. Garland also sells water for Dallas County Manufacturing, Collin County Steam Electric Power, and Dallas County Steam Electric Power. Due to limited supplies from NTMWD, Garland has a projected shortage of 14,000 acre-feet per year in 2010, increasing to 38,200 acre-feet per year by 2060. As NTMWD develops new water supplies, these shortages should be met. The recommended strategies for Garland are to implement water conservation measures and continue purchasing water from the North Texas Municipal Water District. A summary of the recommended water plan for Garland is shown on Table 4E.30. The capital costs for the reuse project are discussed under the City of Forney above. There are no other capital costs for the City of Garland.

Table 4E.30
Recommended Water Management Strategies for the City of Garland
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
NTMWD	*32,889*	*27,041*	*24,465*	*22,575*	*21,386*	*19,538*
Reuse (from Garland to Forney)	*8,979*	*15,600*	*15,600*	*15,600*	*15,600*	*15,600*
Total Existing	***41,868***	***42,641***	***40,065***	***38,175***	***36,986***	***35,138***
Water Management Strategies						
Conservation	1,603	3,511	4,681	5,522	6,190	6,647
Additional water from NTMWD	21,719	31,449	35,848	31,134	46,529	45,870
Total Supplies from Strategies	**23,322**	**34,960**	**40,529**	**36,656**	**52,719**	**52,517**
Total Supplies	**65,190**	**77,601**	**80,594**	**74,831**	**89,705**	**87,655**
Projected Demands	**55,859**	**65,419**	**68,279**	**70,715**	**73,055**	**73,300**
Surplus or (Shortage)	9,331	12,182	12,315	4,116	16,650	14,355

Lake Cities Municipal Utility Authority

The current supplies for Lake Cities Municipal Utility Authority (MUA) include groundwater from the Trinity and Woodbine aquifers and surface water purchased from the Upper Trinity Regional Water District (UTRWD). Lake Cities MUA currently serves and plans to continue serving water to Lake Dallas, Hickory Creek, and Shady Shores. These demands are expected to more than double over the planning period. UTRWD plans to continue to provide water to Lake Cities MUA to meet the projected demands. The shortages identified for Lake Cities MUA are 184 acre-feet per year in 2010, increasing to 2,800 acre-feet per year in 2060. The recommended water management strategies include implementing water conservation measures, drilling supplemental wells in each aquifer, and purchasing additional water from UTRWD. A summary of the recommended water plan for Lake Cities MUA is shown on Table 4E.31. The capital costs for infrastructure projects total $1,797,900, which is associated with the installation of supplemental wells.

Table 4E.31
Recommended Water Management Strategies for Lake Cities MUA
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
UTRWD	*1,472*	*1,245*	*1,183*	*1,234*	*1,449*	*1,461*
Trinity aquifer	*129*	*129*	*129*	*129*	*129*	*129*
Woodbine aquifer	*279*	*279*	*279*	*279*	*279*	*279*
Total Existing	***1,880***	***1,653***	***1,591***	***1,642***	***1,857***	***1,869***
Water Management Strategies						
Conservation	27	142	170	210	259	315
Additional Water from UTRWD	640	2,413	2,514	2,588	3,038	3,731
Supplemental Wells	0	0	0	0	0	0
Total Supplies from Strategies	**667**	**2,555**	**2,684**	**2,798**	**3,297**	**4,046**
Total Supplies	**2,547**	**4,208**	**4,275**	**4,440**	**5,154**	**5,915**
Projected Demands	**2,065**	**2,739**	**3,120**	**3,507**	**4,032**	**4,634**
Surplus or (Shortage)	482	1,469	1,155	933	1,122	1,281

City of Mansfield

The City of Mansfield currently purchases raw water from the Tarrant Regional Water District (TRWD), and has the capacity to treat an average of 10 mgd. Mansfield sells water to Johnson County SUD and plans to continue selling to the SUD through the planning period. In the future, Mansfield plans to sell water to Grand Prairie. With the additional demands on the city, Mansfield has a projected shortage of 6,800 acre-feet per year in 2010, which increases to

27,900 acre-feet per year by 2060. The recommended water management strategies for Mansfield include implementing water conservation measures, purchasing additional water from the TRWD, and expanding its water treatment plant. A summary of the recommended water plan for Mansfield is shown on Table 4E.32. The capital costs for water treatment plant expansions total $86,232,000.

Table 4E.32
Recommended Water Management Strategies for the City of Mansfield
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
TRWD	*11,210*	*11,210*	*11,210*	*11,227*	*11,237*	*11,239*
Total Existing	***11,210***	***11,210***	***11,210***	***11,227***	***11,237***	***11,239***
Water Management Strategies						
Conservation	519	1,388	2,140	2,951	3,602	3,966
Expansion of Water Treatment Plant	0	0	0	0	0	0
Additional Water from TRWD	9,633	16,887	25,759	27,171	37,221	33,417
Total Supplies from Strategies	**10,152**	**18,275**	**27,899**	**30,122**	**40,823**	**37,383**
Total Supplies	**21,362**	**29,485**	**39,109**	**41,349**	**52,060**	**48,622**
Projected Demands	**17,989**	**24,059**	**29,521**	**35,006**	**38,669**	**39,128**
Surplus or (Shortage)	3,373	5,426	9,588	6,343	13,391	9,494

City of Midlothian

The City of Midlothian currently obtains water supplies from the Trinity aquifer and the Trinity River Authority (TRA) supply in Joe Pool Lake. The City of Midlothian supplies water to Mountain Peak WSC, Rockett SUD, Venus (in Region G), Alvarado (indirectly through Venus), Ellis County Manufacturing, and Ellis County Steam Electric Power. Midlothian will need to develop 2,200 acre-feet per year of additional supply by 2010 and 13,000 acre-feet per year of supply by 2060. The recommended water management strategies for Midlothian include implementing water conservation measures, purchasing additional water from Joe Pool Lake, constructing a transmission system in order to purchase water from the Tarrant Regional Water District (through the TRA), expanding the water treatment plant, and drilling supplemental wells. The City of Midlothian also plans to sell water to Grand Prairie. By 2020, Rockett SUD plans to purchase water directly from DWU and to stop purchasing water from Midlothian. A summary of the recommended water plan for Midlothian is shown on Table 4E.33. The capital costs for Midlothian are $10,763,000, which are associated with a treatment plant expansion and supplemental wells. Costs for the Ellis County Water Supply Project, including increased treatment capacity, are shown on Table 4E.12 for TRA.

Table 4E.33
Recommended Water Management Strategies for the City of Midlothian
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
Trinity aquifer	*36*	*36*	*36*	*36*	*36*	*36*
Joe Pool Lake (TRA)	*6,011*	*5,593*	*5,174*	*4,756*	*4,338*	*3,920*
Total Existing	***6,047***	***5,629***	***5,210***	***4,792***	***4,374***	***3,956***
Water Management Strategies						
Conservation	190	530	882	1,165	1,413	1,640
Additional water from Joe Pool Lake and TRA indirect reuse	632	621	423	350	303	260
Expanding Water Treatment Plant	0	0	0	0	0	0
Ellis County Water Supply Project (TRA/TRWD)	2,125	3,943	8,206	9,761	11,628	12,794
Supplemental Wells in Trinity aquifer	0	0	0	0	0	0
Total Supplies from Strategies	**2,947**	**5,094**	**9,511**	**11,276**	**13,344**	**14,694**
Total Supplies	**8,994**	**10,723**	**14,722**	**16,068**	**17,718**	**18,650**
Projected Demands	**8,251**	**9,984**	**13,009**	**14,635**	**16,104**	**16,819**
Surplus or (Shortage)	743	739	1,713	1,433	1,614	1,831

Mustang Special Utility District

Mustang Special Utility District (SUD) is currently supplied from the Trinity aquifer and surface water purchased from the Upper Trinity Regional Water District (UTRWD). The SUD sells water to Cross Roads, Krugerville, and Oak Point and plans to continue these water sales through the planning period. Mustang SUD has a projected shortage of 180 acre-feet per year in 2010 and 8,300 acre-feet per year in 2060. The UTRWD plans to continue providing water to Mustang SUD, and projects developed by UTRWD will be able to meet these shortages. The recommended water management strategies for Mustang SUD include implementing water conservation measures, drilling supplemental wells in the Trinity aquifer, and purchasing additional water from the UTRWD. A summary of the recommended water plan for Mustang SUD is shown on Table 4E.34. The capital costs for infrastructure projects total $3,393,200, and are for supplemental wells. Capital costs for projects developed by UTRWD are shown in the table for UTRWD.

Table 4E.34
Recommended Water Management Strategies for the Mustang SUD
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
Trinity aquifer	*331*	*331*	*331*	*331*	*331*	*331*
UTRWD Sources	*1,398*	*1,687*	*2,048*	*2,665*	*3,596*	*3,765*
Total Existing	***1,729***	***2,018***	***2,379***	***2,996***	***3,927***	***4,096***
Water Management Strategies						
Conservation	45	192	303	476	721	968
Additional Water from UTRWD	608	3,272	4,308	5,583	7,767	10,099
Supplemental Wells in Trinity aquifer	0	0	0	0	0	0
Total Supplies from Strategies	**653**	**3,464**	**4,611**	**6,059**	**8,488**	**11,067**
Total Supplies	**2,382**	**5,482**	**6,990**	**9,055**	**12,415**	**15,163**
Projected Demands	**1,909**	**3,543**	**5,123**	**7,316**	**10,097**	**12,387**
Surplus or (Shortage)	473	1,939	1,867	1,739	2,318	2,776

City of North Richland Hills

The current water supplies for the City of North Richland Hills include groundwater from the Trinity aquifer, water purchased from the City of Fort Worth (from the Tarrant Regional Water District), and water purchased from the Trinity River Authority (from the Tarrant Regional Water District). North Richland Hills sells water to Watauga and Tarrant County Manufacturing. The city plans to continue supplying water to these customers. North Richland Hills has projected shortages of 1,730 acre-feet per year beginning in 2010, increasing to over 11,000 acre-feet per year by 2060. The proposed water management strategies for North Richland Hills are implementing water conservation measures, drilling supplemental wells, purchasing additional water from Fort Worth (from the Tarrant Regional Water District), adding another pipeline to Fort Worth, and purchasing additional water from the Trinity River Authority (from Tarrant Regional Water District). A summary of the recommended water plan for North Richland Hills is shown on Table 4E.35. The capital costs for infrastructure projects total $3,673,520, including the city's share of the pipeline from Fort Worth and supplemental wells. Capital costs for projects to provide additional treated water from TRA and Fort Worth are discussed under those providers.

Table 4E.35
Recommended Water Management Strategies for the City of North Richland Hills
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
Trinity aquifer	*14*	*14*	*14*	*14*	*14*	*14*
TRWD (through Fort Worth and TRA)	*14,534*	*13,499*	*12,715*	*11,989*	*10,719*	*9,305*
Total Existing	***14,548***	***13,513***	***12,729***	***12,003***	***10,733***	***9,319***
Water Management Strategies						
Conservation	516	1,226	1,522	1,743	1,936	2,125
Additional Water from Fort Worth (TRWD)	1,624	3,152	5,721	5,237	8,354	8,166
Additional Water from TRA (TRWD)	1,056	2,106	3,888	3,598	5,763	5,641
Supplemental Wells in Trinity aquifer	0	0	0	0	0	0
Total Supplies from Strategies	**3,196**	**6,484**	**11,131**	**10,578**	**16,053**	**15,932**
Total Supplies	**17,744**	**19,997**	**23,860**	**22,581**	**26,786**	**25,252**
Projected Demands	**16,278**	**17,773**	**18,810**	**19,441**	**19,948**	**20,394**
Surplus or (Shortage)	1,466	2,224	5,050	3,139	6,838	4,858

Parker County Utility District #1

The Parker County Utility District #1 will obtain water supplies from the Tarrant Regional Water District (TRWD) through the City of Weatherford. Hudson Oaks is the Parker County Utility District's only current customer. Parker County Utility District #1 plans to provide water to Annetta, Annetta South, Willow Park, and Parker County-Other in the future. Parker County Utility District #1 also plans to increase the contract amount in order to sell additional water to Hudson Oaks. There currently is no infrastructure in place to deliver treated water to these customers. Parker County Utility District #1 will need to develop the infrastructure to deliver 2,500 acre-feet per year to east Parker County. The recommended water management strategies for the Utility District include water conservation, East Parker County Project, and additional water from TRWD through Weatherford. A summary of the recommended water plan for Parker County Utility District #1 is shown on Table 4E.36. The capital costs for East Parker County infrastructure projects total $6,129,000.

Table 4E.36
Recommended Water Management Strategies for the Parker County Utility District #1
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
Supplies through Weatherford	*102*	*102*	*102*	*102*	*102*	*102*
Total Existing	***102***	***102***	***102***	***102***	***102***	***102***
Water Management Strategies						
Conservation	6	177	178	191	205	222
Additional water from TRWD (Weatherford)	90	1,814	2,231	2,129	2,719	2,779
Total Supplies from Strategies	**96**	**1,991**	**2,409**	**2,320**	**2,924**	**3,001**
Total Supplies	**198**	**2,093**	**2,511**	**2,422**	**3,026**	**3,103**
Projected Demands	**155**	**1,641**	**1,866**	**2,048**	**2,265**	**2,541**
Surplus or (Shortage)	43	452	645	375	761	563

City of Rockwall

Rockwall's current water supply is water purchased from North Texas Municipal Water District (NTMWD). Rockwall sells water to Blackland WSC, Mt. Zion WSC, McLendon-Chisholm (indirectly), R-C-H WSC, Rockwall County-Other, and Rockwall County Manufacturing. The City of Rockwall plans to continue supplying water to its current customers. Rockwall has projected shortages of 3,000 to 17,000 acre-feet per year from 2010 to 2060. The recommended water management strategies for Rockwall are shown on Table 4E.37, and include implementing water conservation measures and purchasing additional water from the North Texas Municipal Water District. There are no capital costs to the City of Rockwall to implement these strategies.

Table 4E.37
Recommended Water Management Strategies for the City of Rockwall
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
NTMWD	*7,236*	*9,426*	*10,227*	*10,032*	*9,466*	*8,750*
Total Existing	***7,236***	***9,426***	***10,227***	***10,032***	***9,466***	***8,750***
Water Management Strategies						
Conservation	294	926	1,358	1,725	1,990	2,215
Additional water from NTMWD	5,231	11,615	15,566	14,512	21,147	20,990
Total Supplies from Strategies	**5,525**	**12,541**	**16,924**	**16,237**	**23,137**	**23,205**
Total Supplies	**12,761**	**21,967**	**27,151**	**26,269**	**32,603**	**31,955**
Projected Demands	**10,253**	**17,300**	**21,780**	**24,419**	**25,349**	**25,732**
Surplus or (Shortage)	2,508	4,667	5,371	1,850	7,254	6,223

Rockett Special Utility District

The current supplies for Rockett Special Utility District (SUD) include the Trinity aquifer and water purchased from Midlothian and Waxahachie. The SUD also has water supply contracts with DWU and TRA/TRWD. Rockett SUD plans to discontinue its current sources of supply after 2010 and purchase water from DWU and TRA. Rockett SUD currently provides water to Pecan Hill, Red Oak, and Ferris. Rockett SUD plans to sell water to Buena Vista-Bethel SUD, Mountain Peak WSC, Palmer, and Sardis-Lone Elm WSC. It does not intend to sell water to Red Oak after 2010. With only a small amount of groundwater supply, Rockett SUD will need to develop 14,000 acre-feet per year of supply by 2060. The recommended water management strategies for Rockett SUD include implementing water conservation measures, purchasing water from DWU, purchasing water from TRA through the Ellis County Water Supply Project, and drilling supplemental wells. A summary of the recommended water plan for Rockett SUD is shown on Table 4E.38. The capital cost for the infrastructure projects total $17,006,000, including costs for the DWU connection and supplemental wells. Capital costs for the Ellis County Water Supply Project are shown in Table 4E.12 for TRA.

Table 4E.38
Recommended Water Management Strategies for the Rockett SUD
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
Midlothian	*1,590*	*0*	*0*	*0*	*0*	*0*
Waxahachie	*1,085*	*0*	*0*	*0*	*0*	*0*
Trinity aquifer	*71*	*71*	*71*	*71*	*71*	*71*
Total Existing	***2,746***	***71***	***71***	***71***	***71***	***71***
Water Management Strategies						
Conservation	274	791	911	1,099	1,375	1,733
Contract with DWU	3,306	7,022	6,455	7,672	9,269	11,297
Ellis County Water Supply Project	0	1,487	1,825	1,850	2,298	2,434
Supplemental Wells	0	0	0	0	0	0
Total Supplies from Strategies	**3,580**	**9,300**	**9,191**	**10,621**	**12,942**	**15,464**
Total Supplies	**6,325**	**9,371**	**9,262**	**10,692**	**13,013**	**15,535**
Projected Demands	**5,913**	**7,379**	**7,865**	**9,243**	**11,059**	**13,363**
Surplus or (Shortage)	412	1,992	1,397	1,449	1,954	2,173

City of Seagoville

The City of Seagoville currently obtains its water supply from Dallas Water Utilities (DWU). Seagoville provides water to Combine WSC, and indirectly to the City of Combine. Over the planning period, the sales to Combine WSC and the City of Combine are expected to exceed 1,000 acre-feet per year. Seagoville and DWU are planning to continue to serve these customers through supplies developed by DWU. A summary of the recommended plan is shown in Table 4E.39. There is no capital cost associated with Seagoville's recommended plan.

City of Terrell

The current supplies for the City of Terrell include Lake Terrell and water purchased from the Sabine River Authority. These supplies are currently limited by the capacity of the pipeline from Lake Terrell to the water treatment plant. Terrell has a contract to purchase water from NTMWD, but there is no infrastructure in place. The city's long-term plans are to purchase treated water from NTMWD and reduce dependence on its raw water sources. The City of Terrell currently sells water to College Mound, High Point WSC, Hunt County-Other, Kaufman

County-Other, and Kaufman Manufacturing. Terrell plans to continue supplying these customers with water during the planning period, and will need to develop 3,300 acre-feet per year of additional supply by 2060. The recommended water management strategies for Terrell include implementing water conservation measures and purchasing treated water from NTMWD. Table 4E.40 shows the recommended plan for Terrell. The total capital costs for the connection to NTMWD are estimated at $6,301,000.

Table 4E.39
Recommended Water Management Strategies for the City of Seagoville
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
DWU Sources	*2,359*	*2,495*	*2,585*	*2,649*	*2,601*	*2,518*
Total Existing	***2,359***	***2,495***	***2,585***	***2,649***	***2,601***	***2,518***
Water Management Strategies						
Conservation	43	152	189	231	278	335
Additional DWU water	823	1,731	2,312	3,090	3,762	3,725
Total Supplies from Strategies	**866**	**1,883**	**2,501**	**3,321**	**4,040**	**4,060**
Total Supplies	**3,225**	**4,378**	**5,087**	**5,971**	**6,642**	**6,578**
Projected Demands	**3,209**	**3,795**	**4,297**	**4,817**	**5,381**	**6,050**
Surplus or (Shortage)	16	583	790	1,154	1,261	528

Table 4E.40
Recommended Water Management Strategies for the City of Terrell
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
Lake Tawakoni	*9,718*	*9,646*	*9,573*	*9,501*	*9,428*	*9,356*
Lake Terrell	*2,200*	*2,200*	*2,200*	*2,200*	*2,200*	*2,200*
Total Existing (limited by Pipeline Capacity)	***5,125***	***5,125***	***5,125***	***5,125***	***5,125***	***5,125***
Water Management Strategies						
Conservation	140	330	477	590	684	807
Purchase NTMWD Water	5,710	6,589	7,034	6,012	8,195	8,620
Total Supplies from Strategies	**5,850**	**6,919**	**7,511**	**6,602**	**8,879**	**9,427**
Total Supplies	**10,975**	**12,044**	**12,636**	**11,727**	**14,003**	**14,552**
Projected Demands	**5,279**	**6,030**	**6,685**	**7,126**	**7,620**	**8,388**
Surplus or (Shortage)	5,696	6,014	5,951	4,601	6,383	6,164

Walnut Creek Special Utility District (SUD)

Walnut Creek Special Utility District (SUD) purchases raw water from TRWD and provides treated water to entities in Parker and Wise Counties. Its current customers include Boyd, Rhome, West Wise WSC, Reno, Aurora (indirectly through Rhome) and smaller entities that fall under Parker County-Other and Wise County-Other. Walnut Creek SUD plans to provide treated water to Newark and New Fairfield through Rhome by 2010. The supplies to these customers are currently limited by the capacity of the water treatment plant (2,800 acre-feet per year). To meet the projected demands Walnut Creek SUD will need to develop 600 acre-feet per year of new treatment capacity before 2010, and 6,800 acre-feet per year of treated water supplies by 2060. The recommended water management strategies for Walnut Creek SUD include implementing water conservation measures, expanding their current water treatment facilities, constructing new treatment facilities, building a second pipeline to Boyd and Rhome, and purchasing additional water from TRWD. Table 4E.41 shows the recommended plan for Walnut Creek SUD. Table 4E.42 shows the capital and unit costs for the infrastructure strategies. The total capital costs for Walnut Creek SUD are estimated at $59,145,000.

Waxahachie

The City of Waxahachie obtains its current water supply from Lake Waxahachie, a contract with the Trinity River Authority (TRA) for water, and indirect reuse from Bardwell Lake. These supplies total over 11,000 acre-feet per year, but are limited to 8,400 acre-feet per year by water treatment capacity. Waxahachie currently serves its retail customers, Rockett SUD, Nash-Forreston WSC (Ellis County-Other) and manufacturing in Ellis County. After 2010, the city is expected to provide to its retail and manufacturing customers. Waxahachie will need to develop additional treatment capacity to utilize its existing sources and develop 13,000 acre-feet of new supplies by 2060. The recommended strategies to meet these needs include:

- Conservation
- Additional water from TRA/Waxahachie indirect reuse
- Purchase water from Dallas
- Participate in the Ellis County Water Supply Project.

These strategies are discussed individually below.

Table 4E.41
Recommended Water Management Strategies for Walnut Creek SUD
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
TRWD Sources	*3,500*	*3,935*	*4,075*	*4,071*	*3,945*	*3,836*
Total Currently Available Supplies[1]	***3,500***	***3,935***	***4,075***	***4,071***	***3,945***	***3,836***
WTP Capacity = 5 mgd	***2,800***	***2,800***	***2,800***	***2,800***	***2,800***	***2,800***
Water Management Strategies						
Conservation - Basic Package	71	264	363	473	598	758
WTP Expansion of 2 mgd	1,121	1,121	1,121	1,121	1,121	1,121
WTP Expansion of 2 mgd		1,121	1,121	1,121	1,121	1,121
Second Pipeline to Boyd/Rhome			0	0	0	0
WTP Expansion of 3 mgd			1,682	1,682	1,682	1,682
New WTP (2 mgd) & parallel raw water line from TRWD				1,121	1,121	1,121
Expand new WTP by 2 mgd					1,121	1,121
Expand new WTP by 2 mgd						1,121
Total Supplies from Strategies	**1,192**	**2,506**	**4,287**	**5,518**	**6,764**	**8,045**
Total Supplies	**3,992**	**5,306**	**7,087**	**8,318**	**9,564**	**10,845**
Projected Demands	**3,401**	**4,805**	**5,941**	**7,027**	**8,178**	**9,571**
Surplus or (Shortage)	591	501	1,146	1,291	1,386	1,274

Table 4E.42
Summary of Costs for Walnut Creek SUD's Recommended Water Management Strategies

Strategy	Develop Dates	2060 Quantity (Ac-Ft/Yr)	Capital Cost	Unit Cost ($/kGal.)	
				Pre-Amort.	Post-Amort.
WTP Expansion of 2 mgd (7 mgd total)	2010	1,121	$5,011,000	$1.35	$0.35
WTP Expansion of 2 mgd (9 mgd total)	2020	1,121	$5,011,000	$1.35	$0.35
Second Pipeline to Boyd/Rhome (7 mgd)	2020	0	$16,447,000	N/A	N/A
WTP Expansion of 3 mgd (12 mgd total)	2030	1,682	$7,200,000	$1.31	$0.35
New WTP (2 mgd)	2040	1,121	$7,976,000	$1.94	$0.35
Parallel raw water line from TRWD	2040	0	$7,478,000	N/A	N/A
Expand new WTP by 2 mgd (4 mgd total)	2059	1,121	$5,011,000	$1.35	$0.35
Expand new WTP by 2 mgd (6 mgd total)	2060	1,121	$5,011,000	$1.35	$0.35
TOTAL CAPITAL COSTS			**$59,145,000**		

Conservation. Conservation is the projected conservation savings for Waxahachie and its customers, based on the recommended Region C water conservation program. Not including savings from low-flow plumbing fixtures (which amount to about 5 percent of demand and are built into demand projections) and not including reuse, conservation by Waxahachie and its customers is projected to reach 2,598 acre-feet by 2060.

Additional Water from TRA/Waxahachie Indirect Reuse. By 2010, Waxahachie will begin using additional indirect reuse from Bardwell Lake, making full use of its existing water supply sources and water rights. This will require a 12 mgd expansion to the city's water treatment plant capacity and a 20-inch diameter pipeline from Lake Waxahachie to the city's water treatment plant. Due to sedimentation in Lake Waxahachie and Bardwell Lake, the additional supply from this strategy will decline over time from approximately 3,112 acre-feet per year in 2010 to approximately 1,846 acre-feet per year in 2060.

Purchase Water from Dallas Water Utilities. By 2010, Waxahachie would purchase water from Dallas Water Utilities. This project would require a water transmission system that would be shared with Rockett SUD and Red Oak. This project is currently in the early design stage.

Participate in Ellis County Water Supply Project. By 2020, Waxahachie would purchase water from the Trinity River Authority's Ellis County Water Supply Project. The Ellis County Water Supply Project would require a new transmission system and a new or expanded water treatment plant. The city may be the water treatment provider for part of the Ellis County Water Supply Project. The city has a contract with the Trinity River Authority for 5,212 acre-feet per year.

Table 4E.43 shows the recommended water management strategies for the City of Waxahachie. Approximately 38 percent of the projected 2060 supply will be from conservation and reuse. Table 4E.44 gives information on the capital and unit costs for the recommended water management strategies. Capital costs for the Ellis County Water Supply Project are shown on Table 4E.12 with the costs for Trinity River Authority. The total capital cost for Waxahachie is approximately $28 million, based on 2002 construction costs.

Table 4E.43
Recommended Water Management Strategies for the City of Waxahachie
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
Lake Waxahachie	*2,667*	*2,573*	*2,480*	*2,387*	*2,293*	*2,200*
Bardwell Lake	*3,855*	*3,669*	*3,483*	*3,297*	*3,111*	*2,925*
TRA/Waxahachie Indirect Reuse	*1,886*	*2,166*	*2,445*	*2,724*	*3,004*	*3,283*
Total Currently Available Supplies	***8,408***	***8,408***	***8,408***	***8,408***	***8,408***	***8,408***
Water Management Strategies						
Water Conservation	232	606	958	1,375	1,891	2,598
Additional TRA/Waxahachie Indirect Reuse	3,112	2,963	2,684	2,405	2,125	1,846
Purchase water from Dallas	1,121	1,611	3,838	6,726	6,726	6,727
Ellis County Water Supply Project		511	511	512	2,392	5,212
Total Supplies from Strategies	**4,465**	**5,691**	**7,991**	**11,018**	**13,134**	**16,383**
Total Supplies	**12,873**	**14,099**	**16,399**	**19,426**	**21,542**	**24,791**
Projected Demands	**8,688**	**9,179**	**11,405**	**14,206**	**17,817**	**22,436**
Surplus or (Shortage)	4,185	4,921	4,994	5,220	3,725	2,355

Table 4E.44
Summary of Costs for Waxahachie's Recommended Water Management Strategies

Strategy	Develop Dates	2060 Quantity	Capital Cost	Unit Cost ($/kGal.)	
				Pre-Amort.	Post-Amort.
Additional TRA/Waxahachie Indirect Reuse	2010	1,846	$19,385,000	$1.82	$0.39
Purchase water from Dallas	2010	6,726	$8,652,000	$1.47	$0.93
TOTAL CAPITAL COSTS			**$28,037,000**		

City of Weatherford

The City of Weatherford provides municipal and manufacturing water to users in Parker County. Weatherford also provides a small amount of water from Lake Weatherford for steam electric power. Weatherford's water supply consists of water the city has rights to use out of Lake Weatherford and Benbrook Lake and raw water the city purchases from Tarrant Regional Water District. Weatherford also has some groundwater supplies from the Trinity aquifer that it uses on a temporary basis until new subdivisions can be connected to the city's distribution system. The currently available supplies for Weatherford are limited to 4,550 acre-feet per year because of treatment plant capacity. To fully utilize its existing water rights and contracts, Weatherford will need to expand its water treatment plant capacity by 2010 and expand the pumping capacity of the pipeline from Benbrook Lake. The city also plans to initiate an indirect reuse project to Lake Weatherford for steam electric power use. The recommended water management strategies for Weatherford include implementing water conservation measures, increasing treatment capacity, increasing transmission pump capacity from Benbrook Lake, installing supplemental wells, indirect reuse to Lake Weatherford and purchasing additional water from the TRWD. Table 4E.45 shows the recommended plan for Weatherford. The total capital costs for the treatment and transmission expansions are estimated at $39 million.

West Cedar Creek Municipal Utility District

West Cedar Creek Municipal Utility District's (MUD) water supply is water purchased from the Tarrant Regional Water District (TRWD). West Cedar Creek MUD currently provides water to Seven Points and Tool and plans to continue selling water to these entities in the future. The current supplies to West Cedar Creek MUD are limited by contract, resulting in projected water shortages of 1,000 acre-feet per year in 2010 and increasing to 6,900 acre-feet per year by 2060. The recommended water management strategies include implementing water conservation measures, purchasing additional water from the TRWD, and expanding the water treatment capacity. Table 4E.46 shows the recommended water management strategies for the West Cedar Creek MUD. The total capital costs for expanding the water treatment plant is $19,764,000. Capital costs associated with developing new supplies by TRWD are shown in Table 4E.5 for TRWD.

Table 4E.45
Recommended Water Management Strategies for the City of Weatherford
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
Lake Weatherford	*2,750*	*2,600*	*2,450*	*2,300*	*2,150*	*2,000*
Benbrook Lake and Tarrant Regional Water District (Limited by WTP)	*1,802*	*1,937*	*2,082*	*2,228*	*2,377*	*2,531*
Trinity aquifer	*50*	*50*	*50*	*50*	*50*	*50*
Total Currently Available Supplies	***4,552***	***4,537***	***4,532***	***4,528***	***4,527***	***4,531***
Water Management Strategies						
Conservation - Basic & Expanded Packages	171	749	989	1,206	1,416	1,666
Supplemental Well in Trinity aquifer	0	0	0	0	0	0
WTP Expansion of 4 mgd	2,242	2,242	2,242	2,242	2,242	2,242
WTP Expansion of 6 mgd		3,363	3,363	3,363	3,363	3,363
Add 7 mgd to Existing Pump Station Capacity & Build New WTP for 8 mgd			4,484	4,484	4,484	4,484
Indirect Reuse to Lake Weatherford		5,000	5,000	5,000	5,000	5,000
Total Supplies from Strategies	**2,413**	**11,354**	**16,078**	**16,295**	**16,505**	**16,755**
Total Supplies	**6,965**	**15,891**	**20,610**	**20,823**	**21,032**	**21,286**
Projected Demands	**6,039**	**13,878**	**15,333**	**16,532**	**17,820**	**19,353**
Surplus or (Shortage)	926	2,013	5,277	4,292	3,212	1,934

Table 4E.46
Recommended Water Management Strategies for the West Cedar Creek MUD
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
TRWD Sources	*1,714*	*1,714*	*1,714*	*1,714*	*1,714*	*1,714*
Total Existing	***1,714***	***1,714***	***1,714***	***1,714***	***1,714***	***1,714***
Water Management Strategies						
Conservation	49	198	261	332	424	543
Additional water from TRWD	1,709	2,907	4,489	4,699	7,098	8,003
Expanding Water Treatment Plant	0	0	0	0	0	0
Total Supplies from Strategies	**1,758**	**3,105**	**4,750**	**5,031**	**7,522**	**8,546**
Total Supplies	**3,472**	**4,819**	**6,464**	**6,745**	**9,236**	**10,260**
Projected Demands	**2,763**	**3,957**	**4,961**	**5,886**	**7,074**	**8,570**
Surplus or (Shortage)	709	862	1,503	859	2,162	1,690

Wise County Water Supply District

The current water supply for Wise County Water Supply District (WSD) is water purchased from the Tarrant Regional Water District (TRWD). Wise County WSD supplies water to Decatur and Wise County Manufacturing and plans to continue doing so. Wise County WSD is projected to have a small water shortage in 2020, increasing to 3,000 acre-feet per year by 2060. The recommended strategies for Wise County WSD include implementing water conservation measures, purchasing additional water from TRWD, and expanding the water treatment capacity. Table 4E.47 shows the recommended plan for water supply development for the Wise County WSD. The total capital costs for expanding the water treatment plant is $23,009,000. Capital costs associated with developing new supplies by TRWD are shown in Table 4E.6 for TRWD.

Table 4E.47
Recommended Water Management Strategies for the Wise County WSD
- Values in Acre-Feet per Year -

Source	2010	2020	2030	2040	2050	2060
Currently Available Supplies						
Tarrant Regional Water District	*1,834*	*1,822*	*2,097*	*2,307*	*2,519*	*2,511*
Total Existing	***1,834***	***1,822***	***2,097***	***2,307***	***2,519***	***2,511***
Water Management Strategies						
Conservation	48	112	198	295	419	540
Additional Water from TRWD	281	619	1,450	1,654	3,319	3,727
Expanding Water Treatment Plant	0	0	0	0	0	0
Total Supplies from Strategies	**329**	**731**	**1,648**	**1,949**	**3,738**	**4,267**
Total Supplies	**2,163**	**2,554**	**3,745**	**4,256**	**6,257**	**6,778**
Projected Demands	**1,708**	**2,091**	**2,837**	**3,635**	**4,686**	**5,501**
Surplus or (Shortage)	455	463	907	620	1,570	1,277

SECTION 4E
LIST OF REFERENCES

(1) Chiang, Patel and Yerby, Inc.: *Draft 2005 Update to the City of Dallas Long Range Water Supply Plan*, Dallas, February 2005, and related presentations to the City Council and Council Committees.

(2) City of Dallas: Letter from Acting City Manager Mary Suhm to Region C Chair Jim Parks, Dallas, March 17, 2005.

(3) Alan Plummer Associates, Inc.: *City of Dallas 5-Year Strategic Plan for Water Conservation*, Dallas, April 2005.

(4) Freese and Nichols, Inc., Alan Plummer Associates, Inc., Chiang, Patel & Yerby, Inc., and Cooksey Communications, Inc.: *Region C Water Plan*, prepared for the Region C Water Planning Group, Fort Worth, January 2001.

(5) Alan Plummer Associates, Inc.: *Draft Recycled Water Implementation Plan*, Dallas, August 2004.

(6) Espey Consultants, Inc., Brown and Root, Inc., Freese and Nichols, Inc. GSG, Inc., Crespo Consulting Services, Inc., *Final – Water Availability Models for the Trinity, Trinity-San Jacinto, and Neches Trinity Basins*, prepared for the Texas Water Development Board, Austin, March 2002.

(7) U.S. Army Corps of Engineers, Tulsa District, *Draft Environmental Assessment, Lake Texoma Storage Reallocation Study, Lake Texoma, Oklahoma and Texas*, Tulsa, January 2005.

(8) Schaumburg & Polk, Inc., *Initially Prepared East Texas Region Plan*, prepared for the East Texas Regional Water Planning Group, May 2005.

4F. Recommended Water Management Strategies for Water User Groups by County

Appendix V includes a summary by water user group of the projected demands, current water supplies, and recommended water management strategies to provide additional supplies. Summaries for wholesale water providers are discussed in Section 4E. The recommended strategies for each water user group in Region C are summarized by county below. Water user groups that are located in multiple counties are listed in each county.

4F.1 Collin County

Table 4F.1 presents a summary of the projected need for additional supplies, the current sources, and the sources of additional supply for each water user group in Collin County. The North Texas Municipal Water District (NTMWD) supplies most of the water used in Collin County and will continue to do so in the future. Water user groups that currently get water from NTMWD will purchase additional water from NTMWD to meet future demands. Section 4E discusses the details of the current and future supplies for NTMWD.

The Greater Texoma Utility Authority (GTUA) would sponsor the Collin-Grayson Municipal Alliance Pipeline project, which will supply NTMWD water to water user groups in Collin and Grayson Counties. Table 4F.2 lists the participants in the project and the amount of water each would receive. The project would be developed in two phases, the first connecting customers to McKinney and reimbursing McKinney for their pumping facilities. The second phase would increase system capacity. The opinion of probable capital cost for the Collin-Grayson Municipal Alliance Pipeline Project is approximately $51.5 million.

Water user groups that will obtain additional water from sources other than NTMWD include the following:

- The small portion of Dallas located in Collin County will continue to be supplied by Dallas Water Utilities.
- Gunter Rural WSC will continue using water from the Trinity aquifer and will be supplied by the Greater Texoma Utility Authority's Grayson County Water Supply Project.
- Hickory Creek SUD is primarily located in Region D. Hickory Creek SUD will continue to use groundwater from the Woodbine aquifer in Hunt County (Region D).

- Prosper will be supplied by the North Texas Municipal Water District and the Upper Trinity Regional Water District.

Table 4F.3 shows the estimated capital costs for Collin County water management strategies not covered under the wholesale water providers. While conducting the infrastructure financing survey, Region C discovered that Danville WSC is planning to dissolve within the next four years. Their current service area will likely be absorbed by Celina, McKinney, and Prosper.

Table 4F.1
Recommended Water Management Strategies for Collin County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Sources	Recommended Water Management Strategies
Allen	24,029	NTMWD	Water conservation Additional NTMWD water
Anna	10,261	Trinity aquifer Woodbine aquifer	Water conservation New wells in both aquifers Overdraft both aquifers in 2010 Supplemental wells in both aquifers Collin-Grayson Municipal Alliance Project (GTUA/NTMWD)
Blue Ridge	2,663	Woodbine aquifer	Water conservation New well in 2010 Overdraft Woodbine aquifer in 2010 Supplemental wells Purchase NTMWD water
Caddo Basin SUD	1,019	NTMWD	Water conservation Additional NTMWD water
Celina	27,724	Trinity aquifer Woodbine aquifer UTRWD	Water conservation Supplemental wells Additional UTRWD water Purchase GTUA water (Grayson County Water Supply Project) Purchase NTMWD water
Culleoka WSC	1,657	Princeton (NTMWD)	Water conservation Additional Princeton (NTMWD) water
Dallas	12,150	See Table 4E.1 in Section 4E.	Water conservation See DWU wholesale water provider information in Section 4E.
Danville WSC	1,525	McKinney (NTMWD)	Water conservation Additional McKinney (NTMWD) water
East Fork SUD	842	NTMWD	Water conservation Additional NTMWD water

Table 4F.1, Continued

Water User Group	Maximum Needs	Current Sources	Recommended Water Management Strategies
Fairview	8,479	NTMWD	Water conservation Additional NTMWD water
Farmersville	2,845	NTMWD	Water conservation Additional NTMWD water
Frisco	40,263	Trinity aquifer NTMWD	Water conservation Supplemental wells in Trinity aquifer Additional NTMWD water
Garland	0	NTMWD	See Table 4F.__
Gunter Rural WSC	936	Trinity aquifer	Water conservation New wells Supplemental wells Overdraft Trinity aquifer in 2010 Purchase GTUA water (Grayson County Water Supply Project)
Hickory Creek SUD	10	Woodbine aquifer (Hunt County)	Water conservation Region D groundwater in Hunt County (Woodbine aquifer)
Josephine	177	NTMWD	Water conservation Additional NTMWD water (including Hunt County portion)
Lavon WSC	2,378	NTMWD	Water conservation Additional NTMWD water
Lowry Crossing	1,535	Milligan WSC (NTMWD)	Water conservation Additional Milligan WSC (NTMWD) water
Lucas	3,001	NTMWD	Water conservation Additional NTMWD water
McKinney	71,716	NTMWD	Water conservation Additional NTMWD water
Melissa	7,041	Woodbine aquifer NTMWD	Water conservation Supplemental wells Collin-Grayson Municipal Alliance Project (GTUA/NTMWD)
Milligan WSC	121	NTMWD	Water conservation Additional NTMWD water
Murphy	3,800	NTMWD	Water conservation Additional NTMWD water
Nevada	3,456	NTMWD	Water conservation Additional NTMWD water
New Hope	2,082	North Collin WSC (NTMWD)	Water conservation Additional North Collin WSC (NTMWD) water

Table 4F.1, Continued

Water User Group	Maximum Needs	Current Sources	Recommended Water Management Strategies
North Collin WSC	1,326	NTMWD	Water conservation Additional NTMWD water
Parker	12,790	NTMWD	Water conservation Additional NTMWD water
Plano	54,817	NTMWD	Water conservation Additional NTMWD water
Princeton	7,612	NTMWD	Water conservation Additional NTMWD water
Prosper	9,373	Woodbine aquifer Frisco (NTMWD)	Water conservation Supplemental wells Purchase NTMWD water Purchase UTRWD water
Richardson	6,851	NTMWD	Water conservation Additional NTMWD water
Royse City	2,493	NTMWD	Water conservation Additional NTMWD water
Sachse	972	NTMWD	Water conservation Additional NTMWD water
Saint Paul	1,222	NTMWD	Water conservation Additional NTMWD water
South Grayson WSC	44	Trinity aquifer Woodbine aquifer	Water conservation Supplemental wells Collin-Grayson Municipal Alliance Project (GTUA/NTMWD) Purchase NTMWD water Purchase GTUA water (Grayson County Water Supply Project)
Weston	12,638	Woodbine aquifer	Water conservation Supplemental wells Overdraft Woodbine aquifer in 2010 Collin-Grayson Municipal Alliance Project (GTUA/NTMWD)
Wylie	13,537	NTMWD	Water conservation Additional NTMWD water
County-Other	0	Trinity aquifer Woodbine aquifer NTMWD	Water conservation Supplemental wells
Irrigation	360	Irrigation local supply	Purchase NTMWD water
Livestock	0	Livestock local supply	None

Table 4F.1, Continued

Water User Group	Maximum Needs	Current Sources	Recommended Water Management Strategies
Manufacturing	3,903	Woodbine aquifer NTMWD	Water conservation Supplemental wells Additional NTMWD water
Mining	146	Mining local supply	Purchase NTMWD raw water
Steam Electric Power	1,467	Woodbine aquifer NTMWD	Supplemental wells Additional NTMWD water

Table 4F.2
Projected Supply from Collin-Grayson Municipal Alliance Pipeline Project

Water User Group	Projected Supply (acre-feet per year)					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Anna	1,238	2,862	4,295	4,959	7,984	11,992
Howe	222	716	1,117	1,195	1,612	1,721
Melissa	1,130	2,831	3,919	4,023	7,086	8,683
South Grayson WSC	61	122	118	101	120	115
Van Alstyne	603	2,387	3,393	3,386	3,743	3,835
Weston	227	754	1,702	4,222	8,908	14,633
Total	**3,481**	**9,672**	**14,544**	**17,886**	**29,453**	**40,979**

Table 4F.3
Capital Costs for Recommended Water Management Strategies for Collin County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
Water Conservation	$111,255
New groundwater wells	$1,940,000
Reuse	$824,000
Supplemental Wells	$17,195,536
Transmission Costs	$20,323,000
Total	**$40,393,791**

4F.2 Cooke County

The Trinity aquifer provides almost all of the current water supply used in Cooke County. However, the current use from the aquifer is significantly greater than the estimated long-term reliable supply. Table 4F.4 presents a summary of water management strategies to meet demands in Cooke County, which include the following:

- Construction of Muenster Lake and associated transmission and treatment facilities by the City of Muenster
- Development of the Cooke County Water Supply Project consisting of a raw water pipeline from Moss Lake, a treatment plant, and treated water pipelines to deliver water to users throughout the county
- Supplies purchased from Gainesville
- Supplies purchased from the Upper Trinity Regional Water District.

Table 4F.5 shows the estimated capital costs for the recommended water management strategies for Cooke County not covered under wholesale water providers. Based on the Northern Trinity-Woodbine Groundwater Availability Model (GAM) [(1)], the amount of groundwater supply available in Cooke County is less than what was assumed to be available in the 2001 *Region C Water Plan* [(2)].

By 2020, due to limited groundwater availability in Cooke County, Gainesville would develop the Cooke County Water Supply Project. This project would provide treated surface water from Moss Lake to Gainesville and Cooke County customers (Table 4F.6). It is discussed in Section 4E of this report under the City of Gainesville. The estimated capital cost for the Cooke County Water Supply Project is $35.5 million.

It should be noted that under current law, groundwater users cannot be forced to reduce pumping from the Trinity aquifer in Cooke County. However, if the projected available supply from the Trinity aquifer is correct, users will find it necessary to find other supplies. The formation of a groundwater management district for Cooke County might be considered as a way to control use of this limited resource.

Table 4F.4
Recommended Water Management Strategies for Cooke County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Bolivar WSC	113	Trinity aquifer	Water conservation Use additional water from the Trinity aquifer with existing wells Purchase water from Gainesville Purchase water from the Upper Trinity Regional Water District Temporarily overdraft the Trinity aquifer with existing wells Supplemental wells
Gainesville	3,350	Trinity aquifer Moss Lake	See Tables 4E.27 and 4E.28 in Section 4E.
Kiowa Homeowners WSC	0	Trinity aquifer	Water conservation Purchase water from Gainesville Supplemental wells
Lindsay	34	Trinity aquifer	Water conservation Purchase water from Gainesville Temporarily use additional water from the Trinity aquifer with existing wells Temporarily overdraft the Trinity aquifer with existing wells Supplemental wells
Muenster	320	Trinity aquifer	Water conservation Negotiate water right subordination agreement with Dallas or Denton Construct Muenster Lake and water treatment facilities Supplemental wells
Two Way SUD	0	Trinity aquifer (Grayson Co.)	See Grayson County
Valley View	1,636	Purchase water from Bolivar WSC	Water conservation Purchase water distribution system from Bolivar WSC Purchase water from Gainesville Purchase water from Bolivar WSC Supplemental wells.

Table 4F.4, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Woodbine WSC	387	Trinity aquifer	Water conservation Purchase water from Gainesville Temporarily use additional water from the Trinity aquifer with existing wells Temporarily overdraft the Trinity aquifer with existing wells Supplemental wells
County-Other	476	Trinity aquifer	Water conservation Use additional water from the Trinity aquifer with new wells Purchase water from Gainesville Temporarily overdrafting the Trinity aquifer with new wells Supplemental wells
Irrigation	140	Trinity aquifer Irrigation Local Supply Gainesville Direct Reuse	Water conservation Use additional water from the Trinity aquifer with new wells Purchase water from Gainesville Temporarily overdraft the Trinity aquifer with new wells Supplemental wells
Livestock	0	Trinity aquifer Livestock Local Supply	Supplemental wells
Manufacturing	212	Trinity aquifer	Water conservation Purchase water from Gainesville Purchase water from Muenster Supplemental wells
Mining	75	Trinity aquifer Other Local Supply	Use water from the Other aquifer Use additional water from the Trinity aquifer with new wells Temporarily overdraft the Trinity aquifer with new wells Supplemental wells
Steam Electric Power	0	None	None

Table 4F.5
Capital Costs for Recommended Water Management Strategies for Cooke County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
New groundwater wells	$2,219,000
Muenster Lake and Associated Facilities	$11,189,000
Distribution System	$825,000
Supplemental Wells	$33,243,702
Total	**$47,476,702**

Table 4F.6
Projected Supply from Cooke County Water Supply Project

Water User Group	Projected Supply (acre-feet per year)					
	2010	2020	2030	2040	2050	2060
Bolivar WSC	0	118	228	1,028	1,028	1,028
Cooke County-Irrigation	0	51	51	51	51	51
Cooke County-Other	0	132	144	137	131	131
Gainesville	0	242	1,100	1,540	1,705	1,569
Kiowa Homeowners WSC	0	182	205	194	184	184
Lindsay	0	52	57	53	50	50
Valley View	0	71	129	182	323	400
Woodbine WSC	0	240	283	316	368	427
Reserve Supply		1,113	5	337	0	0
TOTAL SUPPLY		2,202	2,202	3,840	3,840	3,840

4F.3 Dallas County

Table 4F.7 presents a summary of the anticipated shortages in the planning period, the current supplies, and the sources of additional supply for each water user group in Dallas County. Most of Dallas County's current demands are met by Dallas Water Utilities (DWU), with North Texas Municipal Water District (NTMWD) also providing major supplies. They will continue to be the largest water providers in the county in the future. Along with additional supplies from DWU and NTMWD, other management strategies for Dallas County include the following:

- Connection of Rockett SUD to Dallas Water Utilities

- Irving, DWU, and NTMWD supply water for manufacturing purposes
- DWU and TRA reuse for steam electric power.

Table 4F.8 shows the estimated capital costs for the Dallas County water management strategies not associated with the wholesale water providers.

Table 4F.7
Recommended Water Management Strategies for Dallas County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Addison	7,130	DWU	Water conservation Additional DWU water May develop ASR May develop groundwater in the Woodbine aquifer
Balch Springs	2,034	Dallas County WCID #6 (DWU)	Water conservation Additional Dallas County WCID #6 (DWU) water
Carrollton	6,380	Trinity aquifer DWU	Water conservation Supplemental wells in Trinity aquifer Additional DWU water Additional pipeline to DWU
Cedar Hill	8,834	Trinity aquifer Woodbine aquifer DWU Joe Pool Lake	Water conservation Supplemental wells in both aquifers Additional DWU water
Cockrell Hill	390	DWU	Water conservation Additional DWU water
Combine	110	Combine WSC (Seagoville from DWU)	Water conservation Additional Combine WSC (Seagoville from DWU) water
Combine WSC	218	Seagoville (DWU)	Water conservation Additional Seagoville (DWU) water Additional pipeline to Seagoville
Coppell	5,701	DWU	Water conservation Additional DWU water
Dallas	341,777	See DWU wholesale water provider information in Section 4E	See DWU wholesale water provider in Section 4E
Dallas County WCID #6	790	DWU	Water conservation Additional DWU water

Table 4F.7, Continued

Water User Group	Maximum Needs	Current Sources	Recommended Water Management Strategies
DeSoto	10,983	Trinity aquifer DWU	Water conservation Supplemental wells in Trinity aquifer Additional DWU water
Duncanville	5,017	DWU Joe Pool Lake (TRA)	Water conservation Additional DWU water
East Fork SUD	87	NTMWD	Water conservation Additional NTMWD water
Farmers Branch	8,722	DWU	Water conservation Additional DWU water
Garland	34,451	NTMWD	Water conservation Additional NTMWD water
Glenn Heights	847	Trinity aquifer DWU	Water conservation Supplemental wells in Trinity aquifer Additional DWU water
Grand Prairie	29,191	Trinity aquifer DWU Fort Worth (Tarrant County portion only)	Water conservation Supplemental wells in Trinity aquifer Additional DWU water Purchase Mansfield water Purchase Midlothian water
Highland Park	0	Dallas County Park Cities MUD	Water conservation
Hutchins	4,668	DWU	Water conservation Additional DWU water
Irving	26,395	Lake Chapman DWU	Water conservation Additional DWU water Indirect reuse Marvin Nichols Reservoir (alternative) Wright Patman Lake (alternative) Oklahoma water (alternative)
Lancaster	12,005	Trinity aquifer DWU	Water conservation Supplemental wells in Trinity aquifer Additional DWU water
Lewisville	0	DWU	Water conservation Additional DWU water Additional pipeline to DWU Water treatment plant expansions
Mesquite	28,222	NTMWD	Water conservation Additional NTMWD water

Table 4F.7, Continued

Water User Group	Maximum Needs	Current Sources	Recommended Water Management Strategies
Ovilla	283	Cedar Hill (DWU)	Water conservation Additional Cedar Hill (DWU) water Purchase DWU water directly Pipeline to DWU
Richardson	16,525	NTMWD	Water conservation Additional NTMWD water
Rockett SUD	616	Water purchased from Midlothian and Waxahachie	Water conservation Purchase water from TRA (Ellis County Water Supply Project) Purchase water from DWU
Rowlett	12,749	NTMWD	Water conservation Additional NTMWD water
Sachse	2,934	NTMWD	Water conservation Additional NTMWD water
Sardis-Lone Elm WSC	0	Trinity aquifer	Water conservation Purchase water from Rockett SUD Supplemental wells in Trinity aquifer
Seagoville	2,249	DWU	Water conservation Additional DWU water May connect another pipeline to DWU
Sunnyvale	3,054	NTMWD	Water conservation Additional NTMWD water
University Park	0	Dallas County Park Cities MUD	Water conservation
Wilmer	2,241	Trinity aquifer	Water conservation Supplemental wells in Trinity aquifer Overdraft Trinity aquifer with existing wells Purchase DWU water from Hutchins or Lancaster
Wylie	223	NTMWD	Water conservation Additional NTMWD water
County-Other	0	Other aquifer DWU	Water conservation Supplemental wells in other aquifer

Table 4F.7, Continued

Water User Group	Maximum Needs	Current Sources	Recommended Water Management Strategies
Irrigation	2,626	Local supply Other aquifer Trinity River Authority DWU Grand Prairie	Water conservation Supplemental wells in other aquifer Reuse Additional DWU
Livestock	0	Local supply Woodbine aquifer	Supplemental wells in Woodbine aquifer
Manufacturing	26,200	Trinity aquifer Woodbine aquifer Direct reuse DWU Irving NTMWD	Water conservation Supplemental wells in both aquifers Additional DWU water Additional Irving water Additional NTMWD water
Mining	247	Local supply Trinity aquifer	Supplemental wells in Trinity aquifer Recycling current water Purchase DWU water
Steam Electric Power	7,104	Trinity aquifer Run-of-the-River Mountain Creek Lake DWU Garland (NTMWD)	Supplemental wells in Trinity aquifer Reuse water from DWU

Table 4F.8
Capital Costs for Recommended Water Management Strategies for Dallas County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
Water Conservation	$247,279
Reuse	$141,468,000
Transmission Facilities	$44,477,000
Aquifer Storage and Recovery	$2,015,000
Supplemental Wells	$21,562,279
Total	**$209,769,558**

4F.4 Denton County

Current groundwater use in from the Trinity and Woodbine aquifers in Denton County exceeds the estimated reliable long-term supply based on the groundwater availability model results [(1)]. Water suppliers in Denton County are increasing their use of surface water supplies. Table 4F.9 lists the current water supplies, amount of additional supply needed, and the recommended water management strategies for the water user groups in Denton County. The Upper Trinity Regional Water District, a wholesale water provider in Region C, supplies water to many water user groups in Denton County and is expected to continue to be a significant water supplier in this area. Dallas Water Utilities, Denton, the North Texas Municipal Water District, and the Tarrant Regional Water District also provide water to Denton County. Table 4F.10 shows the estimated capital costs for the Denton County water management strategies not associated with the wholesale water providers.

Table 4F.9
Recommended Water Management Strategies for Denton County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Argyle	4,566	Argyle WSC	Water conservation Additional Argyle WSC water
Argyle WSC	239	Trinity aquifer UTRWD	Water conservation Supplemental wells in Trinity aquifer Additional UTRWD water
Aubrey	2,978	Trinity aquifer UTRWD	Water conservation Supplemental wells in Trinity aquifer Additional UTRWD water
Bartonville	2,364	Bartonville WSC	Water conservation Additional Bartonville WSC water
Bartonville WSC	53	Trinity aquifer UTRWD	Water conservation Temporarily overdraft the Trinity aquifer with new wells Supplemental wells in Trinity aquifer Additional UTRWD water

Table 4F.9, Continued

Water User Group	Maximum Needs	Current Sources	Recommended Water Management Strategies
Bolivar WSC	12,744	Trinity aquifer	Water conservation Purchase water from Gainesville Purchase water from the Upper Trinity Regional Water District Temporarily overdraft the Trinity aquifer with existing wells Supplemental wells in Trinity aquifer
Carrollton	9,740	Trinity aquifer (Dallas County) DWU	Water conservation Supplemental wells in Trinity aquifer (Dallas County) Additional DWU water Additional pipeline to DWU
Coppell	145	DWU	Water conservation Additional DWU water
Copper Canyon	948	Bartonville WSC	Water conservation Additional Bartonville WSC water
Corinth	4,636	Trinity aquifer UTRWD	Water conservation Supplemental wells in Trinity aquifer Additional UTRWD water
Cross Roads	4,766	Mustang SUD (UTRWD)	Water conservation Additional Mustang SUD water (UTRWD)
Dallas	5,022	See DWU wholesale water provider information in Section 4E	See DWU wholesale water provider information in Section 4E
Denton	67,864	Lewisville Lake Ray Roberts Lake Dallas Water Utilities Reuse	Water conservation Additional DWU water Treatment plant expansions
Denton County FWSD #1	2,644	UTRWD	Water conservation Additional UTRWD water
Double Oak	512	Bartonville WSC	Water conservation Additional Bartonville WSC water
Flower Mound	21,681	UTRWD water DWU water	Water conservation Additional UTRWD water

Table 4F.9, Continued

Water User Group	Maximum Needs	Current Sources	Recommended Water Management Strategies
Fort Worth	15,370	See Fort Worth wholesale water provider information in Section 4E	See Fort Worth wholesale water provider information in Section 4E
Frisco	25,243	Trinity aquifer (Collin County) NTMWD	Water conservation Additional NTMWD water
Hackberry	143	Trinity aquifer	Water conservation Supplemental wells in Trinity aquifer Purchase NTMWD water
Hebron	1,061	UTRWD Carrollton (DWU)	Water conservation Additional UTRWD water Additional Carrollton (DWU) water
Hickory Creek	1,228	Lake Cities MUA (UTRWD)	Water conservation Additional Lake Cities MUA (UTRWD)
Highland Village	1,454	Trinity aquifer UTRWD	Water conservation Supplemental wells in Trinity aquifer Additional UTRWD water
Justin	1,835	Trinity aquifer UTRWD	Water conservation Supplemental wells in Trinity aquifer Additional UTRWD water
Krugerville	299	Mustang SUD (UTRWD)	Water conservation Additional Mustang SUD water (UTRWD)
Krum	1,006	Trinity aquifer UTRWD	Water conservation Supplemental wells in Trinity aquifer Additional UTRWD water
Lake Dallas	1,054	Lake Cities MUA (UTRWD)	Water conservation Additional Lake Cities MUA water (UTRWD)
Lewisville	20,561	DWU	Water conservation Additional DWU water Treatment plant expansions Additional pipeline to DWU
Lincoln Park	249	Trinity aquifer UTRWD	Water conservation Supplemental wells in Trinity aquifer Additional UTRWD water
Little Elm	6,012	Woodbine aquifer NTMWD	Water conservation Supplemental wells in Woodbine aquifer Additional NTMWD water

Table 4F.9, Continued

Water User Group	Maximum Needs	Current Sources	Recommended Water Management Strategies
Mustang SUD	1,747	Trinity aquifer UTRWD	Water conservation Supplemental wells in Trinity aquifer Additional UTRWD water
Northlake	2,386	Woodbine aquifer Fort Worth (TRWD)	Water conservation Supplemental wells in Woodbine aquifer Additional Fort Worth (TRWD) water Additional pipeline to Fort Worth Purchase UTRWD water
Oak Point	1,247	Trinity aquifer Mustang SUD (UTRWD)	Water conservation Supplemental wells in Trinity aquifer Additional Mustang SUD (UTRWD) water
Pilot Point	1,748	Trinity aquifer	Water conservation Overdraft Trinity aquifer with existing wells Supplemental wells in Trinity aquifer Purchase UTRWD water
Plano	1,448	NTMWD	Water conservation Additional NTMWD water
Ponder	6,290	Trinity aquifer	Water conservation Supplemental wells in Trinity aquifer Purchase UTRWD water
Prosper	4,989	Woodbine aquifer Frisco (NTMWD)	Water conservation Supplemental wells in Woodbine aquifer Purchase NTMWD water Purchase UTRWD water
Roanoke	3,471	Trinity aquifer Fort Worth	Water conservation Supplemental wells in Trinity aquifer Additional Fort Worth water Additional pipeline to Fort Worth
Sanger	3,433	Trinity aquifer UTRWD	Water conservation Supplemental wells in Trinity aquifer Additional UTRWD water
Shady Shores	483	Lake Cities MUA (UTRWD)	Water conservation Additional Lake Cities MUA water (UTRWD)
Southlake	1,073	Fort Worth	Water conservation Additional Fort Worth water Additional pipeline to Fort Worth

Table 4F.9, Continued

Water User Group	Maximum Needs	Current Sources	Recommended Water Management Strategies
The Colony	3,589	Trinity aquifer DWU NTMWD (through Plano)	Water conservation Supplemental wells in Trinity aquifer Additional DWU water Additional pipeline to DWU Additional NTMWD water (through Plano) Aquifer storage and recovery (ASR)
Trophy Club	1,917	Trophy Club MUD #1 (Fort Worth)	Water conservation Additional Trophy Club MUD #1 water Participate in additional pipeline to Fort Worth
County-Other	8,911	Trinity aquifer Woodbine aquifer Other aquifer Fort Worth UTRWD	Water conservation Supplemental wells Additional Fort Worth water Additional UTRWD water
Irrigation	0	Trinity aquifer Direct reuse from UTRWD, Denton, and Trophy Club MUD #1	Supplemental wells in Trinity aquifer
Livestock	0	Livestock local supply Trinity aquifer Woodbine aquifer	Supplemental wells in both aquifers
Manufacturing	1,083	Trinity aquifer UTRWD Denton DWU	Water conservation Supplemental wells in Trinity aquifer Additional UTRWD water Additional Denton water Additional DWU water
Mining	202	Local supply Trinity aquifer	Supplemental wells in Trinity and Woodbine aquifers New wells in Woodbine aquifer
Steam Electric Power	0	Direct reuse from Denton	None

Table 4F.10
Capital Costs for Recommended Water Management Strategies for Denton County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
Water Conservation	$138,562
New Water Treatment Plants	$2,174,000
Water Treatment Plant Expansions	$36,986,000
Aquifer Storage and Recovery	$2,015,000
Transmission	$11,209,000
New wells	$934,000
Supplemental Wells	$41,714,719
Total	**$95,171,281**

4F.5 Ellis County

Table 4F.11 summarizes the current water supplies, shortages with current supplies, and sources of additional supplies for Ellis County. Current use from the Woodbine aquifer in Ellis County exceeds the estimated long-term reliable supply [(1)]. The Trinity River Authority supplies a large amount of the water to Ellis County and is expected to continue to do so in the future.

By 2010, due to limited groundwater availability in Ellis County, the Trinity River Authority (TRA) would develop the Ellis County Water Supply Project to supply surface water to customers in Ellis and Johnson Counties (Table 4F.12). TRA would purchase raw water for this project from the Tarrant Regional Water District (TRWD), taking delivery at three points from the TRWD pipelines that run through Ellis County. The raw water would be treated at regional water treatment facilities, probably operated by Ennis, Waxahachie, and Midlothian. This strategy would require three raw water pipelines, water treatment plant expansions, and a treated water transmission system. The opinion of probable capital cost for the Ellis County Water Supply Project is approximately $95.2 million.

By 2010, Dallas Water Utilities would deliver treated surface water to Rockett SUD, Waxahachie, and Red Oak (Table 4F.13). This strategy would require a treated water transmission system. The opinion of probable capital cost for the Rockett SUD-Waxahachie-Red Oak Water Supply Project is approximately $30.0 million.

Other water management strategies to provide additional water for Ellis County include:

- Community Water Company and Rice WSC will purchase additional water from Corsicana.
- Glenn Heights will purchase from DWU.
- Ovilla will purchase water directly from DWU.
- Grand Prairie will purchase water from Midlothian and Mansfield as well as DWU.
- Johnson County SUD will purchase water from DWU (Ellis County) and TRA (Johnson County).
- Manufacturing will be supplied by Waxahachie, Midlothian, and Ennis.
- Direct reuse will be used for steam electric power.

Table 4F.14 shows the estimated capital cost for water management strategies for Ellis County not covered by wholesale water providers.

Table 4F.11
Recommended Water Management Strategies for Ellis County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Bardwell	170	Woodbine aquifer	Water conservation Use additional water from the Woodbine aquifer with new wells Construct new water treatment facilities Supplemental wells
Brandon-Irene WSC	0	Water purchased from Aquilla WSD (Lake Aquilla)	Water conservation
Buena Vista – Bethel SUD	774	Trinity aquifer	Water conservation Use additional water from the Trinity aquifer with existing wells Purchase water from TRA (Ellis County Water Supply Project) Purchase water from Rockett SUD Supplemental wells
Cedar Hill	0	Water purchased from Dallas	Water conservation See Section 4E for wholesale water provider
Community Water Company	226	Water purchased from Ennis and Corsicana	Water conservation Purchase additional water from Ennis (up to current contract amount) Purchase additional water from Corsicana

Table 4F.11, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Ennis	8,011	Water purchased from TRA (Bardwell Lake) Direct reuse (reclaimed water sold to Steam Electric Power)	Water conservation Indirect reuse from Bardwell Lake Purchase water from TRA (from TRWD pipelines and Ellis County Water Supply Project) Expand water treatment plant capacity (Ellis County Water Supply Project)
Ferris	0	Woodbine aquifer Water purchased from Rockett SUD	Water conservation Purchase water from TRA (Ellis County Water Supply Project) Purchase additional water from Rockett SUD Drill supplemental wells
Files Valley WSC	0	Water purchased from Aquilla WSD (Lake Aquilla)	Water conservation
Glenn Heights	521	Trinity aquifer in Dallas County Water purchased from Dallas	Water conservation Purchase additional water from Dallas
Grand Prairie	1,722	Trinity aquifer (Dallas County) Water purchased from Dallas Water purchased from Fort Worth (Tarrant County)	Water conservation Purchase additional water from Dallas Purchase treated water from Mansfield Purchase treated water from Midlothian Supplemental wells
Italy	299	Trinity aquifer Woodbine aquifer	Water conservation Use additional water from the Woodbine aquifer with new wells Purchase water from TRA (Ellis County Water Supply Project) Drill supplemental wells
Johnson County SUD	101	Trinity aquifer Water purchased from BRA (Lake Granbury)	Water conservation Purchase water from DWU Reuse from TRA (for Johnson County - Brazos G Region)
Mansfield	1,037	Water purchased from TRWD	Water Conservation Purchase additional water from TRWD Expand water treatment plant capacity

Table 4F.11, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Maypearl	41	Trinity aquifer Woodbine aquifer	Water conservation Use additional water from the Woodbine aquifer with existing and new wells Purchase water from TRA (Ellis County Water Supply Project) Supplemental wells
Midlothian	7,281	Trinity aquifer Water purchased from TRA (Joe Pool Lake)	Water conservation Use additional water from Joe Pool Lake Purchase water from TRA (Ellis County Water Supply Project) Expand water treatment plant capacity Supplemental wells
Milford	0	Woodbine aquifer Water purchased from Files Valley WSC (Lake Aquilla)	Water conservation Supplemental wells
Mountain Peak WSC	1,542	Trinity aquifer Water purchased from Midlothian	Water conservation Use additional water from the Trinity aquifer with new wells Purchase additional water from Midlothian Purchase water from Rockett SUD Supplemental wells
Oak Leaf	374	Water purchased from Glenn Heights, Rockett SUD and Sardis-Lone Elm WSC	Water conservation Purchase additional water from Glenn Heights, Rockett SUD and Sardis-Lone Elm WSC
Ovilla	1,055	Woodbine aquifer Water purchased from Cedar Hill	Water conservation Purchase water directly from Dallas Supplemental wells
Palmer	22	Woodbine aquifer	Water conservation Use additional water from the Woodbine aquifer with existing wells Purchase water from TRA (Ellis County Water Supply Project) Purchase water from Rockett SUD Supplemental wells
Pecan Hill	174	Other aquifer Water purchased from Rockett SUD	Water conservation Purchase additional water from Rockett SUD Supplemental wells

Table 4F.11, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Red Oak	1,819	Woodbine aquifer Water purchased from Rockett SUD	Water conservation Purchase water from Dallas Purchase water from TRA (Ellis County Water Supply Project) Supplemental wells
Rice WSC	110	Water purchased from Corsicana (Navarro Mills Lake) Water purchased from Ennis (Bardwell Lake)	Water conservation Purchase additional water from Corsicana Purchase additional water from Ennis (up to current contract amount)
Rockett SUD	7,536	Trinity aquifer Water purchased from Midlothian and Waxahachie	Water conservation Purchase water from Dallas Purchase water from TRA (Ellis County Water Supply Project) Supplemental wells
Sardis-Lone Elm WSC	1,545	Trinity aquifer	Water conservation Temporarily overdraft the Trinity aquifer with new wells Purchase water from Rockett SUD Supplemental wells
Venus	0	No demands in Region C	Purchase water from Midlothian
Waxahachie	13,343	Water purchased from Ellis County WCID #1 (Lake Waxahachie, raw and indirect reuse water from Bardwell Lake (purchased from TRA))	Water conservation Use additional indirect reuse water from Bardwell Lake Purchase water from Dallas Purchase water from TRA (Ellis County Water Supply Project) Expand water treatment plant capacity (Ellis County Water Supply Project)
County-Other	1,141	Other aquifer Trinity aquifer Woodbine aquifer Water purchased from Ennis (Bardwell Lake) Water purchased from Waxahachie	Water conservation Use additional water from the Trinity aquifer with new wells Use additional water from the Woodbine aquifer with new wells Purchase water from TRA (Ellis County Water Supply Project) Supplemental wells

Table 4F.11, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Irrigation	563	Trinity aquifer Irrigation Local Supply	Water conservation Use additional water from the Woodbine aquifer with new wells Direct reuse of reclaimed water Supplemental wells
Livestock	0	Local Supply Woodbine aquifer	Supplemental wells
Manufacturing	1,248	Trinity aquifer Woodbine aquifer Water purchased from Midlothian and Waxahachie	Additional water from the Woodbine aquifer with new wells Purchase additional water from Waxahachie Purchase additional water from Midlothian Purchase water from Ennis Supplemental wells
Mining	0	Woodbine aquifer	Supplemental wells
Steam Electric Power	35,964	Ennis direct reuse Water purchased from Midlothian	Purchase additional water from Midlothian Direct reuse of reclaimed water

4F.6 Fannin County

Table 4F.15 summarizes the current water supplies, shortages with current supplies, and sources of additional supplies for Fannin County. Hickory Creek SUD and North Hunt WSC are primarily located in Region D. The recommended strategies for these water user groups will be included in the Region D plan.

The North Texas Municipal Water District plans to develop Lower Bois d'Arc Creek Reservoir, which would be used to supply surface water to a county-wide system in Fannin County. The North Texas Municipal Water District would cooperate with Fannin County entities to develop the Fannin County Water Supply Project starting by 2020 in order to provide treated surface water from Lower Bois D'Arc Creek Reservoir to Fannin County customers (Table 4F.16). The Fannin County Water Supply Project would include a raw water pipeline, one or more water treatment plants having a total capacity of approximately 16 million gallons per day, and a treated water transmission system. The opinion of probable capital cost for the Fannin County Water Supply Project is approximately $55.5 million.

Table 4F.12
Projected Supply from the Ellis County Water Supply Project

Water User Group	Projected Supply (Acre-Feet per Year)					
	2010	2020	2030	2040	2050	2060
Ennis	341	596	1,836	3,393	3,545	3,776
Community Water Company	0	23	67	112	162	188
Ellis County-Manufacturing	0	50	128	195	250	274
Ellis County-Other	0	27	66	96	120	137
Rice WSC	0	14	34	49	62	71
Ennis Subtotal	**341**	**710**	**2,131**	**3,845**	**4,139**	**4,446**
Midlothian and customers	1005	1,702	5,966	7,520	9,386	10,553
Grand Prairie	1,120	2,241	2,241	2,241	2,241	2,241
Midlothian Subtotal	**2,125**	**3,943**	**8,207**	**9,761**	**11,627**	**12,794**
Waxahachie	0	511	511	511	2,392	5,212
Buena Vista – Bethel SUD	0	261	283	319	365	421
Ellis County-Other	0	1,045	1,024	1,013	1,002	1,002
Ferris	0	30	30	30	30	30
Italy	0	140	172	207	249	299
Maypearl	0	73	71	68	66	66
Palmer	0	50	52	53	56	60
Red Oak	0	387	519	657	660	660
Rockett SUD	0	1,126	1,296	1,274	1,662	1,743
Pecan Hill	0	37	41	46	51	56
Sardis-Lone Elm WSC	0	200	214	205	280	309
Mountain Peak WSC	0	124	274	325	305	326
Waxahachie Subtotal	**0**	**3,984**	**4,487**	**4,708**	**7,118**	**10,184**
TOTAL	**2,466**	**8,637**	**14,825**	**18,314**	**22,884**	**27,424**

Table 4F.13
Projected Supply from Rockett SUD-Waxahachie-Red Oak Water Supply Project

Water User Group	Projected Supply (Acre-Feet per Year)					
	2010	2020	2030	2040	2050	2060
Rockett SUD	1,852	5,114	4,472	5,025	5,716	6,578
Buena Vista – Bethel SUD	337	408	442	500	572	658
Ferris	0	79	42	34	30	30
Mountain Peak WSC	471	596	674	960	1,435	2,041
Palmer	30	30	30	30	30	30
Pecan Hill	31	100	88	118	134	155
Sardis-Lone Elm WSC	585	695	706	1,004	1,354	1,809
Red Oak	309	305	422	544	828	1,159
Waxahachie	1,121	1,611	3,838	6,639	6,726	6,726
TOTAL	**4,738**	**8,938**	**10,714**	**14,854**	**16,825**	**19,186**

Table 4F.14
Capital Costs for Recommended Water Management Strategies for Ellis County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
Water Conservation	$51,057
Reuse	$0
Transmission	$5,647,000
New wells	$16,663,000
Supplemental Wells	$39,851,085
Total	**$62,212,142**

The Upper Trinity Regional Water District plans to develop Lake Ralph Hall in Southeastern Fannin County and transport 90 percent of the yield to Denton County. The remaining 10 percent will be available for use in southern Fannin County.

Table 4F.17 shows the estimated capital cost for water management strategies for Fannin County not covered by wholesale water providers.

Table 4F.15
Recommended Water Management Strategies for Fannin County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Bonham	5,020	Lake Bonham	Water conservation Use additional water from Lake Bonham Expand water treatment capacity Purchase water from NTMWD (Fannin County Water Supply Project)
Ector	0	Woodbine aquifer	Water conservation Purchase water from NTMWD (Fannin County Water Supply Project) Temporarily overdraft the Woodbine aquifer with existing wells Use water from the Trinity aquifer with new wells Supplemental wells
Hickory Creek SUD	27	Woodbine aquifer in Hunt County	Water conservation Other strategies to be determined by the Region D Water Planning Group Supplemental wells in Woodbine aquifer

Table 4F.15, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Honey Grove	103	Woodbine aquifer	Water conservation Purchase water from NTMWD (Fannin County Water Supply Project) Temporarily overdraft the Woodbine aquifer with existing wells Supplemental wells
Ladonia	779	Trinity aquifer	Water conservation Overdraft the Trinity aquifer with new wells Purchase water from UTRWD (Ralph Hall Reservoir) Construct water treatment plant Supplemental wells
Leonard	1,023	Woodbine aquifer	Water conservation Purchase water from NTMWD (Fannin County Water Supply Project) Temporarily overdraft the Woodbine aquifer with existing wells Supplemental wells
North Hunt WSC	0	Trinity aquifer in Hunt County Water purchased from Commerce	Water conservation Other strategies to be determined by the Region D Water Planning Group
Savoy	0	Woodbine aquifer	Water conservation Purchase water from NTMWD (Fannin County Water Supply Project) Temporarily overdraft the Woodbine aquifer with existing wells Supplemental wells
Southwest Fannin County SUD	787	Woodbine aquifer	Water conservation Purchase water from NTMWD (Fannin County Water Supply Project) Temporarily overdraft the Woodbine aquifer with existing and new wells Supplemental wells
Trenton	1,361	Woodbine aquifer	Water conservation Purchase water from NTMWD (Fannin County Water Supply Project) Supplemental wells
Whitewright	1	Woodbine aquifer in Grayson County	See Grayson County water management strategies

Table 4F.15, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
County-Other	338	Trinity aquifer Woodbine aquifer Local Supply Water purchased from Bonham (Lake Bonham)	Water conservation Use additional water from the Woodbine aquifer with new wells Purchase more water from Bonham Purchase water from NTMWD (Fannin County Water Supply Project) Supplemental wells
Irrigation	0	Other aquifer Local Supply	Supplemental wells
Livestock	0	Trinity aquifer Woodbine aquifer Livestock Local Supply	Supplemental wells
Manufacturing	0	Woodbine aquifer Water purchased from Bonham (Lake Bonham)	Purchase more water from Bonham Supplemental wells
Mining	0	Local Supply	None
Steam Electric Power	0	Woodbine aquifer Lake Texoma	Supplemental wells

Table 4F.16
Projected Supply from Fannin County Water Supply Project

Water User Group	Projected Supply (Acre-Feet per Year)					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Bonham	0	8	9	610	3,017	5,009
Fannin County-Other	0	24	24	24	24	192
Ector	0	9	7	5	4	5
Honey Grove	0	50	49	51	70	103
Leonard	0	85	213	478	810	1,076
Fannin County-Manufacturing	0	0	0	0	0	11
Savoy	0	10	8	5	4	4
Southwest Fannin County SUD	0	404	552	651	736	830
Trenton	0	113	307	591	974	1,361
TOTAL	**0**	**703**	**1,169**	**2,415**	**5,638**	**8,591**

Table 4F.17
Capital Costs for Recommended Water Management Strategies for Fannin County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
Water Treatment Plant Expansions	$2,838,000
Transmission	$13,602,000
New Wells	$3,485,000
Supplemental Wells	$30,461,509
Total	**$50,386,509**

4F.7 Freestone County

Table 4F.18 presents a summary of the projected need for additional supplies, the current sources, and the sources of additional supply for each water user group in Freestone County. Only four water user groups are expected to have water shortages if no additional supplies are developed.

In 2001, the Texas Legislature established the Mid-East Texas Conservation District [3] in Freestone, Leon, and Madison Counties. Figure 4F.1 shows the groundwater conservation districts in Texas. Groundwater conservation districts develop groundwater management plans to prevent waste, collect data, and educate the public to protect the aquifer [4]. Groundwater conservation districts may establish minimum well spacing requirements, as well as maximum well production limits.

Table 4F.19 shows the estimated capital costs for Freestone County water management strategies not covered under the wholesale water providers.

Table 4F.18
Recommended Water Management Strategies for Freestone County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Supplies	Proposed Water Management Strategies
Fairfield	695	Carrizo-Wilcox aquifer	Water conservation New well in Carrizo-Wilcox aquifer Supplemental wells TRWD system

Table 4F.18, Continued

Water User Group	Maximum Needs	Current Supplies	Proposed Water Management Strategies
Flo Community WSC	0	Carrizo-Wilcox aquifer	Water conservation Supplemental wells
Teague	459	Carrizo-Wilcox aquifer Teague City Lake	Water conservation New wells Supplemental wells
Wortham	255	Wortham Lake Mexia	Water conservation Purchase Corsicana water New water treatment plant
County-Other	0	Carrizo-Wilcox aquifer Run-of-the-river water TRWD	Supplemental wells
Irrigation	0	Carrizo-Wilcox aquifer Local Supply	Supplemental wells
Livestock	0	Carrizo-Wilcox aquifer Queen City aquifer Other aquifer Local Supply	Supplemental wells
Manufacturing	0	None	None
Mining	0	Carrizo-Wilcox aquifer Local Supply	Supplemental wells
Steam Electric Power	15,606	Carrizo-Wilcox aquifer Lake Fairfield Tarrant Regional Water District Lake Livingston	Supplemental wells Purchase additional TRWD water Purchase indirect reuse from TRA

4F.8 Grayson County

For many water user groups in Grayson County, the Trinity and Woodbine aquifers provide much of the current water supply, and the current use from those aquifers is significantly greater than the estimated long-term reliable supply [(1)]. Temporary overdrafting of the Trinity aquifer is recommended in 2010 and 2020 to allow water user groups time to develop new supplies or

Table 4F.19
Capital Costs for Recommended Water Management Strategies for Freestone County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
Water Treatment Plant Expansions	$1,392,000
Transmission	$10,868,000
New Wells	$1,081,000
Supplemental Wells	$5,639,809
Total	**$18,980,809**

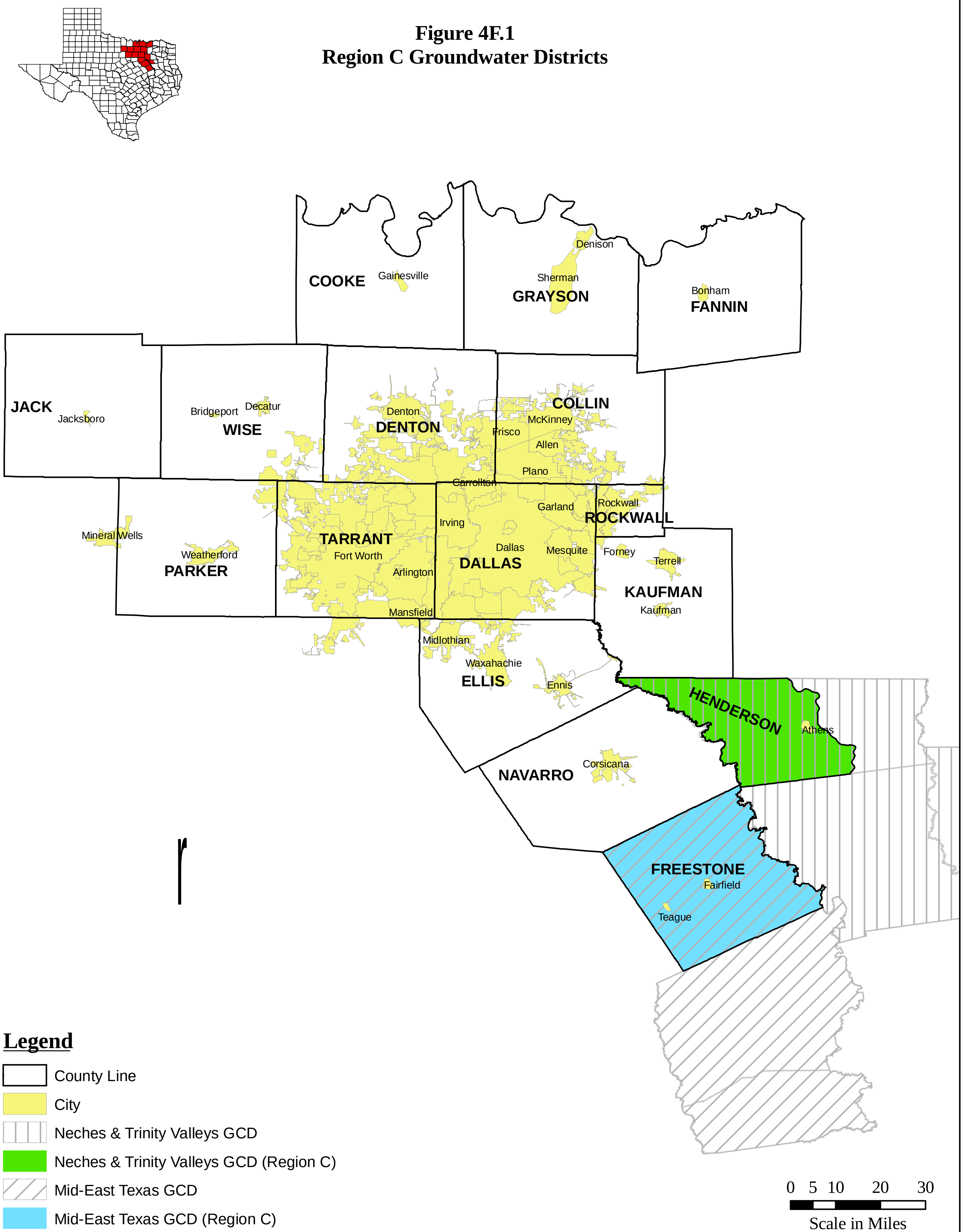
connect to new suppliers. The temporary overdrafting is not expected to cause any long-term damage to the aquifer.

Water user groups in Grayson County would participate in the Collin-Grayson Municipal Alliance Pipeline Project and is discussed in more detail in Section 4E. Table 4F.2 summarized the amount of supply that would be provided to each participant in the project, including the entities located in Grayson County.

By 2020, the Greater Texoma Utility Authority (GTUA) would develop the Grayson County Water Supply Project to provide treated surface water from Lake Texoma to Grayson County customers (Table 4F.20). Phase 1, including a raw water pipeline, a new 25 million gallon per day water treatment plant, a new 1 million gallon per day water treatment plant in northwestern Grayson County, and a treated water transmission system, would be constructed by 2020. Phase 2, including a 20 million gallon per day water treatment plant expansion, would be constructed by 2040.

This strategy would use all remaining water currently permitted under GTUA's existing water right in Lake Texoma and would require that GTUA obtain an additional water right (with interbasin transfer authorization) in Lake Texoma. The U.S. Army Corps of Engineers is conducting a reallocation study of the storage in Lake Texoma. After completion of this study, GTUA would contract with the Corps of Engineers for storage in Lake Texoma (approximately

Figure 4F.1
Region C Groundwater Districts



50,000 acre-feet) and would apply to the TCEQ for a new water right in Lake Texoma (approximately 56,500 acre-feet per year).

The opinion of probable capital cost for the Grayson County Water Supply Project is approximately $215.4 million.

Table 4F.20
Projected Supply from the Grayson County Water Supply Project

Water User Group	Projected Supply (Acre-Feet per Year)					
	2010	2020	2030	2040	2050	2060
Bells	0	147	205	258	312	359
Celina	0	21	487	2,086	4,079	4,800
Collinsville	0	245	353	451	559	676
Grayson County-Other	0	1,348	1,476	1,520	1,536	1,528
Gunter	0	372	498	612	733	865
Gunter Rural WSC	0	205	370	608	936	1,302
Luella WSC	0	126	213	275	329	428
Grayson County-Manufacturing	0	711	2,014	2,617	3,357	4,393
Sherman	0	0	612	2,142	4,162	7,096
South Grayson WSC	0	50	51	50	57	164
Southmayd	0	162	246	319	390	461
Tioga	0	222	345	415	484	535
Tom Bean	0	100	160	200	241	284
Two Way SUD	0	444	609	773	938	1,120
Whitesboro	0	682	861	974	1,070	1,156
Whitewright	0	176	354	532	731	962
TOTAL	**0**	**5,013**	**8,852**	**13,834**	**19,914**	**26,129**

Table 4F.21 presents a summary of water management strategies to meet demands in Grayson County. Strategies in addition to the surface water project described above include:

- Denison will use additional Lake Texoma water.
- Gunter and Gunter Rural WSC will purchase water from Sherman, as well as the Grayson County Water Supply Project.
- Pottsboro will obtain water from Lake Texoma and purchase additional water from Denison.
- South Grayson WSC will purchase water from North Texas Municipal Water District in addition to participating in the Grayson County Water Supply Project.
- Bells, Gunter, Howe, Luella WSC, Sherman, Southmayd, Tioga, Tom Bean, Two Way SUD, Van Alstyne, Whitewright, County-Other, irrigation, manufacturing, and mining will use additional groundwater.

- Collinsville, Gunter, Gunter Rural WSC, Tioga, Two Way SUD, and Whitesboro temporarily will overdraft the Trinity aquifer.

Table 4F.22 shows the estimated capital costs for Grayson County water management strategies.

Table 4F.21
Recommended Water Management Strategies for Grayson County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Bells	301	Trinity aquifer Woodbine aquifer	Water conservation Use more water from the Woodbine aquifer with new wells Purchase water from GTUA (Grayson County Water Supply Project) Supplemental wells
Collinsville	616	Trinity aquifer	Water conservation Purchase water from GTUA (Grayson County Water Supply Project) Temporarily overdraft the Trinity aquifer with existing wells Supplemental wells
Denison	743	Lake Randell Lake Texoma Trinity aquifer Woodbine aquifer	Water conservation Use additional water from Lake Texoma Expand water treatment capacity Supplemental wells
Gunter	935	Trinity aquifer	Water conservation Use more water from the Trinity aquifer with existing wells Purchase water from Sherman Purchase water from GTUA (Grayson County Water Supply Project) Temporarily overdraft the Trinity aquifer with existing wells Supplemental wells
Gunter Rural WSC	540	Trinity aquifer	Water conservation Purchase water from Sherman Purchase water from GTUA (Grayson County Water Supply Project) Temporarily overdraft the Trinity aquifer with new wells Supplemental wells

Table 4F.21, Continued

Water User Group	Maximum Needs	Current Sources	Recommended Water Management Strategies
Howe	1,245	Woodbine aquifer	Water conservation Use more water from the Woodbine aquifer with existing wells Collin-Grayson County Municipal Alliance Project (GTUA/NTMWD) Supplemental wells
Luella WSC	264	Woodbine aquifer	Water conservation Use more water from the Woodbine aquifer with existing wells Purchase water from GTUA (Grayson County Water Supply Project) Supplemental wells
Pottsboro	1,292	Woodbine aquifer Water purchased from Denison	Water conservation Obtain water right for Lake Texoma supply Purchase additional water from Denison, parallel pipeline Supplemental wells
Sherman	5,877	Water purchased from GTUA (Lake Texoma) Trinity aquifer Woodbine aquifer	Water conservation Use more water from the Woodbine aquifer with existing wells Purchase water from GTUA (Grayson County Water Supply Project) Expand water treatment plant capacity Supplemental wells
South Grayson WSC	133	Trinity aquifer Woodbine aquifer	Water conservation Use more water from the Woodbine aquifer with existing wells Collin-Grayson County Municipal Alliance Project (GTUA/NTMWD) Purchase water from GTUA (Grayson County Water Supply Project) Supplemental wells

Table 4F.21, Continued

Water User Group	Maximum Needs	Current Sources	Recommended Water Management Strategies
Southmayd	504	Trinity aquifer Woodbine aquifer	Water conservation Use more water from the Trinity aquifer with existing wells Use more water from the Woodbine aquifer with new or purchased wells Purchase water from GTUA (Grayson County Water Supply Project) Supplemental wells
Southwest Fannin County SUD	0	Woodbine aquifer	Water conservation Supplemental wells
Tioga	627	Trinity aquifer	Water conservation Use more water from the Trinity aquifer with existing wells Purchase water from GTUA (Grayson County Water Supply Project) Temporarily overdraft the Trinity aquifer with existing and new wells Supplemental wells
Tom Bean	160	Woodbine aquifer	Water conservation Use water from the Trinity aquifer with new wells Use more water from the Woodbine aquifer with new wells Purchase water from GTUA (Grayson County Water Supply Project) Supplemental wells
Two Way SUD	1,067	Trinity aquifer	Water conservation Use more water from the Trinity aquifer with existing wells Purchase water from GTUA (Grayson County Water Supply Project) Temporarily overdraft the Trinity aquifer with existing and new wells Supplemental wells

Table 4F.21, Continued

Water User Group	Maximum Needs	Current Sources	Recommended Water Management Strategies
Van Alstyne	3,554	Trinity aquifer	Water conservation Use more water from the Trinity aquifer with new wells Collin-Grayson County Municipal Alliance Project (GTUA/NTMWD) Supplemental wells
Whitesboro	876	Trinity aquifer	Water conservation Purchase water from GTUA (Grayson County Water Supply Project) Temporarily overdraft the Trinity aquifer with existing and new wells Supplemental wells
Whitewright	1,134	Woodbine aquifer	Water conservation Use more water from the Woodbine aquifer with new wells Purchase water from GTUA (Grayson County Water Supply Project) Supplemental wells
Woodbine WSC	0	Trinity aquifer (Cooke County)	Water conservation
County-Other	0	Trinity aquifer Woodbine aquifer Other aquifer Water purchased from Denison Water purchased from Red River Authority (Lake Texoma)	Water conservation Use more water from the Trinity aquifer with new wells Use more water from the Woodbine aquifer with new wells Purchase water from GTUA (Grayson County Water Supply Project) Purchase additional water from Denison Purchase additional water from the Red River Authority Purchase water from Pottsboro Supplemental wells

Table 4F.21, Continued

Water User Group	Maximum Needs	Current Sources	Recommended Water Management Strategies
Irrigation	232	Woodbine aquifer Local Supply Water purchased from Red River Authority (Lake Texoma)	Use more water from the Woodbine aquifer with new wells Supplemental wells
Livestock	0	Woodbine aquifer Local Supply	Supplemental wells
Manufacturing	5,928	Woodbine aquifer Local Supply Water purchased from Denison Water purchased from Sherman	Water conservation Use more water from the Trinity aquifer with new wells Use more water from the Woodbine aquifer with new wells Purchase additional water from Sherman Purchase additional water from Denison Purchase additional water from Howe Supplemental wells
Mining	0	Trinity aquifer Woodbine aquifer Water purchased from Red River Authority (Lake Texoma)	Supplemental wells
Steam Electric Power	0	None	None

Table 4F.22
Capital Costs for Recommended Water Management Strategies for Grayson County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
Water Conservation	$77,777
Transmission	$6,197,000
New Wells	$14,491,000
Supplemental Wells	$116,295,111
Total	**$137,060,888**

4F.9 Henderson County

Table 4F.23 presents a summary of the projected need for additional supplies, the current sources, and the sources of additional supply for each Region C water user group in Henderson County. Henderson County is divided between Regions C and I. The Trinity River Basin portion of Henderson County is located in Region C, while the Neches Basin is located in Region I. The Athens Municipal Water Authority is a local wholesale water provider in Henderson County. Lake Athens (owned and operated by the Athens MWA) is actually located in Region I, but the water supply is used primarily in Region C. Region I users have contracts for water from Lake Athens as livestock supply for the fish hatchery and a small amount of irrigation supply for the homeowners around the lake. The Tarrant Regional Water District also supplies significant amounts of water to the water user groups in Henderson County. A number of water user groups rely on the Carrizo-Wilcox and other aquifers and will continue to do so in the future. Water user groups that will obtain additional water from sources other than the wholesale water providers include the following:

- Bethel-Ash WSC is partially located in Regions C, D, and I. Region D will meet the needs of the portion of this water user group that falls in that area. Region C recommends additional groundwater from the Carrizo-Wilcox aquifer in Henderson County to the Region C and I portions of the entity.
- Eustace, Log Cabin, and Virginia Hill WSC will use additional water from the Carrizo-Wilcox aquifer.

In 2001, the Texas Legislature established a groundwater conservation district, the Neches and Trinity Valleys Groundwater Conservation District [(5)], in Henderson, Anderson, and Cherokee Counties. Groundwater conservation districts develop groundwater management plans to prevent waste, collect data, and educate the public to protect the aquifer [(4)]. Groundwater conservation districts may establish minimum well spacing requirements, as well as maximum well production limits.

Table 4F.24 shows the estimated capital costs for Henderson County water management strategies not covered under the wholesale water providers.

Table 4F.23
Recommended Water Management Strategies for Henderson County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Athens	3,773	Carrizo Wilcox Athens MWA	Water conservation Supplemental wells in Carrizo-Wilcox aquifer Additional Athens MWA water
Bethel-Ash WSC	170	Carrizo-Wilcox aquifer	Water conservation New wells in Carrizo-Wilcox aquifer Supplemental wells in Carrizo-Wilcox aquifer Region D will meet the entity's demands in the portion that is located in that region. Region C will meet the entity's needs in Regions C and I with Carrizo-Wilcox water from Region C.
East Cedar Creek FWSD	4,733	TRWD	Water conservation Additional TRWD water Plant expansion
Eustace	68	Carrizo-Wilcox aquifer	Water conservation New wells in Carrizo-Wilcox aquifer Supplemental wells
Gun Barrel City	2,073	East Cedar Creek FWSD (TRWD)	Water conservation Additional East Cedar Creek FWSD water
Log Cabin	55	Carrizo-Wilcox aquifer	Water conservation New wells in Carrizo-Wilcox aquifer Supplemental wells in Carrizo-Wilcox aquifer
Mabank	55	TRWD	Water conservation Additional TRWD water
Malakoff	0	TRWD Carrizo-Wilcox aquifer	Water conservation Supplemental wells in Carrizo-Wilcox aquifer
Payne Springs	189	East Cedar Creek FWSD (TRWD)	Water conservation Additional East Cedar Creek FWSD water
Seven Points	284	West Cedar Creek MUD (TRWD)	Water conservation Additional West Cedar Creek MUD
Tool	556	West Cedar Creek MUD (TRWD)	Water conservation Additional West Cedar Creek MUD

Table 4F.23, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Trinidad	0	Trinidad City Lake	Water conservation
Virginia Hill WSC	0	Carrizo-Wilcox aquifer	Water conservation Supplemental wells in Carrizo-Wilcox
West Cedar Creek MUD	2,791	TRWD	Water conservation Additional TRWD Water treatment plant expansions
County-Other	0	Carrizo-Wilcox aquifer Other aquifer TRWD	Water conservation Supplemental wells in Carrizo-Wilcox aquifer
Irrigation	0	Carrizo-Wilcox aquifer Direct reuse from Pinnacle Local Supply	Supplemental wells in Carrizo-Wilcox aquifer
Livestock	0	Local supply Carrizo-Wilcox aquifer Queen City aquifer Other aquifer	Supplemental wells in Carrizo-Wilcox, Queen City, and Other aquifers
Manufacturing	133	Carrizo-Wilcox aquifer City of Athens (Athens MWA)	Water conservation Supplemental wells in Carrizo-Wilcox aquifer Additional City of Athens (Athens MWA) water
Mining	0	Carrizo-Wilcox aquifer TRWD	Supplemental wells in Carrizo-Wilcox aquifer
Steam Electric Power	0	Carrizo-Wilcox aquifer TRWD Lake Trinidad Forest Grove Reservoir (TXU)	Supplemental wells in Carrizo-Wilcox aquifer

Table 4F.24
Capital Costs for Recommended Water Management Strategies for Henderson County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
Water Conservation	$41,519
New Wells	$729,000
Supplemental Wells	$10,744,041
Total	**$11,514,560**

4F.10 Jack County

Table 4F.25 shows the needs for additional supplies, current sources, and new sources of supply for Jack County. Three of the nine water user groups in this county will need additional supplies during the planning period. Table 4F.26 shows the estimated capital costs for Jack County water management strategies.

Table 4F.25
Recommended Water Management Strategies for Jack County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Bryson	97	Lake Bryson	Water conservation New wells in Other aquifer Supplemental wells in Other aquifer Purchase Graham water
Jacksboro	0	Lost Creek/Lake Jacksboro System	Water conservation Expand water treatment plant and delivery capacity
County-Other	269	Lost Creek/Lake Jacksboro System Lake Bryson Other aquifer	Water conservation Purchase Jacksboro water New wells in other aquifer Supplemental wells in other aquifer Purchase Graham water

Table 4F.25, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Irrigation	0	Local supply Other aquifer Reuse from Jacksboro Direct reuse from Bryson	Supplemental wells
Livestock	0	Local supply Other aquifer	Supplemental wells
Manufacturing	0	Lost Creek/Lake Jacksboro System	None
Mining	0	Other aquifer Local supply	Supplemental wells
Steam Electric Power	7,102	Tarrant Regional Water District	Renew contract with TRWD Purchase additional TRWD water Expand pipeline from TRWD

Table 4F.26
Capital Costs for Recommended Water Management Strategies for Jack County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
Water Treatment Plant Expansions	$2,088,000
Transmission	$8,603,000
New Wells	$800,000
Supplemental Wells	$758,036
Total	**$12,249,036**

4F.11 Kaufman County

Table 4F.27 shows the needs for additional supplies, current sources, and new sources of supply for Kaufman County. North Texas Municipal Water District, Dallas Water Utilities, and Tarrant Regional Water District are wholesale water providers in Kaufman County, and they provide much of the supply to the county. These providers plan to continue supplying this area in the future. Water user groups that will obtain additional water from other sources:

- Able Springs WSC is provided water by the Sabine River Authority through expansions of the MacBee WSC water treatment plant and the Toledo Bend project.
- Reuse for steam electric power.

Table 4F.28 shows the estimated capital costs for Kaufman County water management strategies.

Table 4F.27
Recommended Water Management Strategies for Kaufman County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Able Springs WSC	941	SRA water treated by MacBee WSC	Water conservation Additional SRA water Assist with expansion of MacBee WSC water treatment plant
College Mound WSC	1,892	NTMWD Terrell	Water conservation Additional NTMWD (from Terrell) water
Combine	261	Combine WSC (Seagoville from DWU)	Water conservation Additional Combine WSC (Seagoville from DWU) water
Combine WSC	694	Seagoville (DWU)	Water conservation Additional Seagoville (DWU) water Additional pipeline to Seagoville
Crandall	1,562	NTMWD	Water conservation Additional NTMWD water Additional pipeline to NTMWD
Dallas	0	See Dallas Water Utilities wholesale water provider information in Section 4E	See Dallas Water Utilities wholesale water provider information in Section 4E
Forney	4,662	NTMWD	Water conservation Additional NTMWD water
Forney Lake WSC	1,801	NTMWD	Water conservation Additional NTMWD water
Gastonia-Scurry WSC	1,601	NTMWD	Water conservation Additional NTMWD water

Table 4F.27, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
High Point WSC	929	Lake Terrell Lake Tawakoni Forney (NTMWD)	Water conservation Additional Forney (NTMWD) water
Kaufman	2,003	NTMWD	Water conservation Additional NTMWD water
Kemp	91	TRWD	Water conservation Additional TRWD water
Mabank	645	TRWD	Water conservation Additional TRWD water Water treatment plant expansions
MacBee WSC	0	SRA	Water conservation Water treatment plant expansions
Mesquite	0	NTMWD	Water conservation Additional NTMWD water
Oak Grove	187	Kaufman (NTMWD)	Water conservation Additional Kaufman (NTMWD) water
Seagoville	0	DWU	Water conservation See Dallas County
Talty	2,620	Forney (NTMWD)	Water conservation Additional Forney (NTMWD) water
Terrell	2,479	Lake Terrell SRA NTMWD (contract in place)	Water conservation Connect to NTMWD
West Cedar Creek MUD	3,225	TRWD	Water conservation Additional TRWD Water treatment plant capacity
County-Other	904	Nacatoch aquifer TRWD through Kemp and Mabank NTMWD Terrell	Water conservation Supplemental wells in Nacatoch aquifer Additional TRWD water through Kemp and Mabank Additional NTMWD water Additional Terrell water (NTMWD)
Irrigation	2,147	Local Supply Nacatoch aquifer TRWD Direct reuse	Water conservation Supplemental wells in Nacatoch aquifer Additional TRWD water Purchase NTMWD reuse water
Livestock	0	Local Supply Nacatoch aquifer Woodbine aquifer	Supplemental wells in Nacatoch aquifer

Table 4F.27, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Manufacturing	604	NTMWD Terrell	Water conservation Additional NTMWD water
Mining	0	Local Supply	None
Steam Electric Power	31,403	Reuse water from Forney (from Garland)	Purchase NTMWD raw water Additional reuse water from Forney (Garland) up to current contract limit Purchase reuse from TRA

Table 4F.28
Capital Costs for Recommended Water Management Strategies for Kaufman County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
Water Conservation	$59,168
Water Treatment Plant Expansions	$10,679,000
Reuse	$13,157,000
Transmission Facility Improvements	$9,394,000
Supplemental Wells	$450,840
Total	**$33,740,008**

4F.12 Navarro County

Table 4F.29 summarizes the current supply sources, need for additional supplies, and recommended sources of additional supply for water user groups in Navarro County. Corsicana is a wholesale water provider and supplies treated water for most of the water user groups in Navarro County. A detailed discussion of the water management strategies for Corsicana is included in Section 4E of this plan.

Table 4F.30 shows the estimated capital costs for Navarro County water management strategies, excluding those for Corsicana which are shown in Section 4E of this plan.

Table 4F.29
Recommended Water Management Strategies for Navarro County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Blooming Grove	41	Corsicana (TRA)	Water conservation Additional Corsicana water
Brandon-Irene WSC	0	Aquilla WSC	Water conservation
Chatfield WSC	489	Corsicana (TRA)	Water conservation Additional Corsicana water
Community Water Company	108	Corsicana (TRA)	Water conservation Additional Corsicana water
Corsicana	2,090	Lake Halbert Navarro Mills Lake (TRA)	Water conservation Plant expansions Connect to Richland-Chambers Reservoir
Dawson	70	Corsicana (TRA)	Water conservation Additional Corsicana water
Frost	0	Corsicana (TRA)	Water conservation Supplemental wells (emergency backup) Additional Corsicana water
Kerens	0	Corsicana (TRA) Run-of-the-river water	Water conservation Additional Corsicana water
M E N WSC	183	Corsicana (TRA)	Water conservation Additional Corsicana water
Navarro Mills WSC	331	Corsicana (TRA)	Water conservation Additional Corsicana water
Rice	137	Rice WSC (Ennis and Corsicana)	Water conservation Additional Rice WSC water
Rice WSC	625	Corsicana (TRA) Ennis (TRA)	Water conservation Additional Corsicana water
County-Other	96	Trinity aquifer Woodbine aquifer TRWD Dawson (Corsicana) Corsicana	Water conservation Supplemental wells Dawson Corsicana
Irrigation	0	Irrigation Local Supply	None

Table 4F.29, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Livestock	0	Livestock Local Supply Carrizo-Wilcox aquifer Nacatoch aquifer Other aquifer	Supplemental wells
Manufacturing	780	Corsicana TRWD	Water conservation Additional Corsicana water Additional TRWD water
Mining	0	Carrizo-Wilcox aquifer Nacatoch aquifer	Supplemental wells
Steam Electric Power	0	None	None

Table 4F.30
Capital Costs for Recommended Water Management Strategies for Navarro County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
Supplemental Wells	$1,207,204
Total	**$1,207,204**

4F.13 Parker County

Table 4F.31 presents a summary of the projected need for additional supplies, the current sources, and the sources of additional supply for each water user group in Parker County. The Tarrant Region Water District (TRWD), Weatherford, and Fort Worth (from TRWD) are wholesale water providers in Parker County. Detailed descriptions of the current and recommended future supplies for each of these wholesale water providers is included in Section 4E. These providers currently supply water in the county or plan to do so in the future. Water user groups that currently get water from one of these suppliers will purchase additional water from the supplier to meet future demands.

Current groundwater use exceeds the reliable supply from the Trinity and other aquifers. Temporary overdrafting is recommended through 2010 to allow these water user groups time to develop new supplies or connect to a water provider. The temporary overdrafting of the aquifers is not expected to damage the aquifer.

The East Parker County System is recommended to deliver treated water to various cities in the county. The project would likely be developed by the Parker County Municipal Utility District with Weatherford supplying treated water to the participants (using raw water from TRWD). The participants in the project would include Annetta, Annetta South, Hudson Oaks, and Willow Park. The projected capital cost for the East Parker County System is $6.1 million.

Water user groups that will obtain additional water from sources other than those provided by these wholesale water providers or the East Parker County System include the following:

- Aledo, Annetta, Annetta South, Hudson Oaks, and Reno will overdraft the Trinity aquifer in 2010.
- The portion of County-Other and manufacturing supplied by Mineral Wells (Region G) will continue to purchase water from Mineral Wells.
- Steam electric power will be supplied by reuse from Weatherford and raw water from the Brazos River Authority (Region G).

Table 4F.32 shows the estimated capital costs for the Parker County water management strategies not associated with the wholesale water providers.

Table 4F.31
Recommended Water Management Strategies for Parker County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Aledo	904	Trinity aquifer	Water conservation Supplemental wells in Trinity aquifer Overdraft Trinity aquifer in 2010 Purchase Fort Worth (TRWD) water
Annetta	231	Trinity aquifer	Water conservation Supplemental wells in Trinity aquifer Overdraft Trinity aquifer in 2010 East Parker County System
Annetta South	64	Trinity aquifer	Water conservation Supplemental wells in Trinity aquifer Overdraft Trinity aquifer in 2010 East Parker County System

Table 4F.31, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Azle	612	TRWD	Water conservation Additional TRWD water Treatment plant expansions
Fort Worth	14,140	See Fort Worth wholesale water provider information in Section 4E	See Fort Worth wholesale water provider information in Section 4E
Hudson Oaks	855	Trinity aquifer Parker County Utility District (Weatherford)	Water conservation Supplemental wells in Trinity aquifer Overdraft Trinity aquifer in 2010 Parker County Utility District (Weatherford)
Mineral Wells	0	Lake Palo Pinto	Water conservation See Brazos G Regional Plan
Reno	95	Trinity aquifer Springtown (TRWD) Walnut Creek SUD (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional Springtown (TRWD) water Additional Walnut Creek SUD (TRWD) water
Springtown	563	Trinity aquifer TRWD	Water conservation Supplemental wells in Trinity aquifer Additional TRWD water Walnut Creek SUD (TRWD) water
Walnut Creek SUD	2,815	TRWD	See Section 4E for wholesale water providers
Weatherford	6,598	Trinity aquifer Lake Weatherford TRWD	See Section 4E for wholesale water providers
Willow Park	706	Trinity aquifer	Water conservation Supplemental wells in Trinity aquifer East Parker County System
County-Other	382	Trinity aquifer Other aquifer Mineral Wells (Region G) TRWD (from Weatherford and Walnut Creek SUD)	Water conservation Supplemental wells in Trinity aquifer Purchase TRWD water (from Weatherford, Walnut Creek SUD, and Fort Worth) Purchase additional Mineral Wells (Brazos G Region)

Table 4F.31, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Irrigation	0	Local Supply Trinity aquifer Direct reuse from Weatherford	Supplemental wells in Trinity aquifer
Livestock	0	Local Supply Trinity aquifer	Supplemental wells in Trinity aquifer
Manufacturing	860	Trinity aquifer Mineral Wells Weatherford	Water conservation Supplemental wells in Trinity aquifer Additional Mineral Wells water Additional Weatherford water
Mining	0	Mining Local Supply Trinity aquifer BRA (Possum Kingdom Lake)	Supplemental wells in Trinity aquifer
Steam Electric Power	8,877	Weatherford	Purchase raw water from BRA Purchase reuse water from Weatherford

Table 4F.32
Capital Costs for Recommended Water Management Strategies for Parker County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
Water Conservation	$19,443
Reuse	$4,017,000
Transmission	$13,067,000
Supplemental Wells	$20,914,348
Total	**$38,017,791**

4F.14 Rockwall County

Table 4F.33 presents a summary of the projected need for additional supplies, the current sources, and the sources of additional supply for each water user group in Rockwall County. The North Texas Municipal Water District (NTMWD) supplies most of the water used in Rockwall County and will continue to do so in the future. Water user groups that currently get water from

NTMWD will purchase additional water from NTMWD to meet future demands. Water user groups that will obtain additional water from sources other than NTMWD include the following:

- The small portion of Dallas located in Rockwall County will continue to be supplied by Dallas Water Utilities.
- Cash SUD is partially supplied by the Sabine River Authority (Region D), as well as the NTMWD. Cash SUD plans to purchase additional water supplies from the Sabine River Authority in the future.

Table 4F.34 shows the estimated capital costs for Rockwall County water management strategies not covered under the wholesale water providers.

Table 4F.33
Recommended Water Management Strategies for Rockwall County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Blackland WSC	955	Rockwall (NTMWD)	Water conservation Additional water from Rockwall (NTMWD)
Cash SUD	127	NTMWD SRA (Lake Tawakoni)	Water conservation Additional SRA (Region D only)
Dallas	0	See DWU wholesale water provider information in Section 4E	See DWU wholesale water provider information in Section 4E
East Fork SUD	5	NTMWD	Water conservation Additional NTMWD water
Forney Lake WSC	1,801	NTMWD	Water conservation Additional NTMWD water
Heath	3,744	NTMWD	Water conservation Additional NTMWD water
High Point WSC	102	City of Terrell Forney (NTMWD)	Water conservation Additional Forney (NTMWD) water Additional Terrell (NTMWD) water
Lavon WSC	939	NTMWD	Water conservation Additional NTMWD water

Table 4F.33, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
McLendon-Chisholm	309	Blackland WSC (NTMWD) R-C-H WSC (NTMWD) High Point WSC (NTMWD)	Water conservation Additional Blackland WSC (NTMWD) Additional R-C-H WSC (NTMWD) Additional High Point WSC (NTMWD)
Mt. Zion WSC	573	NTMWD	Water conservation Additional NTMWD
R-C-H WSC	385	Mt. Zion WSC (NTMWD)	Water conservation Additional Mt. Zion (NTMWD)
Rockwall	14,600	NTMWD	Water conservation Additional NTMWD
Rowlett	1,078	NTMWD	Water conservation Additional NTMWD
Royse City	4,177	NTMWD	Water conservation Additional NTMWD water
Wylie	317	NTMWD	Water conservation Additional NTMWD
County-Other	102	Other aquifer Rockwall (NTMWD)	Water conservation Supplemental wells in other aquifer Additional NTMWD water
Irrigation	341	Local Supply NTMWD reuse Direct reuse from Royce City	Additional NTMWD reuse
Livestock	0	Local Supply Other aquifer	Supplemental wells in other aquifer
Manufacturing	23	Rockwall (NTMWD)	Water conservation Additional Rockwall (NTMWD)
Mining	0	Local Supply	None
Steam Electric Power	0	None	None

Table 4F.34
Capital Costs for Recommended Water Management Strategies for Rockwall County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
Supplemental Wells	$288,456
Total	**$288,456**

4F.15 Tarrant County

Table 4F.35 presents a summary of the projected need for additional supplies, the current sources, and the sources of additional supply for each water user group in Tarrant County. The Tarrant Regional Water District (TRWD) supplies most of the water used in Tarrant County, and will continue to do so in the future. Fort Worth and the Trinity River Authority (TRA) purchase water from TRWD, treat the water, and sell it to various water user groups in Tarrant and surrounding counties. Section 4E discusses the current supplies and recommended strategies for these wholesale water providers.

The current use of groundwater in the Trinity aquifer exceeds the aquifer's long-term reliable supply [(1)]. The recommended strategy for some of the water user groups currently using groundwater is to temporarily overdraft the aquifer through 2010. This strategy allows these water user groups time to develop new supplies or connect to new suppliers. The temporary overdrafting is not expected to cause long-term damage to the aquifer.

Water user groups that currently get water from TRWD, TRA, or Fort Worth will purchase additional water from these suppliers to meet future demands. Water user groups that will obtain additional water from sources other than these suppliers include the following:

- Grand Prairie will purchase water from Mansfield and Midlothian, as well as DWU and Fort Worth.
- Grapevine will purchase additional water from DWU and additional indirect reuse from Dallas County Park Cities MUD.
- Johnson County SUD will purchase water from BRA, DWU, Grand Prairie, and Mansfield. Johnson County SUD is partially located in Regions C and G. Region G will develop water management strategies for the Region G portion of the SUD.
- Kennedale and Pantego will purchase treated water from Fort Worth and Arlington.
- Kennedale, Lakeside, Pantego, and Pelican Bay will overdraft Trinity aquifer in 2010.

Table 4F.36 shows the estimated capital costs for Tarrant County water management strategies not covered under the wholesale water providers.

Table 4F.35
Recommended Water Management Strategies for Tarrant County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Arlington	50,199	Lake Arlington TRWD	Water conservation Additional TRWD water Treatment plant expansions
Azle	4,568	TRWD	Water conservation Additional TRWD water Treatment plant expansion
Bedford	5,880	Trinity aquifer TRA (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional TRA water
Benbrook	5,599	Benbrook WSA (Trinity aquifer and TRWD)	Water conservation Additional water from Benbrook WSA
Bethesda WSC	1,883	Trinity aquifer Fort Worth (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional Fort Worth water (Tarrant & Johnson Counties) Additional pipeline to Fort Worth
Blue Mound	54	Trinity aquifer Tecon (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional Tecon treated water
Burleson	1,069	Fort Worth (TRWD)	Water conservation Additional Fort Worth water Additional pipeline to Fort Worth
Colleyville	5,080	Trinity aquifer TRA (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional TRA water
Community WSC	228	TRWD	Water conservation Additional TRWD water Treatment plant expansion
Crowley	1,834	Trinity aquifer Fort Worth (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional Fort Worth water Additional pipeline to Fort Worth
Dalworthington Gardens	378	Trinity aquifer Fort Worth (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional Fort Worth water
Edgecliff	233	Fort Worth (TRWD)	Water conservation Additional Fort Worth water

Table 4F.35, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Euless	5,715	Trinity aquifer TRA (TRWD)	Water conservation Supplemental wells Additional TRA water
Everman	329	Trinity aquifer Fort Worth (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional Fort Worth water
Forest Hill	1,304	Fort Worth (TRWD)	Water conservation Additional Fort Worth water
Fort Worth	194,136	See Fort Worth wholesale water provider information in Section 4E	See Fort Worth wholesale water provider information in Section 4E
Grand Prairie	5,312	Trinity aquifer (Dallas County) DWU Fort Worth (Tarrant County, TRWD)	Water conservation Supplemental wells in Trinity aquifer (Dallas County) Additional DWU water Purchase treated water from Mansfield Purchase treated water from Midlothian
Grapevine	8,097	TRA (TRWD) DWU Grapevine Lake Indirect reuse from Dallas Co Park Cities MUD	Water conservation Additional DWU water Purchase TRA water Additional indirect reuse from Dallas Co Park Cities MUD
Haltom City	4,523	Fort Worth (TRWD)	Water conservation Additional Fort Worth water
Haslet	680	Trinity aquifer Fort Worth (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional Fort Worth water
Hurst	3,894	Trinity aquifer Fort Worth (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional Fort Worth water
Johnson County SUD	943	Trinity aquifer BRA (Lake Granbury) Mansfield (supplies Region G only)	Water conservation Supplemental wells in Trinity aquifer Purchase DWU water Region G will supply Region G portion, including additional Mansfield water

Table 4F.35, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Keller	5,797	Fort Worth (TRWD)	Water conservation Additional Fort Worth water Additional pipeline to Fort Worth
Kennedale	1,187	Trinity aquifer	Water conservation Overdraft aquifer in 2010 Supplemental wells in Trinity aquifer Purchase Arlington water Purchase Fort Worth water
Lake Worth	543	Trinity aquifer Fort Worth (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional Fort Worth water
Lakeside	579	Trinity aquifer	Water conservation Supplemental wells in Trinity aquifer Overdraft aquifer in 2010 Purchase TRWD water treated by Azle or Fort Worth
Mansfield	22,368	TRWD	Water conservation Additional TRWD water Treatment plant expansions
North Richland Hills	8,699	Trinity aquifer Fort Worth (TRWD) TRA (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional Fort Worth water Additional TRA water Additional pipeline to Fort Worth
Pantego	180	Trinity aquifer	Water conservation Overdraft aquifer in 2010 Supplemental wells in Trinity aquifer Purchase Fort Worth water Purchase Arlington water
Pelican Bay	259	Trinity aquifer	Water conservation Overdraft Trinity aquifer in 2010 new wells Supplemental wells in Trinity aquifer Purchase Azle (TRWD) water
Richland Hills	775	Trinity aquifer Fort Worth (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional Fort Worth water
River Oaks	502	TRWD	Water conservation Additional TRWD water
Saginaw	2,509	Fort Worth (TRWD)	Water conservation Additional Fort Worth water

Table 4F.35, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Sansom Park Village	105	Trinity aquifer Fort Worth (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional Fort Worth water
Southlake	8,670	Fort Worth (TRWD)	Water conservation Additional Fort Worth water Additional pipeline to Fort Worth
Watauga	2,023	North Richland Hills (Fort Worth from TRWD)	Water conservation Additional North Richland Hills (Fort Worth) water Participate in additional pipeline to Fort Worth
Westover Hills	146	Fort Worth (TRWD)	Water conservation Additional Fort Worth water
Westworth Village	197	Fort Worth (TRWD)	Water conservation Additional Fort Worth water
White Settlement	1,317	Trinity aquifer Fort Worth (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional Fort Worth water
County-Other	1,407	Trinity aquifer Fort Worth (TRWD)	Water conservation Supplemental wells in Trinity aquifer Additional Fort Worth water
Irrigation	2,465	Local Supply Trinity aquifer TRWD Mansfield (raw) Indirect reuse from Dallas Co. Park Cities MUD Direct reuse from Fort Worth and Azle	Supplemental wells in Trinity aquifer Reuse from TRA Additional TRWD water
Livestock	0	Local Supply Trinity aquifer	Supplemental wells in Trinity aquifer
Manufacturing	17,638	TRWD through Fort Worth, Arlington, Mansfield, and North Richland Hills	Water conservation Additional TRWD water through Fort Worth, Arlington, Mansfield, and North Richland Hills

Table 4F.35, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Mining	274	Local Supply	Water conservation Purchase TRWD water
Steam Electric Power	3,906	Run-of-the-river TRWD	Additional TRWD water Reuse from Fort Worth

Table 4F.36
Capital Costs for Recommended Water Management Strategies for Tarrant County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
Water Conservation	$313,160
New Water Treatment Plants	$10,305,000
Water Treatment Plant Expansions	$74,788,000
New Wells	$802,000
Reuse	$3,749,000
Transmission	$18,250,000
Supplemental Wells	$60,849,054
Total	**$169,056,214**

4F.16 Wise County

Table 4F.37 presents a summary of the projected need for additional supplies, the current sources, and the sources of additional supply for each water user group in Wise County. The Tarrant Regional Water District (TRWD) supplies some of the water used in Wise County through Decatur, Walnut Creek SUD, West Wise SUD, and Wise County Water Supply District (Decatur). These suppliers plan to continue meeting these demands in the future. Section 4E discusses the current supplies and recommended strategies for the wholesale water providers in Wise County, including Walnut Creek SUD and West Wise SUD.

The current use of groundwater in the Trinity aquifer exceeds the long-term reliable supply [(1)]. The recommended strategy for some of the water user groups currently using groundwater from these sources is to temporarily overdraft the aquifer through 2010. This strategy allows the water user groups dependent on this source time to develop new supplies or connect to new suppliers. The temporary overdrafting is not expected to cause long-term damage to the aquifer.

Water user groups that will obtain additional water from sources other than the wholesale water suppliers in Wise County include the following:

- Alvord will overdraft the Trinity aquifer.
- Bolivar WSC will purchase water from Upper Trinity Regional Water District.
- Chico will purchase water from Bridgeport.

Table 4F.38 shows the estimated capital costs for Wise County water management strategies not covered under the wholesale water providers.

Table 4F.37
Recommended Water Management Strategies for Wise County
- Values in Acre-Feet per Year -

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Alvord	135	Trinity aquifer	Water conservation Overdraft aquifer in 2010 with new well Supplemental wells Purchase Chico water (from West Wise SUD)
Aurora	101	Trinity aquifer	Water conservation Overdraft aquifer in 2010 with existing well Supplemental wells Purchase Rhome (Walnut Creek SUD) water
Bolivar WSC	777	Trinity aquifer	Water conservation Overdraft aquifer in 2010 Supplemental wells Purchase UTRWD water Purchase Gainesville water (Cooke County portion)
Boyd	92	Trinity aquifer Walnut Creek SUD (TRWD)	Water conservation Overdraft aquifer in 2010 with existing well Supplemental wells Additional Walnut Creek SUD water

Table 4F.37, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
Bridgeport	2,744	TRWD	Water conservation Additional TRWD water Treatment plant expansions Raw water system expansion
Chico	365	Trinity aquifer West Wise SUD (TRWD)	Water conservation Supplemental wells Additional West Wise SUD (TRWD) water Purchase Bridgeport water
Community WSC	9	TRWD	Water conservation Additional TRWD water Treatment plant expansion
Decatur	3,631	Wise County WSD (TRWD)	Water conservation Additional Wise County WSD water Treatment plant expansions (Wise County WSD) Raw water system
Fort Worth	3,689	See Fort Worth wholesale water provider information in Section 4E	See Fort Worth wholesale water provider information in Section 4E
New Fairview	476	Trinity aquifer	Water conservation Supplemental wells Purchase Rhome (Walnut Creek SUD) water
Newark	695	Trinity aquifer	Water conservation Supplemental wells Purchase Rhome (Walnut Creek SUD) water
Rhome	1,859	Trinity aquifer Walnut Creek SUD	Water conservation Supplemental wells Purchase Walnut Creek SUD (TRWD) water
Runaway Bay	372	TRWD	Water conservation Treatment plant expansion Additional TRWD water
Walnut Creek SUD	393	TRWD	Water conservation Additional TRWD water Treatment plant expansion Raw water pipeline system expansion Treated water pipeline system expansion

Table 4F.37, Continued

Water User Group	Maximum Needs	Current Supplies	Recommended Water Management Strategies
West Wise SUD	440	TRWD Walnut Creek SUD (TRWD)	Water conservation Additional TRWD water Additional Walnut Creek SUD (TRWD) New water treatment plant Treatment plant expansion
County-Other	1,564	Trinity aquifer Walnut Creek SUD (TRWD)	Water conservation Overdraft aquifer with existing wells Supplemental wells Additional Walnut Creek SUD (TRWD) water
Irrigation	55	Local Supply Trinity aquifer TRWD	Supplemental wells Additional TRWD water
Livestock	0	Local Supply Trinity aquifer	Supplemental wells
Manufacturing	2,089	Other aquifer Decatur (TRWD) Bridgeport (TRWD)	Water conservation Supplemental wells Additional Decatur (TRWD) water Additional Bridgeport (TRWD) water
Mining	29,193	Trinity aquifer Run-of-the-river Reuse TRWD	Supplemental wells Additional TRWD water Recycling available water
Steam Electric Power	8,827	TRWD	Additional TRWD water Reuse from Bridgeport Reuse from Decatur

Table 4F.38
Capital Costs for Recommended Water Management Strategies for Wise County Not Covered Under Wholesale Water Providers
- Based on 2002 Construction Costs -

Management Strategy	Estimated Capital Cost
Water Conservation	$5,000
New Water Treatment Plants	$10,759,000
Water Treatment Plant Expansions	$16,842,000
Reuse	$5,134,000
Transmission Facility Improvements	$18,456,000
New wells	$297,000
Supplemental Wells	$9,339,489
Total	**$60,832,489**

SECTION 4F
LIST OF REFERENCES

(1) R.W. Harden and Associates, Inc., HDR Engineering, Inc., LBG-Guyton Associates, Freese and Nichols, Inc., United States Geological Survey, and Dr. Joe Yelderman: *Northern Trinity/Woodbine Aquifer Groundwater Availability Model*, prepared for the Texas Water Development Board, Austin, August 31, 2004.

(2) Freese and Nichols, Inc., Alan Plummer Associates, Inc., Chiang, Patel & Yerby, Inc., and Cooksey Communications, Inc.: *Region C Water Plan*, prepared for the Region C Water Planning Group, Fort Worth, January 2001.

(3) Mid-East Texas Groundwater Conservation District created by the Texas Legislature, Chapter 1507, Art. 4 (HB 1784) and Ch. 966, Art. 3, Part 15, (SB 1), 77th Leg., September 2001, confirmed November 2002.

(4) Lesikar, B., R. Kaiser, V. Silvy, *Questions about Groundwater Conservation Districts in Texas*, published by the Texas Cooperative Extension, College Station, June 2002.

(5) Neches and Trinity Valleys Groundwater Conservation District created by the Texas Legislature, Ch. 1387, 77th Leg., September 2001 (SB 1821), confirmed November 2001.

5. Impacts of Recommended Water Management Strategies

The previous section presented a set of recommended water management strategies for Region C wholesale water providers and water user groups. This section discusses the impacts of the recommended water management strategies on key parameters of water quality, the impacts of moving water from rural and agricultural areas, and impacts to third parties.

5.1 Impacts of Recommended Water Management Strategies on Key Water Quality Parameters

For a given water resource, the impact of water management strategies on key water quality parameters is evaluated by comparing current water quality conditions with anticipated water quality conditions when water management strategies are in place. Many of the recommended water management strategies involve diverting water from one water body and discharging this water to another water body. For these strategies, the difference in the quality of the two waters, the quantity of water discharged, and the effectiveness of any mitigation is used to project the impact on the receiving water. Selection of the key water quality parameters used for this comparison is based on the importance of these parameters to the use of the water resource.

The recommended water management strategies can be grouped into the following strategy types:

- Existing surface water sources
- New surface water sources
- Existing groundwater sources
- New groundwater sources
- Direct reuse
- Indirect reuse
- Conservation
- Other

In general, each strategy within a strategy type is anticipated to have a similar qualitative impact on key water quality parameters in the receiving water. Exceptions to this generalization are addressed where appropriate. The strategy type defined as "other" includes strategies that do not involve discharge of one source to another and, therefore, have no impact on water quality in the receiving water. Examples of strategies in this category include increased pipeline capacity to a particular water user group or connection of a water user group to a wholesale provider.

The following sections define the parameters selected as key water quality parameters and present the evaluation of impacts of recommended water management strategies on these key parameters.

Selection of Key Water Quality Parameters

Selection of key water quality parameters involved a two-stage approach. First, a list of candidate water quality parameters was compiled from several sources. Then, key water quality parameters were selected from the list of potential parameters based on the general guidelines described below.

Candidate water quality parameters were identified using the following sources:

- Parameters regulated by the Texas Commission on Environmental Quality (TCEQ) in the Texas Surface Water Quality Standards (TSWQS) [(1)]
- Parameters considered for the TCEQ Water Quality Inventory in evaluation of whether water body uses are supported, not supported, or have water quality concerns. The designated water body uses included in the Water Quality Inventory are:
    - Aquatic life use
    - Contact recreation use
    - General use
    - Fish consumption use
    - Public water supply use
- Parameters that may impact suitability of water for irrigation
- Parameters that may impact treatability of water for municipal or industrial supply.

The first two categories above represent environmental water quality parameters, and the last two categories represent water quality as related to water uses.

To develop a manageable and meaningful list of key water quality parameters, the following general guidelines were established for parameter selection:

- Selected parameters should be representative of water quality conditions that may be impacted on a regional scale and that are likely to be impacted by multiple water management strategies within the region. Water quality issues associated with localized conditions (such as elevated levels of a toxic material within one water body) will be addressed as necessary within the environmental impact evaluations of the individual water management strategies for each water user group.

- Sufficient data must be available for a parameter in order to include it as a key water quality parameter. If meaningful statistical summaries cannot be carried out on the parameter, it should not be designated as a key water quality parameter.

A detailed discussion of the selection of key water quality parameters and definition of baseline conditions for these parameters is included in Appendix P. Table 5.1 summarizes the key water quality parameters selected by the Region C Water Planning Group.

Table 5.1
Region C Key Water Quality Parameters

Surface Water	Groundwater
Ammonia Nitrogen	Total Dissolved Solids (TDS)
Nitrate Nitrogen	
Total Phosphorus	
Chlorophyll-a	
Total Dissolved Solids (TDS)	

Evaluation of Water Quality Impacts

Impacts of recommended water management strategies on key water quality parameters were assessed by comparing the water quality of the source water for a given strategy with that of the receiving water. This comparison included an evaluation of historical median concentrations of key parameters, together with consideration of data quality, relative quantities of water, and planned mitigation measures (e.g., treatment, blending, or other operational strategies that serve to mitigate water quality impacts). Each recommended strategy was assigned one of the following five anticipated impact ratings: low, medium low, medium, medium high, and high. A complete listing of the anticipated impact ratings for each recommended and alternative water management strategy is included in Appendix P. No recommended or alternative water management strategy is anticipated to have more than a "medium" impact on key water quality parameters. A "medium" impact is considered to be an impact that results in some changes in water quality, but does not result in impairment of the designated uses of the water body.

The following sections present a discussion of the anticipated water quality impacts for each strategy type. Table 5.2 summarizes the range of anticipated water quality impacts within these strategy types.

Table 5.2
Range of Anticipated Impacts on Key Water Quality Parameters by Strategy Type

Strategy Type	Range of Anticipated Impacts on Key Water Quality Parameters	Comments
Existing Surface Water Sources	Low - Medium	Lake Texoma strategies assumed to include mitigation for TDS.
Existing Groundwater Sources	Low – Medium Low	
New Surface Water Sources	Low – Medium	Water quality in new sources difficult to predict.
New Groundwater Sources	Medium	
Direct Reuse	Low/Positive	Potential positive impact resulting from reduced nutrient and TDS loadings to surface waters.
Indirect Reuse	Medium	Assumes mitigation to control impacts on nutrients and TDS, if necessary.
Conservation	Low	
Other	Low	Includes strategies that do not involve blending of two water sources (e.g. direct pipeline to a water treatment plant).

Existing Surface Water Sources

For strategies utilizing existing surface water sources, impacts on key water quality parameters vary depending on a number of factors, including the location of the source and the intended destination of the water transfer. For strategies that involve pumping existing surface water directly to a water treatment plant, no impact on water quality is anticipated (resulting in a rating of "low"). However, when water is pumped from one source to another, the impacts will depend on the existing water quality of the two sources, as well as the quantities to be transferred and any mitigation that may be applied.

Many of the recommended and alternative strategies call for increased use of water from East Texas reservoirs. In general, reservoirs in East Texas have higher concentrations of nutrients (i.e., nitrogen and phosphorus) than many of the Region C reservoirs. The ultimate impact of importing water with higher nutrient concentrations to Region C reservoirs is difficult to predict due to the complex kinetic relationships between nutrients and chlorophyll-a. Strategies that involve importing water from East Texas reservoirs to Region C reservoirs may result in increases in ammonia, nitrate, total phosphorus, and/or chlorophyll-a, but are not likely to lead to impacts that would impair the designated uses of the Region C water bodies. In general, the total dissolved solids (TDS) concentrations in East Texas reservoirs are lower than in Region C reservoirs. Therefore, in nearly all cases, transfer of East Texas water to Region C reservoirs will have a positive impact on TDS concentrations in the receiving water bodies. All of the recommended water management strategies involving importation of East Texas water to Region C reservoirs are anticipated to have a "low" or "medium-low" impact on key water quality parameters.

In addition to strategies that include transfers from East Texas reservoirs to Region C reservoirs, several recommended and alternative strategies include intermediate transfers between reservoirs outside of Region C. These include transfers from Wright Patman Lake to Lake Fork Reservoir and Chapman Lake and from Toledo Bend Reservoir to Lake Fork Reservoir, Lake Tawakoni, and Chapman Lake. Although there are some minor variations in water quality among these reservoirs, these strategies are all anticipated to have no more than a "medium-low" impact on the key water quality parameters.

Lake Texoma is included in the recommended and alternative strategies for multiple entities. Currently, typical TDS concentrations in Lake Texoma are in the 800-1,200 milligram per liter (mg/L) range. Most Trinity River basin reservoirs in Region C have TDS standards (from the TSWQS) in the 400-500 mg/L range. Therefore, to import a significant quantity of Lake Texoma water into a Trinity River Basin reservoir, mitigation will likely be needed in the form of desalination or blending with another lower TDS water (such as an East Texas source) to prevent significant increases in TDS concentrations in the receiving body and to prevent violation of the Texas Surface Water Quality Standard for TDS. To project the impact of strategies involving use of Lake Texoma water, it has been assumed that mitigation measures will be used to maintain TDS concentrations in the receiving water body at levels that do not violate the Texas Surface Water Quality Standard for TDS. In addition, for strategies that use desalination treatment as mitigation, disposal of the highly saline reject stream can result in increased TDS concentrations, depending on the method and location of disposal. Based on these issues, each of the recommended strategies involving importation of Lake Texoma water to another reservoir is anticipated to have no more than a “medium” impact on key water quality parameters.

New Surface Water Sources

In general, the impact of the development of new surface water sources on key water quality parameters will be similar to that of existing reservoir sources. All of the proposed reservoir sites identified as potential Region C sources are located in the Red, Sulphur, Sabine, Cypress, or Neches River Basins. As such, the impacts on key water quality parameters from these reservoirs are likely to be similar to the impacts of importing existing East Texas sources to the Trinity River Basin. (The proposed reservoir in the Red River Basin, Lower Bois d’Arc Creek Reservoir, is on a low-TDS tributary of the Red River.) All strategies involving the importation of water from new reservoirs to Trinity River Basin reservoirs are anticipated to have no more than a “medium” impact on key water quality parameters. Water management strategies calling for the pumping of new surface water sources directly to a water treatment plant are anticipated to have a “low” impact on key water quality parameters.

Two new surface water source strategies involve the transfer of water between reservoirs that are both outside of Region C. These include the recommended strategy for Dallas Water Utilities involving transfer of Lake Fastrill water to Lake Palestine and the alternative strategy for Dallas Water Utilities involving transfer of Lake Columbia water to Lake Palestine. These strategies are anticipated to have no more than a “medium” impact on water quality parameters.

Existing Groundwater Sources

Since all recommended strategies involving existing groundwater sources do not involve blending of groundwater within a supply reservoir, no significant impacts on key surface water quality parameters are expected. For those strategies involving the temporary overdrafting of an aquifer, groundwater TDS concentrations could increase in the presence of underlying brackish waters. However, no strategies call for long-term overdrafting of groundwater supplies and, therefore, this potential impact is anticipated to be temporary. Potential impacts on key water quality parameters resulting from alternative and recommended strategies in this category are anticipated to be “low” or “medium low”.

New Groundwater Sources

There are no new major groundwater sources included in the recommended water management strategies for Region C. However, several alternative strategies propose obtaining water from groundwater sources that are new to the region, Roberts County groundwater and Brazos County groundwater. Potential receiving water bodies for groundwater from Roberts County include Ray Roberts Lake (Dallas Water Utilities), Lake Lavon (North Texas Municipal Water District), and Lake Bridgeport (Tarrant Regional Water District). Roberts County groundwater, which is drawn from the Ogallala aquifer, has a median TDS concentration that is only slightly higher than that in the potential receiving water bodies. However, the median nitrate concentration is high in comparison to baseline nitrate concentrations in each of the potential receiving water bodies. As a result of the high nitrate concentration in this groundwater source, this group of strategies is anticipated to have a "medium" impact on key water quality parameters.

Lake Lavon (North Texas Municipal Water District) is the potential receiving water body for Brazos County groundwater. Brazos County groundwater, drawn from the Carrizo-Wilcox aquifer, has a median TDS concentration that is greater than that in Lake Lavon and greater than the stream standard for Lake Lavon. The TDS concentration in Brazos County groundwater relative to the stream standard may limit the use of this resource in Region C. As a result this strategy is anticipated to have a "medium" impact on key water quality parameters.

Direct Reuse

By definition, direct reuse involves the transfer of treated wastewater effluent directly to a point of use and not into another water body. As such, the impact on key water quality parameters for all direct reuse strategies is anticipated to be "low." In some cases there may be a positive impact. By reducing the quantity of effluent discharged into a stream or reservoir segment, the nutrient and TDS loads to that segment will also be reduced, thereby potentially improving downstream water quality.

Indirect Reuse

Indirect reuse is a recommended strategy for multiple entities within Region C. This strategy involves the discharge of treated wastewater effluent into a body of water used for water supply. Treated wastewater can contain nutrient and TDS concentrations that are high in comparison to the receiving water. However, for most of the recommended strategies that include indirect reuse, some form of mitigation (e.g., advanced wastewater treatment, constructed wetlands, blending, etc.) is planned to address potential water quality impacts associated with nutrients and TDS. For the purposes of this evaluation, it is assumed that some form of mitigation for potential water quality impacts associated with the key parameters will be implemented, if necessary, such that the designated uses of the water body will not be impaired. For this reason, recommended indirect reuse strategies are anticipated to have no more than a "medium" impact on key water quality parameters.

Conservation

Conservation is a recommended strategy for all municipal water user groups in Region C, including those without shortages. Water conservation is not expected to impact the key water quality parameters in Region C.

5.2 Impacts of Recommended Water Management Strategies on Moving Water from Rural and Agricultural Areas and Impacts to Third Parties

This section discusses the potential impacts of the recommended water plan on rural and agricultural activities and possible impacts to third party entities, and specifically focuses on the impacts associated with moving water from rural and agricultural areas. This section also discusses the considerations given during the development of the plan to protect rural and agricultural activities.

The recommended Region C water plan includes several strategies that move water from rural areas to urban centers. These strategies fall into two general categories:

- New connections to existing water sources: Toledo Bend Reservoir to TRWD and NTMWD, Wright Patman Lake to DWU, Lake Fork Reservoir to DWU, Lake Palestine to DWU, Texoma to NTMWD and GTUA, Oklahoma water to NTMWD, TRWD and UTRWD, etc.

- New reservoirs: Marvin Nichols, Ralph Hall, Lower Bois d'Arc Creek, and Fastrill.

Large groundwater projects also may move large quantities of water from rural to urban areas, but these are not recommended strategies. Both the Roberts County Project and the Carrizo-Wilcox project in Brazos County are identified as alternate strategies.

The impacts from the recommended water management strategies will vary depending on the location of the project, current use of the water and the quantity of water that is being transferred. The types of impacts that may occur include:

- Transfer of water rights from agricultural use to other uses.
- Removal of agriculture through inundation from new reservoirs.
- Changes in stream flow immediately downstream of a new reservoir.
- Increased water level fluctuations at existing lakes as more water is used.

The recommended water plan considered many different factors as strategies were developed and recommended for inclusion. One consideration is the development of a plan that minimizes the potential impacts to rural and agricultural areas through utilization of existing sources with a strong emphasis on conservation and reuse. Over 25 percent of the water available to Region C in 2060 under this plan is from conservation and reuse – over 35 percent of the new supplies to the region. The emphasis on conservation and reuse reduces the number of strategies and amount of water needed from other sources, including transfers of water from rural and agricultural areas.

Other protections for agricultural and rural uses were incorporated in the process of evaluating and allocating water supplies. Specifically, these include:

- Existing and proposed surface water supplies were evaluated under the prior appropriation doctrine that governs surface water rights and protects senior water rights. In the final Region C Water Plan, there are no transfers of irrigation water rights to urban uses.
- The amount of available supplies from existing sources was limited to firm yield. Existing uses from these sources were protected through the allocation process and only the amount of water that is currently permitted (up to the firm yield) was considered for transfer to Region C. Three existing reservoirs (Texoma, Wright Patman and Toledo Bend) are currently

seeking or are recommended to seek additional water rights. This additional water would not impact agricultural or rural activities.

- Supplies from new reservoirs considered instream flow releases in accordance with the planning guidelines set forth by the TWDB. These releases protect recreational and non-consumptive water needs downstream of the proposed reservoir sites.

In Region C there is little irrigated agriculture. Most of the irrigation water demand is associated with golf course irrigation in and near urban areas, and much of this water need will be met through reuse. There are no recommended transfers of needed irrigation to other uses and all irrigation and livestock water needs are met through the recommended plan. The potential impacts to agricultural and rural areas are limited to the loss of land from inundation of new reservoirs. The total rural acreage that would be flooded under the Region C water plan is 116,300 acres. Of this amount, many acres are bottomlands that are not currently used for agriculture. Impacts from new reservoirs will be mitigated as part of the permitting process. New reservoirs also can stimulate the rural economy through new recreational business and local improvements. The new reservoirs will provide a new water source for rural activities. Each of the proposed reservoir sites includes water set aside for local water supplies.

Possible third party impacts include loss of land and timber, impacts to existing recreational business on existing lakes due to lower lake levels, and impacts to recreational stream activities. Economic studies have been conducted for two of the reservoirs proposed for Region C, and in each case they indicate a significant net economic benefit to the region of origin [2, 3].

The impacts to recreational activities and recreational businesses at existing lakes are expected to be low. While water levels at local and rural lakes may fluctuate more under the recommended plan, these water level changes are within the design constraints of the reservoirs. Four of the major water transmission strategies have water sources that are located in highly prolific rainfall areas. Significant changes in water levels at these sources would be limited to extreme drought.

Impacts to recreational stream activities are mitigated through the permitting process and requirements for instream flow releases. New reservoirs offer new recreational opportunities and recreational business growth that could spur the local economies of rural areas.

CHAPTER 5
LIST OF REFERENCES

(1) Texas Administrative Code, Title 30, Chapter 307, [Online], Available URL: http://www.tceq.state.tx.us/assets/public/legal/rules/rules/pdflib/307%60.pdf, December 2005.

(2) Weinstein, B. L. and T. L. Clower: *The Economic, Fiscal, and Developmental Impacts of the Proposed Marvin Nichols Reservoir Project*, prepared for the Sulphur River Basin Authority, Denton, March 2003.

(3) Clower, T. L. and B. L. Weinstein: *The Economic, Fiscal, and Developmental Impacts of the Proposed Lower Bois d'Arc Reservoir Project*, prepared for the North Texas Municipal Water District, Denton, September 2004.

6. Water Conservation and Drought Management Recommendations

This chapter consolidates the water conservation and drought management recommendations in the *2006 Region C Water Plan*, presenting an introduction (Section 6.1); a summary of Region C Water Planning Group decisions regarding water conservation, reuse, and drought management (Section 6.2); a discussion of trends in per capita water use in different regions of the state (Section 6.3), a discussion of current water conservation practices, current reuse projects, and recommended water conservation and reuse strategies for Region C (Section 6.4); a review of the projected per capita use in Region C with the recommended strategies (Section 6.5), a discussion of water conservation policy recommendations (Section 6.6); a discussion of model water conservation plans (Section 6.7); and a discussion of drought management planning (Section 6.8). An evaluation of consistency of the 2006 *Region C Water Plan* with the water conservation and drought management planning requirements is presented in Section 6.9.

6.1 Introduction

In the 2001 *Region C Water Plan* [(1)], the projected municipal water demands for Region C included water conservation savings of 15 percent in per capita municipal water use for the region. The Region C Water Planning Group adopted the following strategies in the 2001 Plan to pursue water conservation:

- Take active measures to achieve the 15 percent water conservation savings included in the municipal demand projections. Measures would include:
    - Low-flow plumbing fixtures (required by state and federal law)
    - Outdoor water conservation measures
    - Improved indoor water use habits
    - Continued and expanded public education programs for water conservation
        - Education for policy makers
        - Education programs in the public schools.
- Assess the effectiveness and applicability of specific water conservation measures in Region C during the next five years.
- Encourage state funding for research on the effectiveness of water conservation programs and for support of education programs.

Since the Region C Water Planning Group made these recommendations, additional information has been developed regarding the potential for water conservation in Texas, and the Texas Water Development Board (TWDB) has updated the regional water planning rules. New information is discussed below, following a review of the definitions of conservation and drought management measures.

Definitions

The Texas Water Code §11.002(8) defines *conservation* as "the development of water resources; and those practices, techniques, and technologies that will reduce the consumption of water, reduce the loss or waste of water, improve the efficiency in the use of water, or increase the recycling and reuse of water so that a water supply is made available for future or alternative uses." By this definition, it is clear that reuse of treated wastewater effluent is a water conservation measure.

Although water conservation measures and drought or emergency water management measures both save water, water conservation measures are fundamentally different from drought or emergency management measures. *Drought/emergency management measures* are temporary measures that are implemented when certain criteria are met and are terminated when these criteria are no longer met, while water conservation measures are designed to provide permanent or long-term water savings.

Information Developed Since 2001 *Region C Water Plan*

In May 2002, the TWDB-sponsored study [(2)] *Quantifying the Effectiveness of Various Water Conservation Techniques in Texas* was completed. This report provided estimates of potential water savings in each planning region from several municipal and commercial water conservation strategies. This report has been reviewed by the consultants to the Region C Water Planning Group and used in the development and evaluation of potentially feasible water conservation strategies (discussed in Section 6.3).

In Senate Bill 1094, the 78th Texas Legislature created the Water Conservation Implementation Task Force. Among other tasks, the Task Force was asked to identify, evaluate, and select best management practices for municipal, industrial, and agricultural water uses; evaluate the costs and benefits for the selected best management practices; evaluate the implementation of water conservation strategies recommended in regional and state water plans; and advise the TWDB and the Texas Commission on Environmental Quality (TCEQ) on establishing per capita water use targets and goals, accounting for such local effects as climate and demographics.

In 2004, the Task Force published the *Water Conservation Best Management Practices Guide* [3] and the *Report to the 79th Legislature* [4]. The reports included a number of recommendations regarding water conservation and regional water planning. These recommendations include the following:

- The implementation of Best Management Practices (BMPs) and the adoption of goals should be voluntary. State policies should recognize the fundamental decision-making primacy and prerogative of planning groups, municipalities, industrial and agricultural water users, and water providers.
- Municipal water user groups that are developing water conservation plans should consider a target that implements a minimum one percent per year reduction in total per capita water use, based on a rolling five-year average, until the total per capita water use is 140 gallons per capita per day (gpcd) or less. [Note that the Task Force also recommended that water supplied by indirect reuse should be credited against total diversion volumes when computing per capita water use.]
- The TWDB should work with manufacturers of water-using equipment, water utilities, water users, and others to reduce overall statewide residential indoor water use to 50 gpcd through education, research, and funding programs.
- Municipal water user groups with projected water needs should first meet or reduce the need using advanced water conservation strategies (beyond implementation of state plumbing fixture requirements and adoption and implementation of water conservation education programs).

New Regional Planning Requirements

The TWDB has revised its planning guidelines since the last round of regional water planning. For each water user group with a projected water need, the Region C Water Planning Group must:

- include water conservation practices for each water user group that must prepare a water conservation plan under Texas Water Code §11.1271
- consider water conservation practices for other water user groups (and document the reason if it does not adopt a water conservation practice that exceeds minimum levels)
- include a conservation water management strategy for each water user group or wholesale water provider that is to obtain water from a proposed interbasin transfer to which Texas

Water Code §11.085(l) applies that will result in the highest practicable level of water conservation and efficiency achievable

- consider strategies to address any issues identified in the information compiled by the TWDB from the water loss audits performed by retail public utilities [a]
- include drought management measures for each water user group that must prepare a drought contingency plan under Texas Water Code §11.1272
- consider drought management measures for other water user groups (and document the reason if it does not adopt a drought management measure)

The Region C Water Planning Group must also:

- include in its regional water plan a model water conservation plan pursuant to Texas Water Code §11.1271
- include in its regional water plan a model drought contingency plan pursuant to Texas Water Code §11.1272.

6.2 Summary of Region C Water Planning Group Decisions

TWDB planning rules call for "evaluation of all water management strategies that the regional water planning group determines to be potentially feasible," including water conservation practices, reuse of treated wastewater effluent, and drought management measures. This section summarizes the decision of the Region C Water Planning Group for each of these water management strategies.

Water Conservation

As discussed above, the legislature, the Water Conservation Implementation Task Force, and the Texas Water Development Board have been very active in the area of water conservation since the development of the 2001 *Region C Water Plan* [(1)]. A significant amount of new information about the potential for water conservation in Region C has been developed in the interim period, and the revised planning rules require incorporation of water conservation strategies for certain water user groups.

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[a] This requirement was added to the TWDB planning guidelines on December 2, 2004, and does not apply to the 2006 regional water plans. Information from water loss audits will not be available until after the plans are adopted.

(a) Summary of Decision: Incorporate water management strategies involving water conservation as a major component of the long-term water supply for Region C.

Reuse of Treated Wastewater Effluent

Reuse of treated wastewater effluent is becoming an increasingly important source of water in Region C and across the state of Texas. The 2001 *Region C Water Plan* [(1)] projected that the reuse of reclaimed water would provide supply equal to approximately 18 percent of the 2050 Region C water demand [(1)]. There are a number of water reuse projects in operation in Region C, and many others are currently in the planning and permitting process. Reuse will serve a major role in meeting future water supply requirements for the region.

Direct reuse and indirect reuse have significantly different permitting requirements and potential applications. Direct reuse occurs when treated wastewater is delivered from a wastewater treatment plant to a water user, with no intervening discharge to waters of the state. Direct reuse requires a notification to the Texas Commission on Environmental Quality (TCEQ), which is routinely accepted so long as requirements to protect public health are met. Direct reuse is most commonly used to supply water for landscape irrigation (especially golf courses) and industrial uses (especially cooling for steam electric power plants).

Indirect reuse occurs when treated wastewater is discharged to a stream or reservoir and is diverted downstream or out of a reservoir for reuse. The discharged water mixes with ambient water in the stream or reservoir as it travels to the point of diversion. Many of the water supplies within Region C have historically included return flows from treated wastewater as well as natural runoff. Indirect reuse can provide water supplies for municipal use, as well as irrigation and industrial supplies. New indirect reuse projects may require a water right permit from the TCEQ and may also require a wastewater discharge permit from the TCEQ if the discharge location is changed as part of the reuse project. Many Region C reservoirs have water right permits in excess of firm yield, and are currently using return flows in their watersheds to provide a supplement to supply. These return flows may not be a long-term reliable supply if they are diverted for future direct reuse projects.

Potential applications for water reuse in Region C include:

- Landscape irrigation (parks, school grounds, freeway medians, golf courses, cemeteries, residential)
- Agricultural irrigation (crops, commercial nurseries)
- Industrial and power generation reuse (cooling, boiler feed, process water, heavy construction, mining)
- Recreational/environmental uses (lakes and ponds, wetlands, stream flow augmentation)
- Supplementing potable water supplies (surface and groundwater supplies).

There are a number of benefits associated with water reuse as a water management strategy, including:

- Water reuse represents an effective water conservation measure.
- Water reuse provides a reliable source that remains available in a drought.
- Water reuse quantities increase as population increases.
- Water demands that can be met by reuse are often near reuse sources.
- Water reuse is a viable way to defer and avoid construction of new surface water impoundments.

Summary of Decision: Incorporate water management strategies involving reuse as a major component of the long-term water supply for Region C. Encourage planning and implementation of additional reuse projects. Monitor legislation and regulatory actions related to reuse.

Drought Management

Drought management and emergency response planning are intended to preserve water resources for the most essential uses when water supplies are threatened by an extraordinary condition such as a multi-year drought, an unexpected increase in demand, or a water supply system component failure.

Regional water supply plans are required to include potential trigger conditions for drought and emergency response measures and potential measures to be taken for each water source in the region. Appendix R includes a summary of current drought contingency and emergency management plans in Region C and potential triggers and response measures. Drought management measures are also discussed in Section 6.4.

Drought management and emergency response measures are important planning tools for all water suppliers. They provide protection in the event of water supply shortages, but they are not a reliable source of additional supplies to meet growing demands. They provide a backup plan in case a supplier experiences a drought worse than the drought of record or if a water management strategy is not fully implemented when it is needed. Therefore, drought management measures are not recommended as a water management strategy to provide additional supplies for Region C.

Summary of Decision: Continue efforts to implement drought management and emergency response planning, but do not treat these as water management strategies to provide additional long-term supplies.

6.3 Trends in Per Capita Water Use in Various Regions

Figures 6.1 and 6.2 show the historical per capita water use in Region C in a statewide context. As shown in Figure 6.1, the year 2000 municipal per capita water use varies among the Senate Bill One regions from a high of over 200 gallons per person per day (gpcd) in the Panhandle to less than 140 gpcd in the Lavaca region. The Region C year 2000 municipal per capita water use of 203 gpcd was the third highest of the 16 regions and was higher than the statewide average of 173 gpcd. The year 2000 non-agricultural per capita water use (including industrial use) in Region C is significantly lower than the statewide average. As shown in Figure 6.2, the year 2000 total per capita water use (including industrial and agricultural use) in Region C is by far the lowest of any region in the state at 235 gpcd and was much lower than the statewide average of 717 gpcd.. The region with the next lowest total per capita water use was Region N at 340 gpcd.

There are several reasons for these differences in water use across the state. Some of the differences lie in the accounting of water use and the ability of some municipalities to accurately separate municipal water use from other uses that are supplied through the municipal retail provider. In some regions, most of the major users receive water from municipal providers. In other regions, there are significant self-supplied users. (Large users tend to develop their own supplies in areas where major groundwater wells can easily be developed and in areas with substantial surface water available.) Some regions seem to experience higher commercial and institutional

Figure 6.1
Municipal Per Capita Water Use by Region

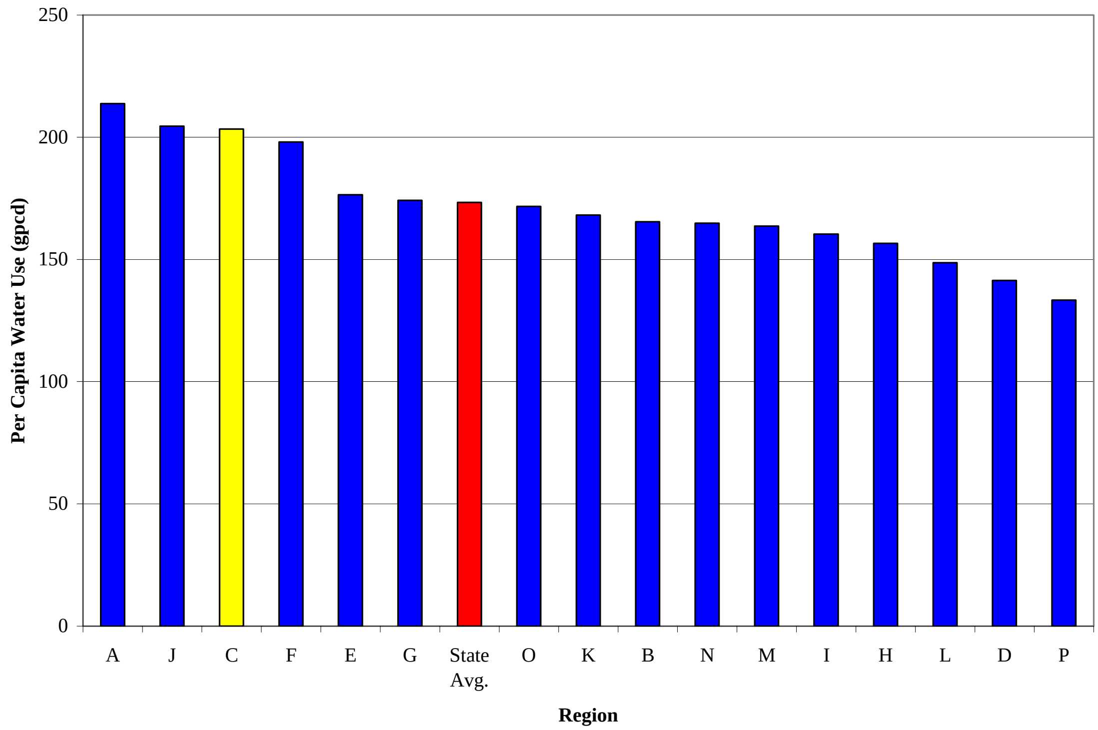
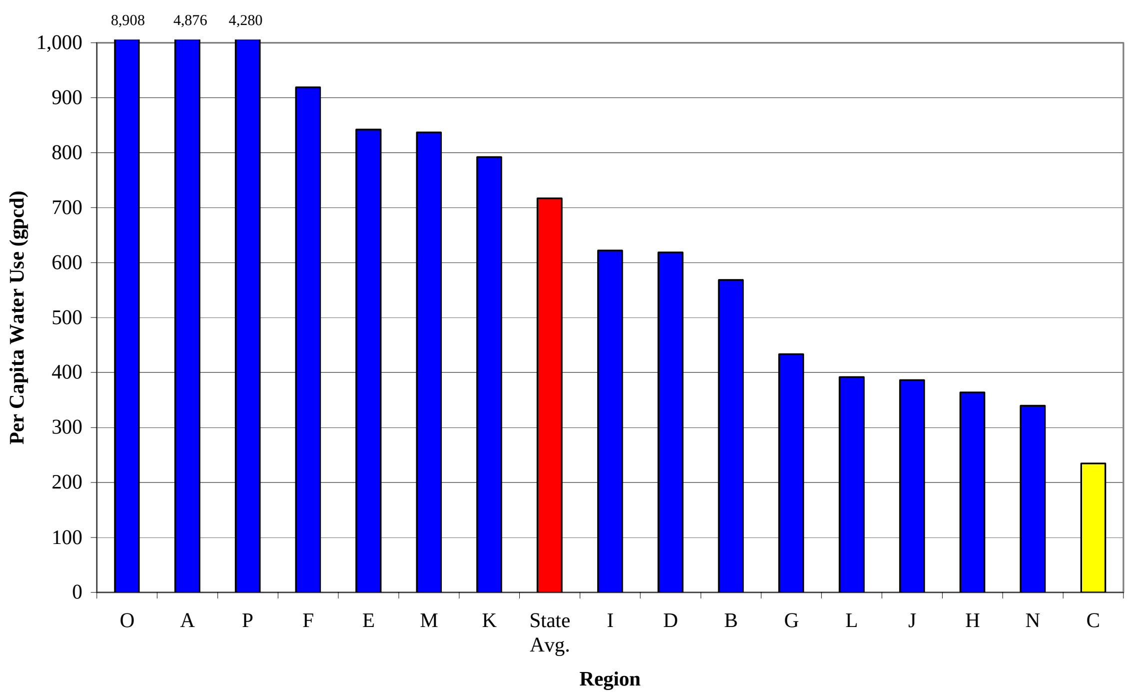


Figure 6.2
Total Per Capita Water Use by Region



water uses than others. Other potential factors that may impact water use include climate, local economy, water prices, availability of water supplies, and active conservation programs.

To better understand the potential impacts of these factors on major metropolitan areas, 12 cities were selected from across the state to evaluate trends in per capita municipal water use and to assess the relative impacts of local factors.

Comparison of Historical Per Capita Municipal Water Use in Various Parts of the State

Twelve major cities in Texas were selected for a comparison of historical per capita municipal water use in various parts of the state: Amarillo, Austin, Beaumont, Brownsville, Corpus Christi, Dallas, El Paso, Fort Worth, Houston, Laredo, Lubbock, and San Antonio.

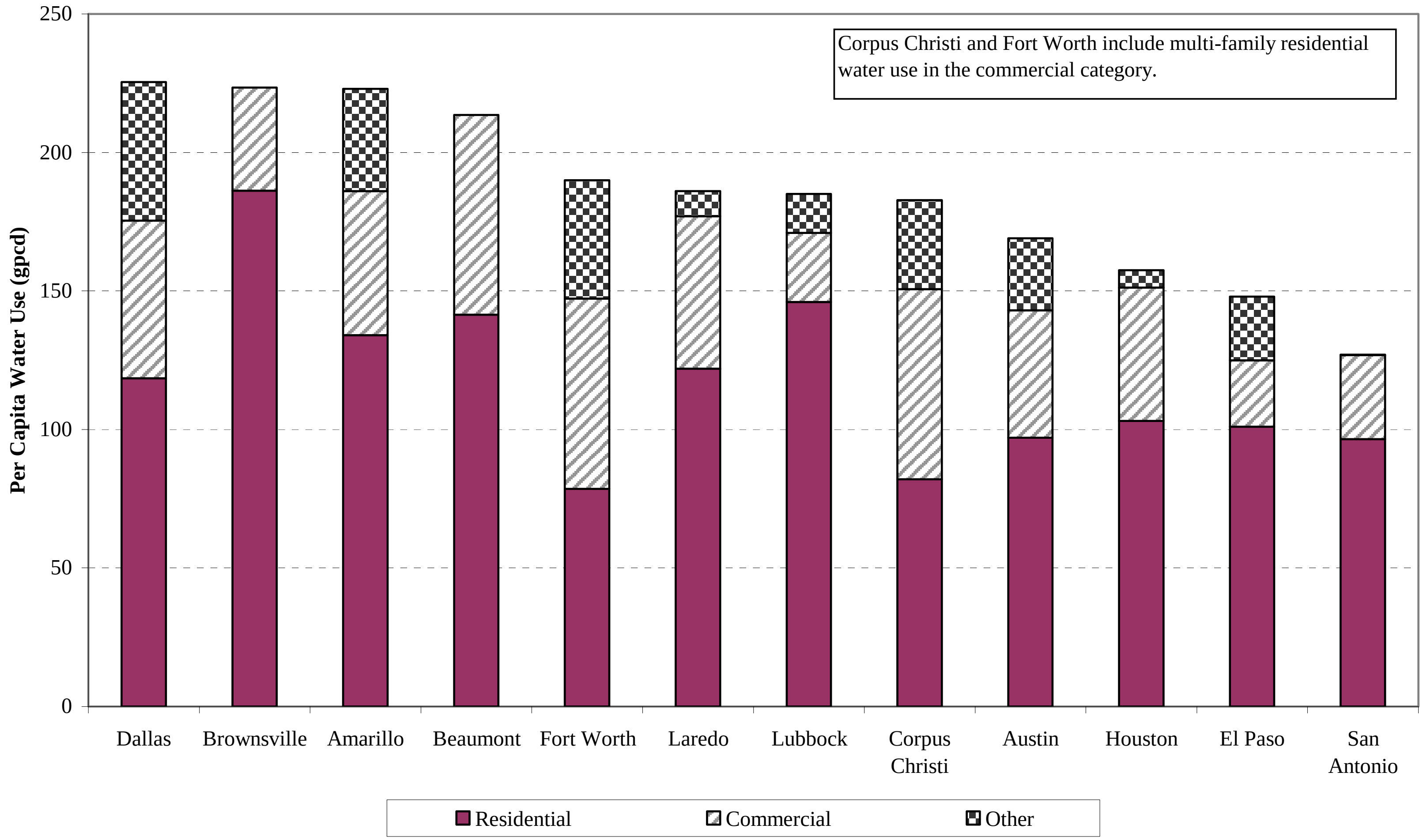
Municipal Per Capita Water Use. Water usage data were requested from each city or city utility. For years where no water use data were provided by the cities, the Texas Water Development Board data were used in the comparison.

There are several different definitions of per capita water use that could be used to compare the suppliers. The Water Conservation Task Force recommended that per capita use be expressed as "the total amount of water diverted and/or pumped for potable use divided by total population. Indirect-reuse-diversion volumes shall be credited against total diversion volumes for the purpose of calculation gpcd for targets and goals."[(4)] The calculation of per capita water use for Senate Bill One planning and this study follows the methodology that has been used by the Texas Water Development Board for previous water planning efforts. The per capita calculations do not include wholesale water sales and industrial water use. The gpcd calculations in this study also do not credit reuse volumes against total use. These values provide historical reference for assessing factors that may impact water use.

Municipal Per Capita Water Use by Category. Beginning in 1994, the Texas Water Development Board (TWDB) requested that cities disclose the percentage of water volume used by the residential, apartments, commercial, and industrial categories. For Amarillo, Beaumont, Brownsville, Corpus Christi, El Paso, Laredo, Lubbock and Houston, averages of the reported percentages, along with the most recent five-year average per capita water use, were used to categorize municipal water use (Figure 6.3). Any water use not covered by the reported

Figure 6.3

Most Recent 5-Year Trailing Average Net Municipal Per Capita Water Use by Category



percentages was placed into the “other” category. Austin, Dallas, Fort Worth, and San Antonio provided a more detailed accounting of water use by category. Industrial water use was not included in the net municipal per capita calculation and therefore is not shown on Figure 6.3. Industrial water sales vary greatly between cities, which may have a significant impact in the calculation of total gpcd as recommended by the Water Conservation Task Force.

In general, cities do not report water volumes for other categories (such as unbilled authorized consumption or water losses) to the TWDB, so to some extent, other categories are included in the residential and commercial estimates for most of the cities in Figure 6.3. Finally, Corpus Christi and Fort Worth include multi-family residential water meters in the commercial category, so a portion of the commercial water use shown in Figure 6.3 is actually residential water use.

For each city, Table 6.1 shows changes in the five-year trailing average per capita water use over time. The five-year trailing average was selected to dampen annual changes in water use that occur due to external factors, such as variations in weather, and for consistency with recommendations of the Water Conservation Implementation Task Force (Chapter 6). Several cities have recent per capita water use greater than 200 gallons per capita per day (gpcd): Amarillo, Dallas, Brownsville, and Beaumont. The San Antonio Water System (SAWS) currently has the lowest current municipal per capita water use (127 gpcd). Over the analysis period, four cities (Beaumont, Amarillo, Brownsville, and Lubbock) experienced an increase in per capita water use of more than 10 percent, and three cities (San Antonio, El Paso, and Houston) experienced decreases of more than 10 percent.

Table 6.1
Five-Year Trailing Average Per Capita Water Use in Selected Cities
- Values in Gallons per Capita per Day (gpcd) -

City	1984	1989	1994	1999	Latest Year		Net Change Over Period
Beaumont	157	147	149	190	214	2002	36.34%
Brownsville	186	179	178	179	223	2002	20.28%
Amarillo	194	191	228	226	223	2003	14.96%
Lubbock	166	162	166	188	185	2002	11.45%
Dallas	212	241	214	222	225	2004	6.55%
Corpus Christi	177	178	174	166	183	2002	3.05%
Laredo	181	180	220	181	186	2002	2.76%
Austin	174	175	163	163	169	2003	-2.91%
Fort Worth	197	200	194	199	190	2004	-3.69%
Houston	182	168	163	150	157	2002	-13.37%
El Paso	188	185	162	163	148	2004	-21.13%
San Antonio Water System	206	181	154	148	127	2004	-38.31%

Analysis of Impact of Various Factors on Municipal Water Use

As shown in Table 6.1, municipal per capita water use varies across the state. It has been suggested that factors such as precipitation, temperature, existing conservation measures, commercial development, water prices, per capita income, water quality, adequacy of supplies, and adequacy of delivery infrastructure may influence water use. Water use is likely influenced by a combination of these factors, and the most influential factors may vary in different parts of the state. Data regarding these factors were collected from available sources for the subject cities, and the potential influence of each factor was analyzed.

Precipitation. Texas experiences a wide range of precipitation, depending on location. Since much of higher municipal water use is typically attributed to outdoor watering in summer months, the relationships of water use to summer precipitation and total precipitation were reviewed. It was found that most cities show a weak relationship or no relationship between summer precipitation and water use, and there does not appear to be a statewide trend in per capita water use versus annual precipitation..

On average, Beaumont and Houston received the most precipitation (approximately 55 inches per year), and El Paso received the least precipitation (approximately 8 inches per year). Although each received plentiful rainfall, Beaumont experienced relatively high per capita water use, and Houston experienced relatively low per capita water use. Among cities that received lesser amounts of rainfall, Laredo and Lubbock experienced moderate per capita water use, while Amarillo and Brownsville experienced relatively high per capita water use.

Temperature. When evaluating the influence of summer average temperature on water use, Fort Worth showed the strongest relationship, with water use increasing with increasing average summer temperature. Houston and El Paso showed essentially no relationship between average summer temperature and water use.

Existing Conservation Measures. Table 6.1 shows that San Antonio (38 percent), El Paso (21 percent), and Houston (13 percent) have each experienced continued decrease in per capita water usage over the last 20 years. During this period, each of these cities has developed an aggressive, multi-faceted water conservation program, and the water usage data indicate that these programs have been effective in reducing water usage. Several of the other cities in Table 6.1 have developed or are developing water conservation programs. San Antonio has experienced the largest decline in per capita use. A substantial portion of San Antonio's decline in per capita use was associated with an aggressive program to decrease water losses, which were very high in San Antonio in the 1980s (exceeding 25 percent). Unfortunately, similar savings in water losses are not possible for most other major Texas cities, since existing losses are generally less than 12 percent in major cities.

Commercial Development. Figure 6.3 shows the estimated breakdown of average per capita water use by category. Each city has a different mix of residential, commercial, and other water use. There does not seem to be a defined trend in the percent of commercial use versus total per capita water use. Based on data available through the TWDB, it is estimated that the cities with lower overall per capita water use (San Antonio and El Paso) also have lower commercial water use in the municipal per capita calculation. Lubbock and Brownsville also indicate low commercial water use, yet the overall per capita use for these cities is high to moderate.

Water Prices. Historical water prices were available for Dallas, Fort Worth, and San Antonio. For Dallas, the historical data show no apparent relationship between residential water price and per capita water use. In Fort Worth, there may be a weak relationship between residential water price and per capita water use, but the decrease in per capita water use may also be due to other factors rather than increasing water prices. For San Antonio, the limited available historical water price data indicate a strong negative correlation between residential water prices and per capita water use. It is likely that much of the decrease in per capita use was due to control of water losses and the conservation program, and it is not clear how much of the decrease is due to increasing water prices.

Per Capita Income. Per capita income also does not seem to have a direct relationship with per capita water use. Higher-income cities experience both relatively low per capita water use (Austin and Houston) to relatively high per capita water use (Dallas). Lower-income cities also experience relatively low (El Paso) to relatively high (Brownsville) per capita water use. Changes in income for each city over time are also inconclusive.

Summary. For the twelve cities, a number of factors that could potentially influence per capita water use were studied. For some cities, there is relatively weak evidence that a decrease in precipitation and/or an increase in summer temperature can result in greater per capita water use. In addition, increasing water rates may be related to decreasing per capita water use in Fort Worth. For other cities, these factors have little apparent influence on per capita water use.

There appears to be a relationship between aggressive conservation programs and decreasing water use. However, the amount of water savings associated with each program can vary widely. Factors unique to each city, including customer service base and historical water losses, contribute to the ability of a city to reduce water use through conservation programs. Over the past twenty years, San Antonio, El Paso and Houston have each experienced decreases in per capita water use of more than 10 percent. These decreases appear to be correlated with implementation of their conservation programs, and are possibly attributed to better accounting practices as part of the conservation programs, reductions in unaccounted for water, as well as demand reductions from customers. Each city had a different mix of residential, commercial, and industrial uses. The cities with the least municipal per capita water use also had the least commercial per capita water use.

6.4 Water Conservation and Reuse in Region C

This section discusses historical water use, current water conservation, current reuse projects, conservation assumptions in the water demand projections and recommended water conservation and reuse strategies.

Historical Water Use in Region C

Water use data obtained from the TWDB were used to analyze historical water use in Region C. Table 6.2 shows the summary of water use in Region C for year 2000. According to these data, 86.7 percent of the water use in Region C in the year 2000 was for municipal purposes. As discussed in Section 6.3, the year 2000 municipal per capita water use in Region C (without credit for indirect reuse) was 203 gpcd. After crediting for indirect reuse, the per capita municipal water use in Region C is 197 gpcd.

TWDB data on use by individual water user groups were used to estimate "base" and "seasonal" water use for the 202 water user groups for which data were available. Base water use does not vary over time and includes indoor municipal water usage. Seasonal water use varies over time and includes most outdoor water use and other temperature-related water use. The statistics on seasonal water use were used to estimate the potential water savings from indoor and outdoor water conservation strategies.

In Region C, the year 2000 base water use was approximately 67 percent of the total annual water usage, and seasonal water use was approximately 33 percent of the total. (Base use for each water user group was estimated to be the minimum reported monthly water use. For each month, seasonal water use was the difference between monthly water use and base water use.)

Table 6.2
TWDB Region C Summary of Water Use for Year 2000

Category	Reported Water Use (acre-feet)	Percentage of Regional Water Use	Population	Per Capita Water Use (gpcd)
Irrigation	40,153	2.9%		6.8
Livestock	19,112	1.4%		3.2
Manufacturing	58,289	4.2%		9.9
Mining	23,479	1.7%		4.0
Municipal	1,196,452	86.7%		203.3
Steam Electric Power	43,071	3.1%		7.3
TOTAL	**1,380,556**	**100.0%**	**5,254,722**	**234.5**

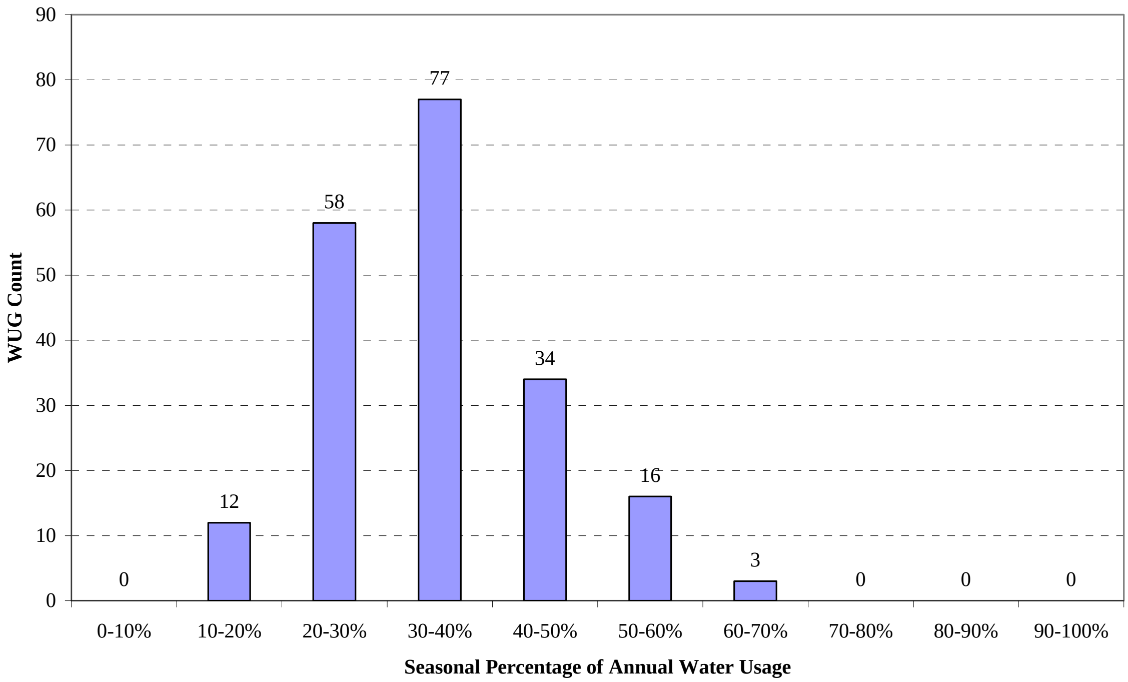
Figure 6.4 shows the range of seasonal water use for individual water user groups in Region C in the year 2000. The minimum estimated seasonal water usage was 13 percent, and the maximum was 68 percent.

The water use data for some water user groups also show the percentage of water use attributed to single-family residential, multi-family residential, commercial, and industrial users. These data were used to estimate the potential water savings for residential and industrial, commercial, and institutional (ICI) water conservation strategies.

Current Water Conservation in Region C

To provide a basis for assessment of potentially feasible water conservation strategies in Region C, it is necessary to identify currently implemented water conservation strategies in the region. To accomplish this, the Region C Water Planning Group surveyed water user groups, reviewed existing water conservation plans, conducted a study of water conservation on a neighborhood scale, and identified existing reuse strategies in the region. Each of these items is discussed below.

Figure 6.4
Seasonal Water Use as a Percentage of Annual Water Use, Year 2000
- Region C Water User Groups -



Water Conservation Survey. Water user groups were surveyed to determine the current level of water conservation practices, the cost of implementation, potential new water conservation practices, and estimated water savings from implementation of conservation strategies. The survey asked questions about unaccounted water, raw water costs, whether wholesale water customers are required to have conservation plans, rebates, incentives, and retrofit kits, public information and school education, water waste prohibition, reuse of treated wastewater effluent, potable water rates, automatic irrigation systems, potentially feasible water conservation strategies, and other water conservation strategies. Responses to the water conservation survey and a memorandum summarizing these responses are presented in Appendix K. For the water user groups (WUGs) that responded to each question:

- 20 percent of the WUGs reported unaccounted water of more than 15 percent.
- The cost for raw water ranged from $0.064 to $1.01 per thousand gallons.
- 3 percent offer rebates, incentives, or retrofit kits.
- 37 percent have some form of public information or school education program.

- 18 percent have an ordinance prohibiting water waste. (Not all WUGs have ordinance enforcement authority.)
- 16 percent reuse treated wastewater effluent.
- 66 percent have an increasing block rate structure for potable water, 33 percent have a flat rate structure, 1 percent has a decreasing block rate structure, and 6 percent have seasonal water rates.
- The percentage of residential connections with automatic irrigation systems ranged from 0 to 100 percent, with a median value of 10 percent. WUGs reporting more than 20 percent were primarily suburban. WUGs reporting 20 percent or less serve a mix of rural, suburban, and urban populations.

Of the wholesale water providers (WWPs) that responded to each question:

- None reported unaccounted water of more than 15 percent.
- The cost for raw water ranged from $0.037 to $0.67 per thousand gallons.
- 79 percent require wholesale water customers to have water conservation plans.
- 21 percent offer rebates, incentives, or retrofit kits.
- 62 percent have some form of public information or school education program.
- 31 percent have an ordinance prohibiting water waste. (Not all WWPs have ordinance enforcement authority.)
- 69 percent reuse treated wastewater effluent.
- Of the WWPs that provide retail potable water, 44 percent have an increasing block rate structure for potable water, and 56 percent have a flat rate structure.

Table 6.3 shows the percentage of WUGs and WWPs that have implemented certain water conservation strategies. In Region C, a significant percentage of WUGs and WWPs report having implemented system/utility water conservation strategies. Few report having implemented customer-based water conservation strategies aimed at indoor, outdoor, or industrial, commercial, and institutional (ICI) water use. A small percentage of WUGs and a large percentage of WWPs report reusing treated wastewater effluent.

Water Conservation Plans. Many Region C WUGs and WWPs are required to prepare water conservation plans. Available water conservation plans were reviewed to determine the current level of water conservation practices, the cost of implementation, potential new water conservation practices, and estimated water savings from implementation of conservation strategies. A total of 182 water conservation plans were reviewed, and 84 of these contained information specific to an individual WUG or WWP. In general, other plans did not provide water conservation information specific to a particular WUG but referenced the water conservation plan of that WUG's wholesale water provider.

Table 6.3
Implemented Water Conservation Strategies in Region C

Type	Method	WUGs	WWPs
System/Utility	Public information/school education	37%	62%
	Water conservation pricing	47%	36%
	System water audit and water loss prevention	68%	73%
	Pressure control and leak detection	49%	45%
	Water waste prohibition	18%	22%
Indoor	Customer indoor water audit	3%	0%
	Showerhead/faucet aerator retrofit program	7%	9%
	Toilet replacement program	4%	0%
	Clothes washer rebate program	0%	0%
Outdoor	Customer irrigation audit	7%	9%
	Landscape irrigation systems rebate	1%	0%
	Landscape design and conversion program	11%	18%
Industrial, Commercial, and Institutional (ICI)	General ICI rebate	0%	0%
	Site-specific ICI program	0%	11%
Reuse	Reuse of treated effluent	16%	69%

The water conservation plans reflect similar information to that obtained from the water conservation surveys. Of the 84 WUG- or WWP-specific water conservation plans:

- 71 percent describe a universal metering and/or meter testing, repair, and replacement program.
- 70 percent describe a leak detection and repair program.
- 1 percent describe a water use audit program.
- 92 percent describe a public education program.
- 60 percent describe conservation-oriented water rates.
- 6 percent describe a pressure control program.
- 48 percent describe adoption of plumbing codes.

- 46 percent encourage voluntary retrofit of inefficient plumbing fixtures (1 percent describe an active retrofit or rebate program).
- 2 percent describe programs where treated wastewater effluent is provided to water users.
- 52 percent encourage landscape water management through public education materials, demonstration projects, and by setting an example at municipal facilities.
- 35 percent describe procedures for monitoring the effectiveness of the water conservation plan.
- 44 percent set goals for unaccounted water or per capita water use.

As with the water conservation survey, the water conservation plans reveal that implemented water conservation strategies tend to be system/utility strategies (as defined in Table 6.3).

Little information was available from the water conservation surveys or from the water conservation plans on the cost of implementation or the estimated water savings from implementation of water conservation strategies.

Neighborhood Study. A neighborhood-scale study of residential water conservation and water use was conducted to further evaluate current Region C water use and conservation. The local impacts of two water conservation methods were studied: low-flow plumbing fixtures and customer water audits. A summary of the neighborhood water conservation study is presented in Appendix L.

Eight neighborhoods in Arlington, Fort Worth, Dallas, and Plano were selected for evaluation. Neighborhoods were selected based on the availability of seasonal water use data, existing water conservation measures in each area, the age of the neighborhood, and socioeconomic conditions. Neighborhoods were selected to reflect a broad range of family income and housing age. Up to 7 years of water use data, weather data, and socioeconomic data were obtained for each selected neighborhood. Correlations between different types of data were analyzed, and regression equations were derived for indoor and outdoor water use.

With respect to water conservation and water use in the selected neighborhoods, the neighborhood study resulted in the following conclusions:

- Indoor water use increases with increasing family income and increasing lot size (which is strongly correlated to family income).
- Indoor water use is greater in older neighborhoods (which presumably have older plumbing fixtures) than in newer neighborhoods.

- For a given home in the selected neighborhoods, the average conservation savings from retrofits of inefficient plumbing fixtures are projected to range from 17.1 to 22.4 gpcd.
- On average, 51 percent of the housing in the selected neighborhoods was constructed since low-flow plumbing fixtures became mandatory in 1992.
- Outdoor water use increases with increasing cooling degree days and with increasing family income.
- Newer (post-1992) homes have greater outdoor water use than older (pre-1992) homes.
- Residents of the selected neighborhoods use an annual average of approximately 87 gpcd indoors and 83 gpcd outdoors, for a total annual average water use of 170 gpcd.

The City of Denton performs free water audits for its customers upon request. When a customer requests a water audit, city personnel review the customer's bill to determine whether it is within normal seasonal parameters and review water usage habits with the customer. After discussion with the customer, city personnel perform an on-site walk-through, if necessary, to teach the customer how to read the water meter, to evaluate the landscaping and irrigation system, to check for leaks, to review conservative water usage habits, and, if the customer wishes, to install water saving devices. The auditor then provides a report and water saving suggestions. As of October 2003, the city had performed 102 customer water audits over the two-and-a-half years of the program, for a participation rate of 0.16 percent of customers per year. Monthly water usage data were obtained for customers that had participated in the water audits. Pre- and post-audit water usage was analyzed to determine whether the audit resulted in water savings.

With respect to customer water audits, the neighborhood study resulted in the following conclusions:

- Denton's customer water audits have saved approximately 15 percent of pre-audit water usage for the customers that request water audits.
- As it is currently operated, Denton's customer water audit program is cost-effective when compared to the current cost of producing potable water.
- If Denton increased participation through advertising and public education, it is likely that the effectiveness (on a per capita basis) of the program would decline, raising the unit cost. The unit cost of a larger program is probably not cost-effective compared to the current cost of potable water, but it might be cost-effective compared to the future cost of potable water, depending on the distribution costs.

Existing Reuse Projects. Reuse has been a source of water supply in Region C for a number of years. Table 6.4 lists currently operating reuse projects in Region C and the amount that can be used with existing infrastructure. There are several reuse projects that are permitted, but do not have infrastructure to utilize this water. These include the Tarrant Regional Water District indirect reuse projects at Richland-Chambers and Cedar Creek Reservoirs and indirect reuse to Lake Athens. Others are currently being used, but are not fully utilized due to infrastructure limitations. Development of the infrastructure for these projects is considered a water management strategy. Further discussion of current reuse projects is included in Appendix I.

Conservation Assumptions in Water Demand Projections

Significant savings in water use due to water conservation are assumed in the projected demands for Region C adopted by the regional water planning group and the Texas Water Development Board. The projected municipal water demands for Region C include projected savings from conversion to low-flow plumbing fixtures. By 2060, low-flow plumbing fixtures are projected to save approximately 5 percent of total regional water demand. In addition, the water demand projections assume that future steam electric power plants will be more efficient, resulting in an additional savings of approximately 1.8 percent of total regional water demand in 2060.

Recommended Water Conservation Strategies

Regional Summary and Discussion. During the evaluation process, the recommended feasible water conservation strategies for municipal water user groups were divided into two groups based on potential water savings, opinions of probable cost, and likelihood of implementation:

- Basic package
  - Low-flow plumbing fixture rules (included in the water demand projections)
  - Public and school education
  - Water use reduction due to increasing water prices
  - Water system audit, leak detection and repair, and pressure control
  - Federal residential clothes washer standards

Table 6.4
Existing Reuse Projects in Region C
- Values in Acre-Feet per Year

Reuse Description	User	County	2010	2020	2030	2040	2050	2060
NTMWD Stewart Creek Direct Reuse	Frisco/ Golf Courses	Collin	307	307	307	307	307	307
NTMWD Rowlett Creek Direct Reuse	Golf Courses	Collin	1,540	1,540	1,540	1,540	1,540	1,540
Gainesville Direct Reuse	Park irrigation	Cooke	9	9	9	9	9	9
Alcatel Network Systems Direct Reuse	Manufacturing	Dallas	20	20	20	20	20	20
Trinity River Authority/Las Colinas Reuse	Irrigation	Dallas	8,000	8,000	8,000	8,000	8,000	8,000
Cedar Crest Golf Course (Dallas)	Dallas/ Golf Courses	Dallas	561	561	561	561	561	561
Denton (Power Plant - direct reuse)	Denton/Power	Denton	3,363	3,363	3,363	3,363	3,363	3,363
Denton County Direct Reuse	Denton/ Irrigation	Denton	6,165	5,717	4,932	4,372	3,475	2,466
Denton County Indirect Reuse	Denton/ Irrigation	Denton	1,682	2,130	2,915	3,475	4,372	5,381
UTRWD Direct Reuse	Denton Co. FWSD #1	Denton	897	897	897	897	897	897
Collin County Direct Reuse	The Colony	Collin	380	380	380	380	380	380
Denton County Direct Reuse	Trophy Club	Denton	800	896	977	1,049	1,129	1,210
Ennis Direct Reuse	Steam Electric Power	Ellis	3,363	3,363	3,363	3,363	3,363	3,363
TRA/Waxahachie Indirect Reuse	Waxahachie	Ellis	4,998	5,129	5,129	5,129	5,129	5,129
Pinnacle Club Direct Reuse	Golf Course	Henderson	32	32	32	32	32	32
Jack County Direct Reuse	Bryson/ Irrigation	Jack	27	27	26	26	25	25
Jacksboro Direct Reuse	Golf Course	Jack	385	385	385	385	385	385
Country Club WSC Direct Reuse	Golf Course	Kaufman	92	92	92	92	92	92
Crandall Direct Reuse	Crandall	Kaufman	484	666	835	1,024	1,267	1,567
Garland Direct Reuse (sales through Forney)	Steam Electric Power	Kaufman	8,979	15,600	15,600	15,600	15,600	15,600
Weatherford Direct Reuse	Golf Course	Parker	202	202	202	202	202	202
Deer Creek Waterworks Direct Reuse	Golf Course	Parker	11	11	11	11	11	11
Millsap ISD Direct Reuse	Athletic Fields	Parker	2	2	2	2	2	2
NTMWD Buffalo Creek Direct Reuse	Golf Course	Rockwall	672	672	672	672	672	672
Royce City Direct Reuse	Golf Course	Rockwall	112	112	112	112	112	112
Azle Direct Reuse	Azle	Tarrant	811	1,089	1,484	1,930	2,403	2,818
Grapevine reuse (Grapevine Lake)	Grapevine	Tarrant	3,317	3,696	3,964	4,142	4,276	4,386
Fort Worth Direct Reuse	Golf Course	Tarrant	897	897	897	897	897	897
North Texas MWD Lake Lavon Reuse	NTMWD	NA	35,941	35,941	35,941	35,941	35,941	35,941
Wise County Mining Reuse	Mining	Wise	15,930	14,074	12,152	10,643	9,236	8,061
Total			**99,979**	**105,810**	**104,800**	**104,175**	**103,697**	**103,429**

- Expanded package
    - Water conservation pricing structure
    - Water waste prohibition
    - Coin-operated clothes washer rebate
    - Residential water audit
    - Industrial, commercial, and institutional (ICI) general rebate
    - ICI water audit, water waste reduction, and site-specific conservation program
    - Reuse of treated wastewater effluent.

The basic package is recommended for all municipal water user groups. The expanded package is recommended for 129 out of 271 municipal water user groups. Recommended non-municipal water conservation strategies include manufacturing general rebates and golf course conservation.

Recommended Reuse Projects. As discussed in Section 4B.2, over 1 million acre-feet per year of treated wastewater effluent may be available for reuse in Region C by 2060 without impacting existing levels of return flow. Table 6.5 lists recommended reuse strategies for Region C. A total of 34 reuse projects are recommended with a cumulative 2060 supply amount of 795,466 acre-feet per year. Of this amount, 770,988 acre-feet per year is expected to be used in Region C to meet projected shortages. This level of reuse proposed in the Region C plan will result in net return flows remaining near historical levels through 2030 and increasing substantially from 2040 on. More detailed discussions of the recommended reuse projects are included in Chapters 4B and 4E.

Table 6.6 shows a regional summary of estimated water savings from recommended water conservation and reuse strategies. It also shows the amount of conservation that is included in the approved water demands for the region. The projected 2060 Region C water demand with no conservation is 3,553,139 acre-feet per year (this amount includes the TWDB-approved 2060 demand value plus 241,923 acre-feet per year of conservation that is incorporated in the demands). The recommended 2060 water conservation strategies, including those that are assumed in the demands, will provide 1,310,550 acre-feet per year, or 37 percent of pre-conservation demand.

Table 6.5
Recommended Reuse Projects in Region C
- Values in Acre-Feet per Year -

Water Provider	Project	Receiving Water	User Group	2060 Total	Amt to Region C
Athens	Indirect Reuse	Lake Athens	MUN, MFG	2,677	1,596
Dallas	Direct Reuse		IRR	20,456	20,456
Dallas	Southside WWTP Indirect Reuse	Lake Ray Hubbard	MUN, MFG	67,253	67,253
Dallas	Central WWTP Indirect Reuse	Lewisville Lake	MUN, MFG	67,253	67,253
Dallas	Indirect Reuse of Return Flows Above Dallas Lakes	Dallas Lakes	MUN, MFG	79,605	79,605
Ennis	Indirect Reuse	Bradwell Lake	MUN, MFG	3,696	3,696
Fort Worth	Direct Reuse		SEP	2,600	2,600
Fort Worth	Direct Reuse (3 projects)		IRR	8,290	8,290
Gainesville	Indirect Reuse	Moss Lake	MUN, MFG	561	561
NTMWD	Additional Wilson Creek WWTP Indirect Reuse	Lake Lavon	MUN, MFG	35,941	35,941
NTMWD	East Fork Indirect Reuse	Trinity River	MUN, MFG	102,000	102,000
TRWD	Trinity River Indirect Reuse	Richland-Chambers Reservoir	MUN, MFG	63,000	61,866
TRWD	Trinity River Indirect Reuse	Cedar Creek Reservoir	MUN, MFG	52,500	51,555
TRWD	TRWD Additional Yield due to reuse project	Richland-Chambers Reservoir	MUN, MFG	37,465	36,791
TRWD	TRWD Additional Yield due to reuse project	Cedar Creek Reservoir	MUN, MFG	35,800	35,156
TRA	Tarrant County Indirect Reuse	Grapevine Lake	MUN, MFG	7,500	7,500
TRA/Irving	Contract with Irving	Unknown	MUN, MFG	28,000	28,000
TRA	Joe Pool Lake Indirect Reuse (Central WWTP)	Joe Pool Lake	MUN	20,000	0
TRA	Joe Pool Lake Indirect Reuse (New WWTP)	Joe Pool Lake	Unknown	3,500	3,500
TRA	Mountain Creek Direct Reuse		SEP	3,000	3,000
TRA	Ellis County Direct Reuse		SEP	40,000	40,000
TRA	Freestone County Direct Reuse Phases I - II		SEP	20,000	20,000
TRA	Kaufman County Direct Reuse Phases I - II		SEP	15,000	15,000
TRA	Las Colinas Direct Reuse		IRR	7,000	7,000
TRA	Tarrant and Denton Counties Direct Reuse		IRR	7,500	7,500
UTRWD	Indirect Reuse of Lake Ralph Hall Water	Lewisville Lake	MUN	17,760	17,760
UTRWD	Indirect Reuse of Chapman Lake	Lewisville Lake	MUN	7,743	7,743
Weatherford	Indirect Reuse	Lake Weatherford	SEP	5,000	5,000
Waxahachie	Additional TRA/Waxahachie Indirect Reuse	Bradwell Lake	MUN, MFG	1,846	1,846
Bridgeport	Wise County Direct Reuse		SEP	2,000	2,000
Decatur	Wise County Direct Reuse		SEP	2,000	2,000
Local	Wise County Mining Reuse		MIN	28,520	28,520
TOTAL				795,466	770,988

Table 6.6
Summary of Recommended Conservation (Including Reuse) for Region C
- Values in Acre-Feet per Year -

Strategy	2010	2020	2030	2040	2050	2060
Municipal Conservation						
Low-flow plumbing fixture rules	33,173	66,839	98,074	129,088	155,182	176,304
Municipal Basic Package	42,659	94,252	123,878	156,586	195,957	240,866
Municipal Expanded Package	10,345	18,986	32,702	42,049	46,478	51,036
Non-Municipal Conservation						
Efficient new steam electric power plants	3,262	7,824	14,545	26,725	43,403	65,619
Non-municipal conservation strategies	57	1,069	3,334	4,518	5,147	5,737
Reuse Strategies	329,071	569,353	699,097	714,602	753,567	770,988
Total Conservation and Reuse	**418,567**	**758,323**	**971,630**	**1,073,568**	**1,199,734**	**1,310,550**
Total Region C Demands	1,768,463	2,100,518	2,358,432	2,622,512	2,934,926	3,311,216
Total Demand without Conservation [a]	1,804,898	2,175,181	2,471,051	2,778,325	3,133,511	3,553,139
Percent of Total Demand met through Conservation and Reuse Strategies	**23%**	**35%**	**39%**	**39%**	**38%**	**37%**

Note: a. The Total Region C Demands on the line above includes projected conservation savings from low flow plumbing fixtures and efficient new steam electric power plants. These savings were added to the Region C Demands to obtain "Total Demand without Conservation", a projection of Region C's demands if no conservation occurred.

6.5 Per Capita Water Use in Region C with the Implementation of the Recommended Plan

The *Report to the 79th Legislature* (4) from the Water Conservation Implementation Task Force suggested that when establishing conservation targets and goals, a water supplier should consider "a minimum annual reduction of one percent in total gpcd, based upon a five-year rolling average, until such time as the entity achieves a total gpcd of 140 or less." Several aspects of this suggested long-term per capita use goal of 140 gpcd should be emphasized:

- The goal applies to individual water suppliers.
- The goal applies to water supplied as potable water by the water utility to retail water users, which may include municipal, manufacturing, and other uses. Self supplied manufacturing water, wholesale sales, and non-potable water do not count in the computation of per capita use.

- As emphasized repeatedly in the Water Conservation Implementation Task Force report, goals are voluntary and are to be set by the water supplier.
- The suggested per capita use goal includes a credit for reuse, so that water supplied by reuse does not count against the per capita use.
- Since the per capita use goal is based on a five-year moving average, it is more applicable to normal-year water use rather than dry-year water use.

This section of the report compares the per capita water use that would result from implementation of the 2006 Plan to the suggested voluntary goal of 140 gpcd.

Region C Per Capita Municipal Water Use.

The overall per capita municipal water use in Region C in the year 2000 was 203 gallons per capita per day. Since 2000 was a dry year, the normal-year per capita municipal use in Region C would be somewhat less. In addition, some of the municipal use in Region C in the year 2000 was supplied by reuse. After crediting for reuse as required by the Water Conservation Implementation Task Force *Report to the 79th Legislature* (4), the year 2000 per capita municipal use in Region C was 197 gpcd.

This plan recommends significant conservation efforts and the development of substantial new supplies from reuse. Table 6.7 summarizes the projected per capita municipal water use for Region C with the implementation of the plan. Figure 6.5 is a graph of the data from Table 6.7. The figure and the table show the following:

- With no conservation or reuse at all, the projected dry-year per capita municipal water use in Region C would be 211 gpcd in 2060.
- Implementation of the plumbing code requiring the use of low-flow plumbing fixtures had already reduced the per capita use in Region C by 3 gpcd as of the year 2000. It is expected to reduce per capita use by another 12 gpcd, to a total of 15 gpcd, by 2060.
- The recommended water conservation measures in the 2006 Plan will reduce the projected 2060 per capita municipal use by an additional 20 gpcd.
- The existing and recommended municipal water reuse projects will reduce the projected 2060 per capita municipal use by an additional 45 gpcd, to 134 gpcd.
- The projected normal year per capita use would be 10-15 percent lower than dry-year use, well under the recommended goal of 140 gpcd.
- Many of the recommended reuse projects in this plan are proposed for implementation between now and 2030, leading to a rapid reduction in per capita use in Region C after crediting for reuse.

The projected per capita use figures in Table 6.7 and Figure 6.5 are based on assumed full utilization of reuse strategies. It is possible that the reuse strategies will not be fully used in early years. However, these strategies provide an economical water supply, and they can be expected to be implemented fully over time. As a result, the reduction in per capita demand shown in the Table 6.7 and Figure 6.5 may take somewhat longer than shown, but they can be expected to occur if the proposed reuse strategies are implemented.

Region C Per Capita Municipal and Manufacturing Water Use

The Water Conservation Implementation Task Force recommended goal of 140 gpcd is based on use supplied to retail customers as potable water. In Region C, a part of the manufacturing use is supplied as retail potable water, and a part is supplied wholesale, self-supplied or supplied as non-potable water. Therefore, the region-wide per capita use to be compared to the recommended goal of 140 gpcd will be between the region-wide per capita municipal use and the region-wide per capita municipal and manufacturing use.

The overall per capita municipal and manufacturing water use in Region C in the year 2000 was 213 gallons per capita per day. Since 2000 was a dry year, the normal-year per capita municipal and manufacturing use in Region C would be somewhat less. In addition, some of the use in Region C in the year 2000 was supplied by reuse. After crediting for reuse as required by the Water Conservation Implementation Task Force *Report to the 79th Legislature* [(4)], the year 2000 per capita municipal and manufacturing use in Region C was 207 gpcd.

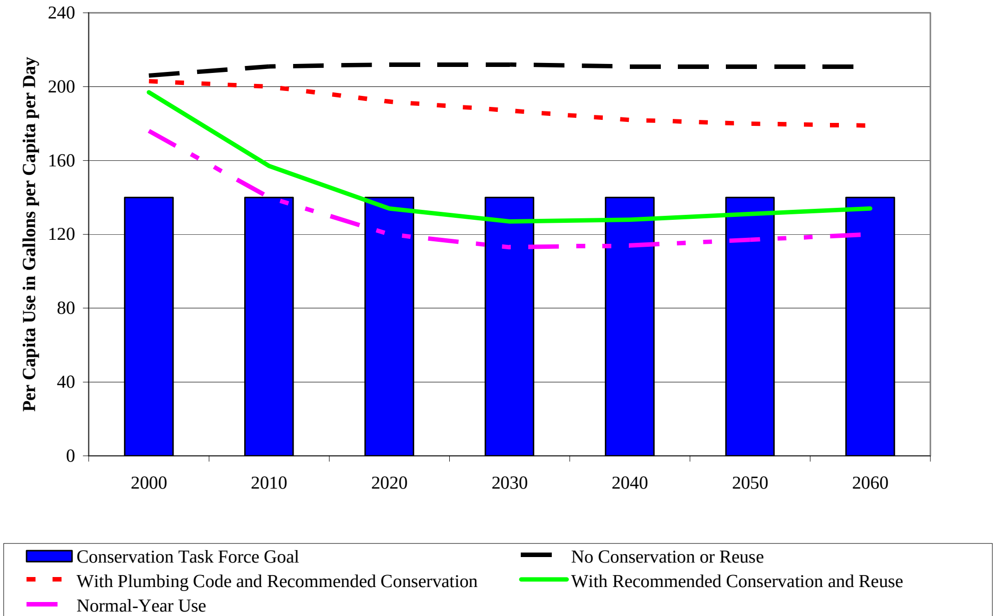
Table 6.8 summarizes the projected per capita municipal and manufacturing water use for Region C with the implementation of this plan. Figure 6.6 is a graph of the data from Table 6.8. The figure and the table show the following:

- With no conservation or reuse at all, the projected per capita municipal and manufacturing water use in Region C would be 218 gpcd in 2060.
- Implementation of the plumbing code requiring the use of low-flow plumbing fixtures had already reduced the per capita use in Region C by 3 gpcd as of the year 2000. It is expected to reduce per capita use by another 12 gpcd, to a total of 15 gpcd, by 2060.
- The recommended water conservation measures in the 2006 Plan will reduce the projected 2060 per capita municipal and manufacturing use by an additional 20 gpcd.

Table 6.7
Projected Municipal Per Capita Use in Region C

	Actual 2000	Projections					
		2010	2020	2030	2040	2050	2060
Basic Data							
Population	5,254,722	6,625,282	7,966,389	9,093,847	10,246,795	11,559,990	13,087,849
Municipal Demand without Low Flow Plumbing (Acre-feet)	N/A	1,567,870	1,895,672	2,158,182	2,423,574	2,729,449	3,092,074
Municipal Demand with Low Flow Plumbing (Acre-feet)	1,196,452	1,534,703	1,828,831	2,060,118	2,294,491	2,574,265	2,915,773
Recommended Municipal Water Conservation (Acre-feet)	0	53,004	113,238	156,580	198,635	242,435	291,902
Current Municipal Reuse (Acre-feet)	36,376	40,240	41,176	42,387	43,324	44,574	45,923
Recommended Municipal Reuse (Acre-feet)	0	275,103	480,743	570,530	582,905	595,547	608,869
Per Capita Use (Gallons per Capita per Day)							
No Conservation or Reuse	206	211	212	212	211	211	211
With Plumbing Code	203	207	205	202	200	199	199
With Plumbing Code and Recommended Conservation	203	200	192	187	182	180	179
With Recommended Conservation and Reuse	197	157	134	127	128	131	134
Normal-Year Use (Assumed 12 Percent Lower than Dry-Year)	176	140	120	113	114	117	120

Figure 6.5
Projected Municipal Per Capita Water Use in Region C



- The existing and recommended water reuse projects will reduce the projected 2060 dry-year per capita municipal and manufacturing use by an additional 46 gpcd, to 140 gpcd.
- The projected normal year per capita use would be 10-15 percent lower than dry-year use, well under the recommended goal of 140 gpcd.

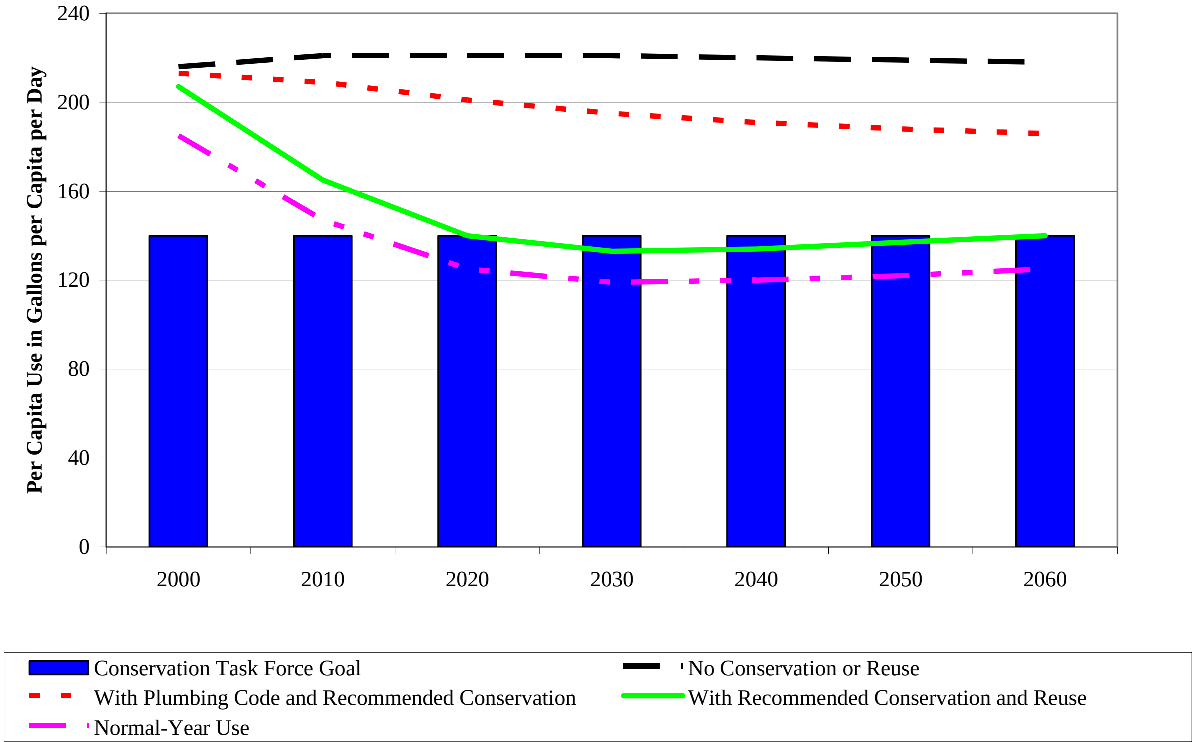
To summarize the recommendations of the Water Conservation Implementation Task Force and the Region C plan:

1. The Water Conservation Implementation Task Force has recommended that water suppliers consider a goal of 140 gallons per capita per day for total potable water supplied to retail water users. The Task Force defines total potable water supplied to exclude water supplied by reuse. The goal is based on a five-year rolling average, which dampens the impact of particularly dry- or wet-years and is more applicable to normal-year use than to dry-year use..
2. Because of the substantial conservation and reuse projects included in the plan, Region C will achieve this recommended goal for the region as a whole.
3. The per capita use for individual water suppliers will vary.

Table 6.8
Projected Municipal and Manufacturing Per Capita Use in Region C

	Actual 2000	Projections					
		2010	2020	2030	2040	2050	2060
Basic Data							
Population	5,254,722	6,625,282	7,966,389	9,093,847	10,246,795	11,559,990	13,087,849
Municipal Demand without Low Flow Plumbing	N/A	1,567,870	1,895,672	2,158,182	2,423,574	2,729,449	3,092,074
Municipal Demand with Low Flow Plumbing	1,196,452	1,534,703	1,828,831	2,060,118	2,294,491	2,574,265	2,915,773
Manufacturing Demand	58,289	72,026	81,273	90,010	98,486	105,808	110,597
Recommended Mun. and Man. Water Conservation	0	53,061	114,307	159,914	203,153	247,582	297,639
Current Municipal and Manufacturing Reuse	37,474	41,338	42,274	43,485	44,422	45,672	47,021
Recommended Municipal and Manufacturing	0	286,734	500,119	590,899	603,660	616,528	630,078
Per Capita Use (Gallons per Capita per Day)							
No Conservation or Reuse	216	221	221	221	220	219	218
With Plumbing Code	213	216	214	211	208	207	206
With Plumbing Code and Recommended Conservation	213	209	201	195	191	188	186
With Recommended Conservation and Reuse	207	165	140	133	134	137	140
Normal-Year Use (Assumed 12 Percent Lower than Dry-Year)	185	147	125	119	120	122	125

Figure 6.6
Projected Municipal and Manufacturing Per Capita Water Use in Region C



6.6 Water Conservation Policy Recommendations

The Region C Water Planning Group Policy Topics Committee issued a memorandum to the planning group regarding policy recommendations that is discussed in Chapter 8 and is included in Appendix X. Several of the Committee's policy recommendations are related to water conservation and are summarized below.

Voluntary Conservation Goals

The Region C Water Planning Group supports the decision of the Water Conservation Implementation Task Force that the targets recommended in their report (4) should be voluntary targets rather than mandatory goals. Per capita water use is unique to each water supplier, and each supplier should strive to incorporate water conservation measures that are appropriate for its particular situation. A statewide per capita water use value is not appropriate for the State of

Texas, given its wide variation of rainfall, economic development, purposes of use, and other factors.

Policies Limiting the Use of Treated Wastewater

The TCEQ has recently implemented policies, some in response to legislative requirements in Senate Bill One, that limit the TCEQ's ability to permit projects for indirect reuse, in which water is returned to a reservoir or watercourse before being diverted for reuse. The policy of discouraging indirect reuse has a number of negative impacts on water suppliers in Region C and throughout the state:

- The policies are logically inconsistent with policies encouraging direct reuse of treated wastewater.
- The policies inhibit reuse for municipal purposes by prohibiting the most effective approach to municipal reuse, which incorporates "multiple barriers" between wastewater discharge and eventual reuse. Streams and reservoirs are among the most effective of such multiple barriers.
- The policies encourage reuse for irrigation and industrial purposes, where direct reuse is appropriate, while discouraging reuse to meet municipal needs, where indirect reuse is a preferred approach.
- It is poor public policy to discourage indirect reuse, a water supply alternative with relatively low environmental impacts.
- It is poor public policy to require the construction of infrastructure for direct reuse in cases when natural watercourses can deliver water much more economically.
- Indirect reuse of treated wastewater is an important element of water supply planning in Region C.

The legislature should revisit the issue of indirect reuse of treated wastewater using the bed and banks of state watercourses, with a view to reducing the obstacles to indirect reuse. The historical discharge of treated wastewater effluent should not make the indirect reuse of wastewater more difficult.

Reuse projects, both direct and indirect, are a significant portion of Region C's future water supplies. For example, large-scale indirect reuse projects are planned for Richland-Chambers Reservoir, Cedar Creek Reservoir, Lake Ray Hubbard, Lewisville Lake, and Lake Lavon. The permitting process for large-scale indirect reuse projects needs to be clearly defined for the applicants. The reuse permit for Richland-Chambers/Cedar Creek reuse project took seven years to process. Clarification of what is needed to pursue such a permit would significantly expedite the process in obtaining such a permit for future projects.

State Funding for Water Conservation Efforts

As a result of the policy recommendations in the 2001 regional water plans, the legislature established a Water Conservation Implementation Task Force and developed a statewide water conservation campaign, "Water IQ – Know Your Water." The conservation campaign was released to the public on January 26, 2005.

The current TWDB regulations require that water conservation be considered as a water management strategy for each water shortage. In Region C, four model water conservation plans have been developed and are included in Appendices N and O. It is important that programs be developed to help local water suppliers achieve the conservation savings recommended in this regional water plan.

The legislature should provide funding to allow the TWDB and other state agencies to undertake or expand the following programs:

- A study of the effectiveness of municipal water conservation programs in Texas and how state agencies can assist local suppliers in achieving conservation goals
    - What are the trends in per capita use in the state, in various regions, and for various suppliers, after adjusting for climate?
    - Where has conservation been particularly effective?
    - What are the elements of effective programs, and how might they be applied elsewhere in the state?
    - What other factors besides conservation programs affect per capita municipal use (positively or negatively)?
    - Are conservation-oriented water rates effective? If so, how might they be implemented?
    - How can state agencies most effectively assist water suppliers in implementing conservation programs?
- Similar studies of the effectiveness of conservation in industrial and irrigation water use and how state agencies can assist in achieving conservation goals
- State funding for educational programs on water conservation in the schools (such as the Major Rivers program and others)
- State funding for seminars on water conservation and conservation issues to educate policy makers and the public-at-large

- State funding should be allocated to support the recently released statewide water conservation campaign “Water IQ – Know Your Water.”

6.7 Model Water Conservation Plans

Model water conservation plans have been developed for four different water user types: municipal, irrigation, manufacturing, and steam electric power. The model water conservation plans are presented in Appendices N and O. The model plans are designed to show the content required by the Texas Commission on Environmental Quality (TCEQ), optional content suggested by the TCEQ, and optional content suggested by the Region C Water Planning Group (e.g., potentially feasible water conservation strategies). The model plans are intended to be a template that Region C water user groups can use as a starting point and customize to develop their own situation-specific water conservation plan.

Who Must Develop a Water Conservation Plan

The TCEQ requires water conservation plans for all municipal, industrial, and mining water users with surface water rights of 1,000 acre-feet per year or more and for all irrigation water users with surface water rights of 10,000 acre-feet per year or more. Water conservation plans are also required for all water users applying for a state water right and may also be required for entities seeking state funding for water supply projects. Recent legislation passed in 2003 requires that, as of May 1, 2005, all updated conservation plans must specify quantifiable 5-year and 10-year water conservation goals and targets [(6)]. While these goals are not enforceable, they must be identified. Water conservation plans were required to be submitted to the Executive Director of the TCEQ by May 1, 2005 [(6)]. Then, water conservation plans must be updated and submitted to the TCEQ by May 1, 2009, and every five years after that date [(6)].

In Region C, 21 entities hold 49 different municipal, industrial, or mining water rights of 1,000 acre-feet per year or more. Of these water rights, 6 are permits; 42 are certificates of adjudication; 1 is a temporary permit. Currently, there are no irrigation water rights of 10,000 acre-feet per year or more in Region C. Table 6.9 lists Region C entities that are required to develop a water conservation plan.

Table 6.9
Region C Water Users Required to Develop Water Conservation Plans

City of Dallas	Extex Laporte
City of Denison	Go-Crete Inc.
City of Denton	Greater Texoma Utility Authority
City of Fort Worth	Hanson Aggregates Central Inc.
City of Gainesville	J-M Manufacturing Co. Inc.
City of Grapevine	Lafarge Corporation
City of Jacksboro	North Texas MWD
City of Mineral Wells	Red River Authority
City of Terrell	Tarrant Regional Water District
City of Weatherford	Trinity River Authority
Dallas County Park Cities MUD	TXU Electric Company
Ellis County WCID No. 1	

Many more water users have contracts with regional water providers for 1,000 acre-feet of water per year or more. Presently, these water users are not required to develop water conservation plans unless the user is seeking state funding, but a wholesale water provider may request that its customers prepare a conservation plan to assist in meeting the goals and targets of the wholesale water provider's plan.

Municipal Water Conservation Plan Requirements

The TCEQ requires the following minimum content in a municipal water conservation plan:

- Utility profile
- Specification of conservation goals
- Accurate metering
- Universal metering
- Determination and control of unaccounted-for water
- Public education and information program
- Non-promotional water rate structure
- Reservoir system operation plan
- Means of implementation and enforcement
- Coordination with regional water planning group.

In addition, the TCEQ requires additional minimum content for municipal entities that are projected to supply 5,000 people or more in the following 10 years:

- Leak detection, repair, and water loss accounting
- Record management system
- Requirement for water conservation plans by wholesale customers.

The TCEQ also suggests optional content for municipal water conservation plans:

- Conservation-oriented water rates
- Ordinances, plumbing codes or rules on water-conserving fixtures
- Programs for the replacement or retrofit of water-conserving plumbing fixtures in existing structures
- Reuse and recycling of wastewater
- Pressure control and/or reduction
- Landscape water management ordinance
- Monitoring method
- Other conservation methods.

Finally, the Region C Water Planning Group suggests optional content consisting of the potentially feasible water conservation strategies that are not discussed elsewhere in the municipal water conservation plan:

- Residential customer water audit
- Water-efficient clothes washer rebate
- Landscape irrigation system rebate
- industrial, commercial, and institutional (ICI) general rebate
- ICI water audit, water waste reduction, and site-specific water conservation program.

Irrigation Water Conservation Plan Requirements

The TCEQ requires the following minimum content in an irrigation water conservation plan:

- Description of the irrigation production process
- Description of the irrigation method or system and equipment
- Accurate metering

- Specification of conservation goals
- Description of water-conserving irrigation equipment and application system
- Leak detection, repair, and water-loss control
- Irrigation timing and/or measuring the amount of water applied
- Land improvements for retaining or reducing runoff and increasing the infiltration of rain and irrigation water
- Tailwater recovery and reuse
- Other conservation practices, methods, or techniques.

Manufacturing and Steam Electric Power Water Conservation Plan Requirements

The TCEQ requires the following minimum content in manufacturing or steam electric power water conservation plans:

- Water use in the production process
- Specification of conservation goals
- Accurate metering
- Leak detection, repair, and water-loss accounting
- Water use efficiency process and/or equipment upgrades
- Other conservation practices
- Review and update of plan.

6.8 Drought Management

As described in Section 6.2, the Region C Water Planning Group decided not to recommend drought management measures as a water management strategy to provide additional supplies for Region C. The consensus of the planning group is that:

- Drought management and emergency response planning are intended to preserve water resources for the most essential uses when water supplies are threatened by an unexpected condition such as a multi-year drought, an unexpected increase in demands, or a water supply system component failure.
- Drought contingency and emergency response measures provide protection in the event of water supply shortages, but they are not a reliable source of additional supplies to meet growing demands. They provide a backup plan in case a supplier experiences a drought worse than the drought of record or if a water management strategy is incomplete when it is needed.

This section presents Texas Commission on Environmental Quality (TCEQ) requirements for drought contingency plans, reviews existing drought contingency plans, and summarizes model drought contingency plans.

Who Must Develop a Drought Contingency Plan

The TCEQ requires drought contingency plans for wholesale and retail public water suppliers and for irrigation districts. Drought contingency plans are also required for all water users applying for a state water right and may also be required for entities seeking state funding for water supply projects.

Wholesale public water suppliers, retail public water suppliers providing water service to 3,300 or more connections, and irrigation districts were required to prepare a drought contingency plan and submit it to the Executive Director of the TCEQ by May 1, 2005 [(6)]. Thereafter, these water users must submit an updated drought contingency plan by May 1, 2009, and every five years after that date [(6)].

All retail public water suppliers were required to prepare and adopt a drought contingency plan and have it available for inspection by the Executive Director upon request by May 1, 2005 [(6)]. Thereafter, all retail public water suppliers must prepare and adopt an updated drought contingency plan by May 1, 2009, and every five years after that date [(6)].

Required Content for Drought Contingency Plans

Drought contingency plans typically identify different stages of drought and specific triggers and response for each stage. In addition, a drought contingency plan must specify quantifiable targets for water use reductions for each stage, and a means and method for enforcement. As with the water conservation plans, drought contingency plans were to be updated and submitted to the TCEQ by May 1, 2005. Required content for different types of drought contingency plans is discussed below.

Municipal. The TCEQ requires the following minimum content in a municipal drought contingency plan:

- Provisions to inform the public and provide opportunity for public input
- Provisions for continuing public education and information

- Coordination with the regional water planning group
- Criteria for initiation and termination of drought stages
- Drought and emergency response stages
- Specific, quantified targets for water use reductions
- Water supply and demand management measures for each stage
- Procedures for initiation and termination of drought stages
- Procedures for granting variances
- Procedures for enforcement of mandatory restrictions
- Consultation with wholesale supplier
- Notification of implementation of mandatory measures
- Review and update of plan.

Irrigation. The TCEQ requires the following minimum content in an irrigation drought contingency plan:

- Provisions to inform the public and provide opportunity for public input
- Coordination with the regional water planning group
- Criteria for initiation and termination of drought stages
- Specific, quantified targets for water use reduction
- Procedures for determining the allocation of irrigation supplies to individual users
- Criteria for initiation and termination of drought stages
- Procedures for use accounting
- Procedures for the transfer of water allocations among individual users
- Procedures for enforcement of water allocation policies
- Consultation with wholesale supplier
- Protection of public water supplies
- Review and update of plan.

Review of Existing Drought Contingency Plans

Regional water plans are required to include potential trigger conditions for drought and emergency response measures and potential measures to be taken for each water source in the region. Appendix R includes a summary of drought contingency and emergency management plans in Region C, including potential triggers and response measures.

Model Drought Contingency Plans

Model drought contingency plans have been developed for municipal and irrigation water users. The TCEQ does not require drought contingency plans for manufacturing or steam electric power water users. The model drought contingency plans are shown as the last chapter in the municipal and irrigation water conservation plans presented in Appendices N and O. The model plans are designed to show the minimum content required by the TCEQ and are intended to be a template that Region C water user groups can use as a starting point and customize to develop their own situation-specific drought contingency plan. Each plan identifies four drought stages: mild, moderate, severe and emergency. The recommended responses range from notification of drought conditions and voluntary reductions in the "mild" stage to mandatory restrictions during an "emergency" stage. Individual entities will customize the trigger conditions for and the appropriate responses to the different stages.

6.9 Evaluation of Water Conservation and Drought Management Planning Requirements

As discussed in Section 6.1, the Texas Water Development Board (TWDB) planning rules [7] require consideration of water conservation and drought management measures for various water user groups. Table 6.10 shows each requirement and documents that the requirements have been fulfilled.

Table 6.10
Evaluation of Water Conservation and Drought Management Planning Requirements

Requirement	Evaluation	Fulfilled?
Include water conservation practices for each water user group that must prepare a water conservation plan under Texas Water Code §11.1271.	Table 6.9 lists Region C entities that are required to develop a water conservation plan under Texas Water Code §11.1271. These entities include municipal water retailers, municipal water wholesalers, manufacturers, and steam electric power generators. The basic conservation package is recommended for each municipal water user group, and the expanded conservation package is recommended for some municipal water user groups. The manufacturing general rebate strategy is recommended in each county with a projected manufacturing water need. The projected steam electric power water demands include the assumption that new power plants will be more efficient than existing power plants.	Yes
Consider water conservation practices for other water user groups (and document the reason if it does not adopt a water conservation practice that exceeds minimum levels).	Water conservation practices were considered for each water user group. In general water conservation practices were not recommended for water user groups that do not have a projected water need (with the exception of some municipal strategies that will occur without action from the water user group). Golf course conservation is recommended for each county that has a projected irrigation water need. There are no projected livestock water needs. The manufacturing general rebate strategy is recommended in each county with a projected manufacturing water need. The basic conservation package is recommended for each municipal water user group, and the expanded conservation package is recommended for some municipal water user groups. The projected steam electric power water demands include the assumption that new power plants will be more efficient than existing power plants.	Yes
Include a conservation water management strategy for each water user group or wholesale water provider that is to obtain water from a proposed interbasin transfer to which Texas Water Code §11.085(l) applies that will result in the highest practicable level of water conservation and efficiency achievable.	As documented above, water conservation strategies are recommended for each water user group that has a projected water need. The recommended water conservation strategies were chosen from the potentially feasible water conservation strategies based on evaluation of quantity, cost, reliability, and other factors in comparison with other water supply alternatives. Based on currently available data and evaluations of competing water supply strategies, the recommended water conservation strategies represent the "highest practicable level of water conservation and efficiency achievable" for each water user group or wholesale water provider that is to obtain water from a proposed interbasin transfer to which Texas Water Code §11.085(l) applies. This issue is discussed further in Section 4B.	Yes
Consider strategies to address any issues identified in the information compiled by the TWDB from the water loss audits performed by retail public utilities.	As part of the evaluation of water conservation strategies, available data on water loss was obtained from the TWDB. These data were used in estimating the potential water savings from the water system audit, leak detection and repair, and pressure control strategy. This strategy is part of the basic conservation package that is recommended for each municipal water user group.	Yes

Table 6.10 (Continued)
Evaluation of Water Conservation and Drought Management Planning Requirements

Requirement	Evaluation	Fulfilled?
Include drought management measures for each water user group that must prepare a drought contingency plan under Texas Water Code §11.1272.	Entities in Region C that are required to develop drought management plans have developed such plans and are currently using these plans during times of drought. Drought management is a current strategy in the region that is used to protect existing supplies during times of drought.	Yes
Consider drought management measures for each projected water need (and document the reason if it does not adopt a drought management measure).	The Region C Water Planning Group considered drought management measures as a water supply strategy. As discussed in Section 6.1, it is the consensus of the planning group that drought management and emergency response measures provide protection in the event of water supply shortages but are not a reliable source of additional supplies to meet growing demands. Therefore, the planning group decided not to recommend drought management measures as a water management strategy to provide additional supplies for Region C.	Yes
Include in its regional water plan a model water conservation plan pursuant to Texas Water Code §11.1271.	Model water conservation plans for municipal, irrigation, manufacturing, and steam electric power water user groups are presented in Appendices N and O.	Yes
Include in its regional water plan a model drought contingency plan pursuant to Texas Water Code §11.1272.	Model drought contingency plans are presented as the last chapter in the municipal and irrigation water conservation plans in Appendices N and O.	Yes

CHAPTER 6
LIST OF REFERENCES

(1) Freese and Nichols, Inc., Alan Plummer Associates, Inc., Chiang, Patel and Yerby, Inc., and Cooksey Communications, Inc: *Region C Water Plan*, prepared for the Region C Water Planning Group, Fort Worth, January 2001.

(2) GDS Associates, Inc.: *Quantifying the Effectiveness of Various Water Conservation Techniques in Texas*, prepared for the Texas Water Development Board, Austin, May 2002.

(3) GDS Associates, Inc., Chris Brown Consulting, Axiom-Blair Engineering, Inc., and Tony Gregg, P.E.: *Texas Water Development Board Report 362 Water Conservation Best Management Practices Guide*, prepared for the Water Conservation Implementation Task Force, Austin, November 2004.

(4) Texas Water Development Board and Water Conservation Implementation Task Force, *Special Report*, *Report to the 79th Legislature*, Austin, [Online] Available URL: http://www.twdb.state.tx.us/assistance/conservation/TaskForceDocs/WCITF_Leg_Report.pdf, November 2004.

(5) Texas Water Development Board (TWDB), Historical water use for the state of Texas (1980 to 2001), received from the TWDB, 2004.

(6) Texas Administrative Code, Title 30, Part 1, Chapter 288, [Online], Available URL: http://info.sos.state.tx.us/pls/pub/readtac$ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=288, December 2005.

(7) Texas Water Development Board: *Chapter 357, Regional Water Planning Guidelines*, Austin, October 1999, amended July 11, 2001.

7. Description of How the Regional Water Plan is Consistent with Long-Term Protection of the State's Water Resources, Agricultural Resources, and Natural Resources

7.1 Introduction

The development of viable strategies to meet the demand for water is the primary focus of regional water planning. However, another important goal of water planning is the long-term protection of resources that contribute to water availability and to the quality of life in the state. The purpose of this chapter is to describe how the *2006 Region C Water Plan* is consistent with the long-term protection of the state's water resources, agricultural resources, and natural resources. The requirement to evaluate the consistency of the regional water plan with protection of resources is found in 31 TAC Chapter 357.14(2)(C) [(1)], which states, in part:

> "The regional water plan is consistent with the guidance principles if it is developed in accordance with §358.3 of this title (relating to Guidelines), §357.5 of this title (relating to Guidelines for Development of Regional Water Plans), §357.7 of this title (relating to Regional Water Plan Development), §357.8 of this title (relating to Ecologically Unique River and Stream Segments), and §357.9 of this title (relating to Unique Sites for Reservoir Construction)."

Chapter 7 provides a general description of how the Region C plan is consistent with protection of water resources, agricultural resources, and natural resources. This chapter also specifically addresses the consistency of the *2006 Region C Water Plan* with the state's water planning requirements.

7.2 Consistency with the Protection of Water Resources

Five river basins provide surface water for Region C, and five aquifers provide groundwater to the region. The four major river basins within Region C boundaries are the Trinity River Basin, the Red River Basin, the Brazos River Basin, and the Sabine River Basin. Only a small portion of the Sulphur River Basin lies within the Region C boundaries, but this basin provides important surface water supplies for Region C from Chapman Lake. These river basins are depicted on Figure I.1, in Chapter 1. The region's groundwater resources include two major aquifers, the Trinity and Carrizo-Wilcox, and three minor aquifers, the Woodbine, the Nacatoch, and the Queen City. The extents of these aquifers within the region are depicted on Figures 1.7 and 1.8 in Chapter 1.

The Trinity River Basin provides the largest amount of water supply in Region C. Surface reservoirs in the Trinity Basin in Region C with conservation storage over 50,000 acre-feet include Lake Bridgeport, Eagle Mountain Lake, Lake Worth, Lake Weatherford, Benbrook Lake, Lake Arlington, Joe Pool Lake, Grapevine Lake, Ray Roberts Lake, Lewisville Lake, Lake Lavon, Lake Ray Hubbard, Bardwell Lake, Lake Waxahachie, Terrell Lake, Navarro Mills Lake, Richland-Chambers Reservoir, Cedar Creek Reservoir, and Lake Fairfield. Lake Texoma is located in Region C in the Red River Basin. Only a small portion of the Sabine River Basin lies within Region C, but two major water supply reservoirs used by Region C are located in the Sabine Basin in Region D (Lake Tawakoni and Lake Fork Reservoir). Only small portions of the Brazos River Basin lie within Region C, and no Brazos River Basin reservoirs with conservation storage over 50,000 acre-feet are located in Region C. Lake Palestine is located in the Neches River Basin in Region I and is already permitted for use in Region C. Chapman Lake is located in the Sulphur River Basin in Region D and provides water supply to Region C.

The Trinity aquifer provides about two-thirds of the groundwater resources in Region C. Almost 20 percent of the region's groundwater comes from the Woodbine aquifer. The remainder of the groundwater is from the Carrizo-Wilcox, the Nacatoch, the Queen City, and undifferentiated/other aquifers.

To be consistent with the long-term protection of water resources, the plan must recommend strategies that minimize threats to the region's sources of water over the planning period. The water management strategies identified in Chapter 4 were evaluated for threats to water resources. The state-developed surface Water Availability Models (WAMs) and Groundwater Availability Models (GAMs) were used to evaluate surface water and groundwater supplies, respectively. The results from these models were used to determine the amount of water supply that could be allocated while still protecting the sustainability of the water resources. The recommended strategies represent a comprehensive plan for meeting the needs of the region while effectively minimizing threats to water resources. Descriptions of the major strategies and the ways in which they minimize threats include the following:

- *Water Conservation*. Strategies for water conservation have been recommended that will significantly reduce the demand for water, thereby reducing the impact on the region's groundwater and surface water sources. Not including reuse, water conservation practices are expected to reduce the water use in Region C by 539,562 acre-feet per year by 2060, reducing impacts on both groundwater and surface water resources (Table 6.6).

- *Reuse Projects*. Reuse projects with a total water supply of 770,988 acre-feet per year as of 2060 have been recommended for use in Region C (Table 6.6). This amount of reuse will result in return flows to the Trinity River Basin near current levels through 2030. By 2060, the projected return flows to the region are significantly higher than historical levels. About 80 percent of the recommended reuse is for municipal purposes. These strategies will provide an economical and environmentally desirable source of water for Region C and delay the need for development of new water supplies.
- *Conservation and Reuse*. Conservation and reuse combined 1,310,550 acre-feet per year in 2060, 37 percent of the region's demand.
- *Full Utilization of Existing Surface Supplies Committed to Region C.* A number of recommended strategies for Region C are intended to make full use of existing supplies. Most reservoirs in Region C will be utilized at or near their firm yield capacities but not beyond, thus protecting these reservoirs and allowing the continued water supplies throughout a drought similar to the drought of record. In addition, by fully utilizing the existing water supplies, water providers will delay the need for new supplies.
- *Investigation of Existing Supplies Not Committed To Region C.* As part of this planning process, the Region C Water Planning Group investigated the cost and availability of existing water supplies that might be made available to Region C. Cost-effective existing supplies are included in the *2006 Region C Water Plan*.
- *Optimal Use of Groundwater*. This strategy is recommended for entities with limited alternative sources and sufficient groundwater supplies to meet needs. Groundwater availability reported in the plan is the long-term sustainability of the aquifer, and is based on aquifer recharge. Overdrafting is recommended in 2010 in limited areas where no other alternatives are available until after 2010. By 2020, the recommended plan calls for groundwater use at a sustainable level, thus maintaining the long-term sustainability of the aquifers.
- *New Surface Reservoirs*. A number of new surface reservoirs have been recommended as water management strategies. They include: Lower Bois d'Arc Creek Reservoir in 2020, Lake Ralph Hall in 2020, Marvin Nichols Reservoir in 2030, and Lake Fastrill in 2050. These reservoirs will have significant impacts on the land, homes, and habitat that will be inundated and on the existing stream segments which will be altered. As part of reservoir development, the Corps of Engineers will determine the quantity of land that should be set aside to mitigate for impacts to aquatic and wildlife habitats. Landowners within the reservoir sites will be compensated for their land. These new reservoirs will make releases for environmental water needs in accordance with environmental regulations and permit conditions, which will help sustain aquatic and wildlife habitat downstream from the reservoir. Water right permits for these reservoirs will be granted based on results from the Water Availability Models (WAMs) which will ensure that these new water rights do not interfere with existing prior water rights, thus protecting existing water resources of the state.

7.3 Consistency with Protection of Agricultural Resources

Many areas of Region C are heavily urbanized, and the region has comparatively little irrigated agriculture. In year 2000, less then 5 percent of the Region's total water use was for irrigation and livestock. None of the recommended water management strategies involve transferring water rights from agricultural use to another use. Thus, the Region C plan protects current agricultural water use.

The proposed reservoirs in the *2006 Region C Water Plan* will inundate some agricultural areas, but agricultural use in the reservoir sites is limited. The proposed reservoirs located in Region C include Lower Bois d'Arc Creek Lake, Lake Ralph Hall, and Muenster Lake. Very little agricultural activity exists in the area of the proposed Lower Bois d'Arc Creek Lake and Lake Ralph Hall. During the permitting process, a site specific analysis would address this topic in more detail. Muenster Lake has already been permitted and is expected to be completed in the spring of 2006.

The proposed reservoirs in the Region C plan that are located outside of Region C include Marvin Nichols Reservoir and Lake Fastrill. The area of the Marvin Nichol Reservoir site has some agricultural activity, including cattle raising. This area is also known to have some hunting leases for game animals. The Lake Fastrill area has limited agricultural use.

7.4 Consistency with Protection of Natural Resources

Region C contains many natural resources that must be considered in water planning. Natural resources include threatened or endangered species; local, state and federal parks and public land; and energy/mineral reserves. The Region C plan is consistent with the long-term protection of these resources. A brief discussion of consistency of the plan with protection of natural resources follows.

Threatened/Endangered Species

A list of threatened or endangered species located within Region C is contained in Table 1.28, in Chapter 1. According to the Texas Parks and Wildlife Department's listing [2], there are 12 endangered species and 19 threatened species whose habitats are located in Region C counties. According to the Federal Listing from the U.S. Fish and Wildlife Service [3], there are 3 endangered species and 11 threatened species whose habitats are located in Region C counties.

All recommended strategies in Region C have been chosen to minimize the effects on these threatened and endangered species. Strategies that are likely to disturb threatened or endangered species habitat include mitigation allowances that set aside additional land for that habitat.

Wetland Habitats

The Region C plan includes some projects that would have impacts to existing wetland habitats. The Marvin Nichols Reservoir and Lake Fastrill projects would inundate a portion of the state's Priority 1 bottomland hardwoods. These wetlands are considered high value to key waterfowl species and would require comparable mitigation. As discussed in Section 7.2, state and federal agencies will determine the quantity of land that should be set aside to mitigate for impacts to aquatic and wildlife habitats during reservoir development. The quantity and quality of the mitigation lands will be designed to achieve no net loss of wetlands functions and values. In addition, the development of a lake will create new wetland and aquatic habitats.

Parks and Public Lands

The Texas Parks and Wildlife Department operates several state parks in Region C: Bonham State Park in Fannin County, Cedar Hill State Park in Dallas County, Eisenhower State Park in Grayson County, Fairfield Lake State Park in Freestone County, Lake Lewisville State Park in Denton County, Lake Mineral Wells State Park in Parker County, Lake Ray Roberts State Park in Denton and Cooke Counties, and Purtis Creek State Park partially in Henderson County. TPWD also operates Caddo Wildlife Management Area in Fannin County, Ray Roberts Wildlife Management Area in Cooke, Denton, and Grayson Counties, Richland Creek Wildlife Management Area in Freestone and Navarro Counties, and Eisenhower State Historic Park in Grayson County.

Federal government natural resource holdings in Region C include the following:

- Parks and other land around all of the Corps of Engineers lakes in the region (Texoma, Ray Roberts, Lewisville, Lavon, Grapevine, Benbrook, Joe Pool, Bardwell, and Navarro Mills)
- Hagerman National Wildlife Refuge on the shore of Lake Texoma in Grayson County
- Caddo National Grasslands in Fannin County
- Lyndon B. Johnson National Grasslands in Wise County.

In addition, there are a number of city parks, recreational facilities, and public lands located throughout the region.

Increased utilization of some reservoirs may lower the lake levels during a severe drought. This may affect the parks and public lands surrounding these reservoirs, but the strategies recommended in the Region C plan will have no additional impact on these water resources beyond what has already been allowed for in their water rights permits. None of the recommended water management strategies evaluated for the Region C plan is expected to adversely impact parks or public lands.

Energy Reserves

Oil and natural gas fields are important natural resources in portions of Region C. Most of the oil production is in Jack, Wise, Cooke, Navarro, and Grayson Counties [(4)], and most of the natural gas production is in Freestone, Parker, Denton, Jack, Tarrant, and Wise Counties [(5)]. None of the 25 top-producing oil fields in Texas (based on 1999 production) is located in Region C, but two of the 25 top-producing gas fields are in the region [(6)]. Since 1999, there has been substantial development of natural gas wells in the Barnett Shale in Tarrant and nearby counties. In addition, there are some lignite coal resources in Region C [(7)], the most significant of which is used to supply TXU Electric's Big Brown Steam Electric Station on Lake Fairfield. None of the recommended water management strategies are expected to impact oil, gas, or coal production in the region.

7.5 Consistency with Protection of Navigation

No commercial navigation activities occur in Region C at this time. For the two river segments identified by the Corps of Engineers as "navigable waters" (Trinity River downstream of Fort Worth and the Red River downstream of Warren's Bend in Cooke County), there are no known plans to initiate navigation activities. This plan has no impact to navigation in Region C.

The Region C recommended strategies also do not impact navigation activities in other regions. Analysis of the proposed reuse projects found that there should be little to no impacts to stream flows from reuse projects, thus protecting potential downstream navigation activities. The recommended reservoirs located in adjacent regions (Marvin Nichols Reservoir and Lake

Fastrill) include sufficient releases that would protect instream uses and downstream navigation activities.

7.6 Consistency with State Water Planning Guidelines

To be considered consistent with long-term protection of the state's water, agricultural, and natural resources, the Region C plan must be determined to be in compliance with the following regulations [1, 8]:

- 31 TAC Chapter 358.3
- 31 TAC Chapter 357.5
- 31 TAC Chapter 357.7
- 31 TAC Chapter 357.8
- 31 TAC Chapter 357.9

The information, data, evaluation, and recommendations included in Chapters 1 through 6 and Chapter 8 of the Region C plan collectively comply with these regulations.

CHAPTER 7
LIST OF REFERENCES

(1) Texas Water Development Board: *Chapter 357, Regional Water Planning Guidelines*, Austin, October 1999, amended July 11, 2001.

(2) Texas Parks and Wildlife Department: *Annotated County Lists of Rare Species*, Austin, October 2003 Draft, November 2003, January 2004, and February 2004.

(3) U.S. Fish and Wildlife Service: *Listed Species Information Central*, [Online], Available URL: http://www.fws.gov/endangered/, January 2000.

(4) Texas Railroad Commission: Oil Well Counts by County, Austin, [Online], Available URL:http://www.rrc.state.tx.us/divisions/og/information-data/stats/ogowlct.pdf, February 2004.

(5) Texas Railroad Commission: Gas Well Counts by County, Austin, [Online], Available URL:http://www.rrc.state.tx.us/divisions/og/information-data/stats/oggwlct.pdf, February 2004.

(6) Texas Railroad Commission: Maps of Oil and Gas Wells and Fields, Austin, [Online], Available URL: http://www.rrc.state.tx.us/divisions/og/activity/top251999.html, August 2003.

(7) Texas Center for Policy Studies: *Texas Environmental Almanac*, Austin, [Online], Available URL: http://www.texascenter.org/almanac/index.html, 1995.

(8) Texas Water Development Board: *Chapter 358, State Water Planning Guidelines*, Austin, October 1999, amended July 11, 2001.

8. Unique Stream Segments, Unique Reservoir Sites, and Legislative Recommendations

The Texas Water Development Board (TWDB) regional water planning guidelines [(1)] require that a regional water plan include recommendations for regulatory, administrative, and legislative changes that will facilitate water resources development and management:

> "**357.7(a)** Regional water plan development shall include the following…(10) regulatory, administrative, or legislative recommendations that the regional water planning group believes are needed and desirable to: facilitate the orderly development, management, and conservation of water resources and preparation for and response to drought conditions in order that sufficient water will be available at a reasonable cost to ensure public health, safety, and welfare; further economic development; and protect the agricultural and natural resources of the state and regional water planning area. The regional water planning group may develop information as to the potential impact once proposed changes in law are enacted."

The guidelines also call for regional water planning groups to make recommendations on the designation of ecologically unique river and stream sites and unique sites for reservoir development. This section also presents the regulatory, administrative, legislative, and other recommendations of the Region C Water Planning Group and the reasons for the recommendations. The recommendations are presented in the following order:

- Summary of recommendations
- Recommendations for ecologically unique river and stream segments
- Recommendations for unique sites for reservoir construction
- Policy and legislative recommendations.

8.1 Summary of Recommendations

- Recommendations for ecologically unique river and stream segments
  - Provide clarification of the impacts of designating a unique stream segment.
- Recommendations for unique sites for reservoir construction
  - Marvin Nichols
  - Lower Bois d'Arc Creek
  - Muenster
  - Fastrill

- Ralph Hall
  - Tehuacana
- Policy and legislative recommendations
  - Senate Bill One Planning Process
    - Allow alternative strategies.
    - Provide clear guidance on resolving consistency issues.
    - Allow waivers of plan amendments for entities with small strategies.
    - Coordinate efforts between TWDB and TCEQ regarding use of the WAMs for planning.
    - Support the water conservation task force recommendation regarding targets for water conservation.
  - TCEQ Policy and Water Rights
    - Allow exemptions from the cancellation of water rights for non-use for certain types of water rights.
    - Remove the unnecessary and counterproductive barriers for interbasin transfers.
    - Dispose of municipal and industrial brine waste according to the same regulations as brine resulting from petroleum development activities.
  - Reuse of Treated Wastewater
    - Remove obstacles to indirect reuse and clarify the permitting process.
  - State and Federal Program – Water Supply Issues
    - Increase state funding for Texas Water Development Board loans and the State Participation Program.
    - Provide state funding for water conservation efforts.
    - Provide funding for NRCS structures as a form of watershed protection.
    - Provide funding assistance for desalination projects.
    - Oversee rule making by groundwater conservation districts.

8.2 Recommendations for Ecologically Unique River and Stream Segments

The Region C Water Planning Group established a committee to review and recommend river and stream segments as ecologically unique. The committee studied the list of proposed river and stream segments provided by the Texas Parks and Wildlife Department [(2)] as listed in Table 8.1 and shown in red in Figure 8.1. The committee met with representatives of the Texas Parks and Wildlife and the Texas Water Development Board.

In the 2001 *Region C Water Plan* [3], the Region C Water Planning Group decided not to recommend any river or stream segments as ecologically unique because of unresolved concerns regarding the implications of such a designation. The Texas Legislature has since clarified that the only intended effect of the designation of a unique stream segment was to prevent the development of a reservoir on the designated segment by a political subdivision of the state. However, the Texas Water Development Board regulations governing regional water planning require analysis of the impact of water management strategies on unique stream segments, which implies some level of protection beyond the mere prevention of reservoir development.

The committee developed a memo summarizing their work and recommendations to the Region C Water Planning Group and is found in Appendix W of this plan. The committee developed a list of seven stream segments for consideration as ecologically unique. Two of those segments were dependent on the recommendation of the adjoining region, which did not recommend the adjoining segments. Thus, the committee had five stream segments for the Region C Water Planning Group to consider recommending as ecologically unique. Appendix W identifies the reasoning behind the decision for each stream segment on the Texas Parks and Wildlife Department's list of recommended segments.

After much debate, the Region C Water Planning Group took action on unique stream segments, but the motion did not pass. The Region C Water Planning Group still has many questions regarding the unintended consequences of designating a river or stream segment as ecologically unique. In the 2001 Plan, the planning group listed questions that the group felt important to be answered before making and recommendations for unique stream segment designations. Of the original questions posed, the following questions appear to remain unanswered:

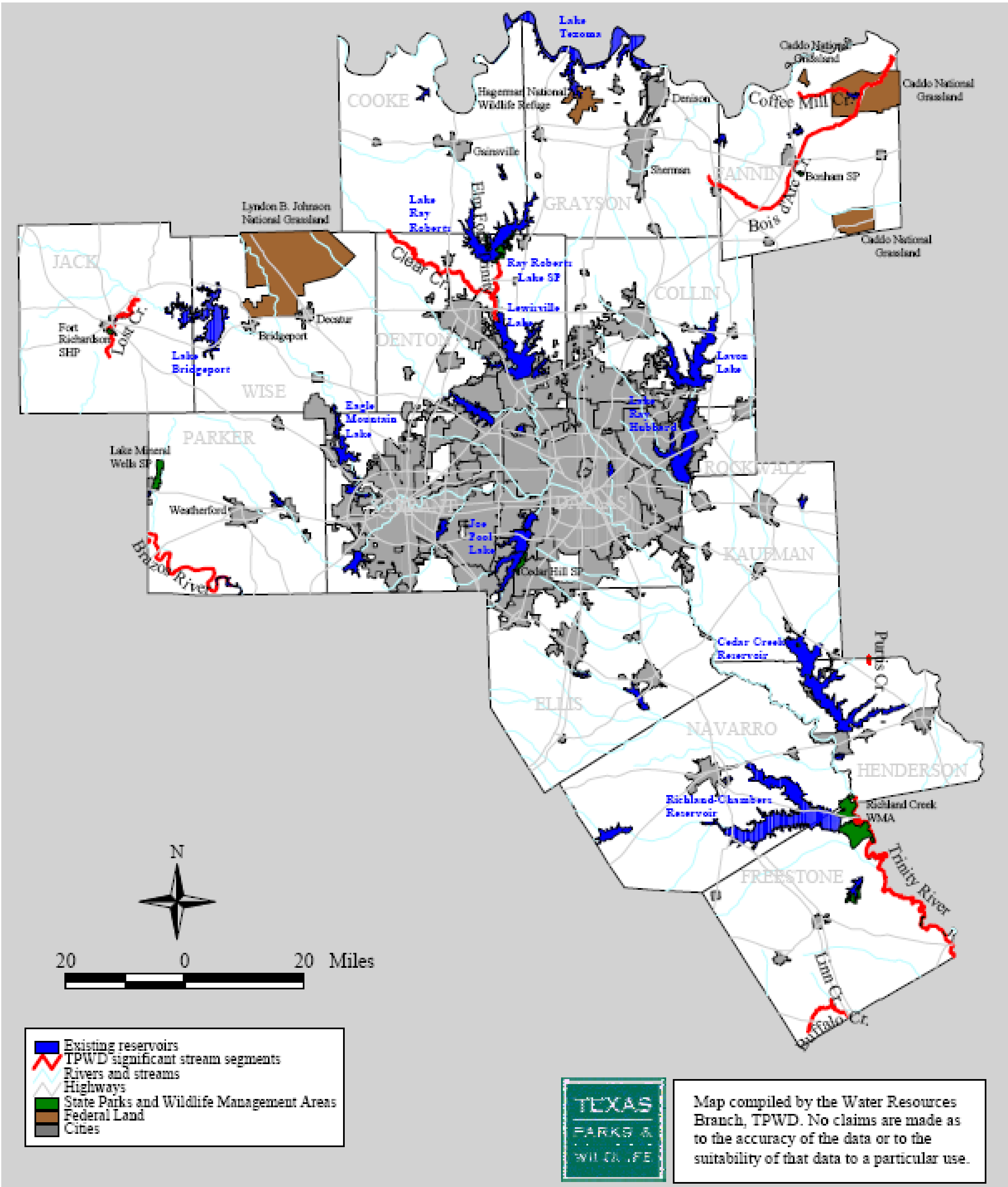
- How would adjacent private properties be affected by the designation?
- How will future water rights be affected? For example, would instream flow requirements be imposed on future water rights upstream?
- How will designation affect regulatory programs to protect water quality?
- What area is affected by the designation? The stream? The entire watershed? An area surrounding the stream?
- Can the designation be reversed?

Table 8.1
Texas Parks and Wildlife Department Recommendations for Designation as Ecologically Unique River and Stream Segments from *Ecologically Significant River and Stream Segments of Region C, April 2002* (2)

River or Stream Segment	Description	Basin	County	TPWD Reasons for Designation [a]				
				Biological Function	Hydro-logic Function	Riparian Conservation Area	High Water Quality/ Aesthetic Value	Endangered Species/ Unique Communities
Bois d'Arc Creek	Entire length	Red	Fannin	X	X	X		
Brazos River	Parker/Palo Pinto Co. line to F.M. 2580	Brazos	Parker	X			X	X
Buffalo Creek	Alligator Ck.-S.H. 164	Trinity	Freestone	X	X			
Clear Creek	Denton/Cooke Co. line to Elm Fork. Trinity R.	Trinity	Denton				X	
Coffee Mill Creek	Entire length	Red	Fannin			X		
Linn Creek	Buffalo Ck. – C.R. 691	Trinity	Freestone	X	X			
Lost Creek	Entire length	Trinity	Jack			X	X	
Purtis Creek	S. Twin Ck. to Henderson Co. line	Trinity	Henderson			X		
Trinity River	Freestone/Leon to Henderson/Anderson Co. line	Trinity	Freestone/ Anderson	X		X		X

Note: a. The criteria listed are from Texas Administration Code Section 357.8. The Texas Parks and Wildlife Department feels that their recommended stream reaches meet those criteria marked with an X.

Figure 8.1
Texas Parks and Wildlife Department Recommendations for Designation as Ecologically Unique River and Stream Segments from *Ecologically Significant River and Stream Segments of Region C, April 2002* [(2)]



The uncertainties posed by these questions led the Region C Water Planning Group to decide against recommending any stream segments for designation as ecologically unique at this time.

8.3 Recommendations for Unique Sites for Reservoir Construction

Section 357.9 of the Texas Water Development Board regional water planning guidelines [(1)] allows a regional water planning group to recommend unique stream sites for reservoir construction:

> "**357.9. Unique Sites for Reservoir Construction.** A regional water planning group may recommend sites of unique value for construction of reservoirs by including descriptions of the sites, reasons for the unique designation and expected beneficiaries of the water supply to be developed at the site. The following criteria shall be used to determine if a site is unique for reservoir construction:
>
> (1) site-specific reservoir development is recommended as a specific water management strategy or in an alternative long-term scenario in an adopted regional water plan; or
>
> (2) the location, hydrologic, geologic, topographic, water availability, water quality, environmental, cultural, and current development characteristics, or other pertinent factors make the site uniquely suited for:
>
> (A) reservoir development to provide water supply for the current planning period; or
>
> (B) where it might reasonably be needed to meet needs beyond the 50-year planning period."

This section presents the Region C Water Planning Group's recommendations for unique sites for reservoir development and the reasons for the recommendations. The Region C Water Planning Group recommends designation of the following unique sites for reservoir development:

- Muenster site on Brushy Elm Creek in Cooke County
- Ralph Hall site on the North Sulphur River in Fannin County
- Lower Bois d'Arc Creek (formerly called New Bonham) site on Bois d'Arc Creek in Fannin County
- Marvin Nichols site on the Sulphur River in Red River, Titus, and Franklin Counties
- Fastrill site on the Neches River in Anderson and Cherokee Counties
- Tehuacana site on Tehuacana Creek in Freestone County.

These sites and the reasons for designating them as unique reservoir sites are discussed below. Figure 4D.1 shows the location of these proposed reservoir sites.

Muenster

Description of the Site. Muenster Reservoir would be located on Brushy Elm Creek in Cooke County. The proposed reservoir has been permitted by the Texas Commission on Environmental Quality for impoundment of 4,700 acre-feet and diversion of 500 acre-feet per year for municipal use. The reservoir would flood 418 acres at the top of conservation storage. Because of its small size, the reservoir would have little environmental impact.

Reasons for Unique Designation. The Muenster Water District and the Natural Resource Conservation Service are developing Muenster Lake for municipal water supply, flood control, and recreation. The project has been permitted by the Texas Commission on Environmental Quality and approved by local voters. The reservoir is currently under construction and is expected to be completed in the spring of 2006. Muenster Lake would reduce Muenster's dependence on the Trinity aquifer, which is overused in Cooke County.

The proposed reservoir was included in the 2002 State Water Plan [(12)] as a recommended water management strategy for Muenster and was recommended by the Texas Water Development Board to the Texas Legislature for designation as unique. The legislature did not designate additional unique reservoir sites based on the 2002 state plan.

The location, geologic, hydrologic, topographic, water availability, water quality, environmental, and current development characteristics make this site uniquely suited to provide water supply for Region C.

Expected Beneficiaries of Water Supply. The expected beneficiaries of this project include Muenster, Cooke County Manufacturing, and Cooke County-Other. The project would indirectly benefit other water user groups in Cooke County by reducing use from the Trinity aquifer.

Ralph Hall

Description of the Site. Lake Ralph Hall would be located on the North Sulphur River in southeast Fannin County, north of Ladonia. The reservoir would have a conservation pool elevation of 550.0 MSL, resulting in a yield of 32,100 acre-feet per year and would flood 7,236 acres. The most significant environmental impacts of Lake Ralph Hall would be the inundation of habitat.

Reasons for Unique Designation. Lake Ralph Hall is a recommended water management strategy for the Upper Trinity Regional Water District. The proposed lake would provide water to southeast Fannin County residents, as well as customers of the Upper Trinity Regional Water District in the Denton County area. The Upper Trinity Regional Water District and the City of Ladonia have reached an agreement for developing the reservoir. Development of Lake Ralph Hall by the Upper Trinity Regional Water District provides additional security in the wholesale water provider's supply.

The location, geologic, hydrologic, topographic, water availability, water quality, and current development characteristics make this site uniquely suited to provide water supply for Region C.

Expected Beneficiaries of Water Supply. The expected beneficiaries of this project would be the Upper Trinity Regional Water District and its current and potential customers, along with residents in the southern area of Fannin County. Appendix H includes a table listing the customers of the Upper Trinity Regional Water District.

Lower Bois d'Arc Creek

Description of the Site. Lower Bois d'Arc Creek Reservoir would be located on Bois d'Arc Creek in Fannin County, immediately upstream from the Caddo National Grassland. The proposed reservoir has been studied in the past with a conservation pool elevation of 534.0, and the Red River Compact gives Texas unlimited use of the waters of Bois d'Arc Creek upstream from the Lower Bois d'Arc Creek site.

With the top of conservation storage at elevation 534.0, the proposed reservoir would have a yield of 123,000 acre-feet per year and would flood 16,400 acres. The most significant environmental impacts of Lower Bois d'Arc Creek Reservoir would be the inundation of habitat, including wetlands and bottomland hardwoods. The lake would inundate part of the Bois d'Arc Creek bottomland hardwoods area, which is designated as a Priority 4 area in the 1984 U.S. Fish and Wildlife Service *Bottomland Hardwood Protection Plan* [(4)]. (A Priority 4 area is a "moderate quality bottomlands with minor waterfowl benefits.") The lake would have no direct impacts on the Caddo National Grasslands, but changes in flow patterns on Bois d'Arc Creek could have an indirect impact on the grasslands. In order to protect the grasslands, the Texas Parks and Wildlife Department nominated Bois d'Arc Creek for designation as an ecologically unique stream segment. Meeting the release requirements from the Texas Water Development Board consensus criteria for releases would minimize the downstream impacts of Lower Bois d'Arc Creek Reservoir.

Reasons for Unique Designation. The North Texas Municipal Water District would be the primary developer of the Lower Bois d'Arc Creek Reservoir, and it is assumed that the District would use 100 percent of the yield of the project. The North Texas Municipal Water District has recently agreed to supply water to Bonham, which is located in Fannin County. Therefore, some of the water developed by the Lower Bois d'Arc Creek Reservoir would remain in Fannin County for Bonham and other potential customers who are anticipated to participate in the Fannin County Water Project that would be supplied by the North Texas Municipal Water District from the Lower Bois d'Arc Creek Reservoir.

The North Texas Municipal Water District needs a major new supply by 2020, approximately 10 years earlier than most of the other wholesale water providers in Region C. Because Lower Bois d'Arc Creek Reservoir is smaller, costs less, and has less environmental impact than Marvin Nichols Reservoir, it could be developed by NTMWD alone and be developed more quickly than the larger reservoir. Water in Lower Bois d'Arc Creek Reservoir would be relatively inexpensive in the lake and would also be relatively inexpensive delivered to the North Texas Municipal Water District.

The proposed reservoir was included in the 2002 State Water Plan [(5)] as a recommended water management strategy for the North Texas Municipal Water District and was recommended by the Texas Water Development Board to the Texas Legislature for designation as unique. The legislature did not designate additional unique reservoir sites based on the 2002 state plan.

The location, geologic, hydrologic, topographic, water availability, water quality, environmental, and current development characteristics make this site uniquely suited to provide water supply for Region C.

Expected Beneficiaries of Water Supply. The expected beneficiaries of this project include North Texas Municipal Water District and its customers, including the potential customers in Fannin County. Appendix H lists all of the current and potential customers that would benefit from the proposed Lower Bois d'Arc Creek Reservoir.

Marvin Nichols

Description of the Site. The Marvin Nichols Reservoir site is located on the Sulphur River upstream from its confluence with White Oak Creek. The dam would be in Titus and Red River Counties, and the reservoir would also impound water in Franklin County. The proposed reservoir has been studied in the past and was included in the 2002 State Water Plan [(5)] as a source of water supply for Region C and Region D. Since the 2002 plan, further studies have suggested that a location somewhat upstream, called Marvin Nichols 1A, would provide the same yield as previously proposed with less environmental impact.

The proposed reservoir would have a yield of 612,300 acre-feet per year (assuming that Lake Ralph Hall is senior and that Marvin Nichols Reservoir (Marvin Nichols 1A) is operated as a system with Wright Patman Lake) and would flood 67,400 acres. The reservoir has a very large yield compared with other potential projects. The most significant environmental impact of the Marvin Nichols Reservoir project would be the inundation of habitat, including wetlands and bottomland hardwoods. The lake would inundate a portion of the Sulphur River Bottom West/Cuckoo Pond bottomland hardwoods area, which is designated as a Priority 1 area in the 1984 U.S. Fish and Wildlife Service *Bottomland Hardwood Protection Plan* [(4)]. (A Priority 1 area is an "excellent quality bottomlands of high value to the key waterfowl species.") There are also lignite deposits and some oil and gas wells in the pool area of the proposed lake.

Reasons for Unique Designation. Marvin Nichols Reservoir would provide a substantial portion of the projected water needs of Region C. It is included in the Region C water plan as a recommended water management strategy of water for the North Texas Municipal Water District, Tarrant Regional Water District, and Upper Trinity Regional Water District. Through these wholesale water providers, the reservoir would supply many of the water user groups in Region C. Marvin Nichols Reservoir has also been analyzed as an alternative supply for Dallas Water Utilities and Irving.

Compared to the alternative of developing a number of other reservoirs in the Sulphur Basin (George Parkhouse North, George Parkhouse South, and Marvin Nichols South), Marvin Nichols Reservoir provides more water at a lower cost and with less environmental impact. The location, geologic, hydrologic, topographic, water availability, water quality, and current development characteristics make this site uniquely suited to provide a major water supply for Region C. The proposed reservoir was included in the 2002 State Water Plan [(5)] as a recommended water management strategy and was recommended by the Texas Water Development Board to the Texas Legislature for designation as unique. The legislature did not designate additional unique reservoir sites based on the 2002 state plan.

Expected Beneficiaries of Water Supply. The expected beneficiaries of this project in Region C include the following water providers and water user groups:

- North Texas Municipal Water District and its customers
- Tarrant Regional Water District and its customers
- Upper Trinity Regional Water District and its customers

Appendix H includes the detailed list of municipal and manufacturing customers that would benefit from Marvin Nichols Reservoir. In all, 56 percent of the water user groups in Region C would benefit from the project assuming that only the three wholesale water providers participate. If the fourth wholesale water provider participates in the alternative version of this project, then 88 percent of Region C would benefit from Marvin Nichols North.

Fastrill

Description of the Site. Lake Fastrill would be located on the Neches River in Anderson and Cherokee Counties, downstream of Lake Palestine and upstream of the Weches dam site. The reservoir would have a conservation pool elevation of 274.0 MSL, resulting in a yield of 148,780 acre-feet per year and would flood 24,950 acres. The most significant environmental impacts of Lake Fastrill would be the inundation of habitat, including wetlands and bottomland hardwoods.

The U.S. Fish and Wildlife Service has prepared a preliminary report to evaluate the development of the Neches River Wildlife Refuge along the Upper Neches River near the same area as the proposed Lake Fastrill. The City of Dallas in cooperation with the Upper Neches River Municipal Water Authority is evaluating the Lake Fastrill project to determine if it can be developed in cooperation with the proposed Neches River Wildlife Refuge.

Reasons for Unique Designation. Lake Fastrill is a recommended water management strategy for Dallas Water Utilities. Lake Fastrill could be operated as a system with Lake Palestine. Approximately 80 percent of the firm yield would be committed to Dallas Water Utilities and the other 20 percent would remain in the Neches Basin for local use. Dallas Water Utilities has included Lake Fastrill in its recently updated long-range water supply plan [(6)].

The location, geologic, hydrologic, topographic, water availability, water quality, and current development characteristics make this site uniquely suited to provide water supply for Region C.

Expected Beneficiaries of Water Supply. The expected beneficiaries of this project would be current and potential customers of Dallas Water Utilities, as well as water user groups in Anderson, Cherokee, Henderson, and Smith Counties. Appendix H includes a table listing the customers of the Dallas Water Utilities.

Tehuacana

Description of the Site. Tehuacana Reservoir would be located on Tehuacana Creek in Freestone County, south of the Richland-Chambers Reservoir. The proposed reservoir was included in the 2002 State Water Plan [(5)] as an alternative source of supply for the Tarrant Regional Water District and was recommended by the Texas Water Development Board to the Texas Legislature for designation as unique. The legislature did not designate additional unique reservoir sites based on the 2002 state plan. The project has been part of TRWD's planning for many years, and it fits well with the District's system. The reservoir would have a conservation pool elevation of 315.0, the same as Richland-Chambers, and the two lakes would be connected by a channel.

With the top of conservation storage at elevation 315.0, the proposed reservoir would have a yield of 56,800 acre-feet per year and would flood 14,900 acres. The most significant environmental impacts of Tehuacana Reservoir would be the inundation of habitat, including wetlands and bottomland hardwoods. There are also lignite resources and oil and gas wells in the area that would be inundated by Tehuacana Reservoir.

Reasons for Unique Designation. Tehuacana Reservoir has been in the plans of the Tarrant Regional Water District for decades. The lake would be connected to the Richland-Chambers Reservoir by a channel, allowing the water supply provided by Tehuacana to be pumped from Richland-Chambers. Development of Tehuacana could allow extension of the Tarrant Regional Water District project of diversions from the Trinity for additional water supply. Although this reservoir is not recommended for development before 2060 if other sources can be developed, it remains desirable as an alternative project.

The location, geologic, hydrologic, topographic, water availability, water quality, and current development characteristics make this site uniquely suited to provide water supply for Region C.

Expected Beneficiaries of Water Supply. The expected beneficiaries of this project would be Tarrant Regional Water District and its existing and potential customers as well as water user groups in Freestone County. Appendix H includes a table listing the customers of the Tarrant Regional Water District. Appendix D lists the water user groups in Freestone County, all of whom might benefit from this project.

8.4 Policy and Legislative Recommendations

The Region C Water Planning Group established a committee to review and recommend water policy topics to include in this plan. Appendix X includes the memorandum prepared by the committee including their recommendations to the planning group. The Region C Water Planning Group approved the memo as presented for inclusion in the Region C plan. The recommendations provided in the memo are discussed here.

Senate Bill One Planning Process

Alternative Strategies. Section 357.7(a)(9) of the TWDB Regional Water Planning guidelines [(1)] requires "specific recommendations of water management strategies to meet the needs…". As we understand the TWDB interpretation of this requirement, listing alternative strategies among which a water supplier can choose is not allowed.

This requirement decreases the local control and flexibility that have been an important part of the successful efforts to meet water needs in Region C and throughout Texas. Water suppliers need to have a full range of options as they seek to provide new water supplies for Texas' future. It is impossible to foresee all the possibilities for new water supplies in a planning process such as this, and changing circumstances can change the preferred alternative for new supplies very quickly. The following steps should be taken to address these concerns:

- Allow willing buyer/willing seller transactions of water rights and treated water to occur without additional regulations.
- The Texas Water Development Board (TWDB) and Texas Commission on Environmental Quality (TCEQ) should interpret existing legislation to give the maximum possible flexibility in determining "consistency" with the regional water plan. Changes in the timing of development, the order in which strategies are developed, the amount of supply, or details of a project should not be considered as making the project inconsistent with the regional plan.
- The TWDB and TCEQ should make liberal use of their ability to waive consistency requirements.
- Legislative and/or regulatory changes should be made to allow alternative water management strategies to be included in the regional water plan.

Clear Guidance on Resolving Consistency Issues. The Texas Water Development Board has implemented a policy that only considers Tables 12 and 13 of the 2001 *Region C Water Plan* [3] to be the recommended strategies and does not consider the text of the 2001 Plan in their determination of "consistency". This policy was not made clear to the regional water planning groups prior to adoption of the 2001 plans. Thus, the planning groups have had to amendment the 2001 plans frequently. The inability of planning groups to recommend alternative projects will compound this problem.

In the future, the TWDB should publish the criteria for what projects will be considered consistent with regional water plans prior to these plans being adopted by the regional water planning groups. This will allow the regional water planning groups time to adjust the regional water plans accordingly.

Allow Waivers of Plan Amendments for Entities with Small Strategies. Region C recommends that the Texas Water Development Board allow waivers for consistency issues for plan amendments that involve projects resulting in small amounts of additional supply.

Coordination between TWDB and TCEQ Regarding Use of the WAMs for Planning. The TWDB requires that the Water Availability Models (WAMs) developed under the direction of TCEQ to be used in determining available surface water supplies. The models were developed for the purpose of evaluating new water rights permit applications and are not appropriate for water supply planning. The TWDB and TCEQ should coordinate their efforts to determine the appropriate data and tools available through the WAM program for use in regional water planning. The TWDB should allow the regional water planning groups some flexibility in applying the models made available for planning purposes.

Support Water Conservation Task Force Recommendation Regarding Target for Water Conservation. The Water Conservation Task Force [(7)] recommended that the targets they developed be used as voluntary per capita water goals for entities to consider. The Task Force indicated that these voluntary goals should not be mandatory. Per capita water use is unique to each water supplier. A statewide per capita water use value is not appropriate for the State of Texas, considering its wide variation in rainfall, economic development, and other factors. The Region C Water Planning Group supports the decision of the Water Conservation Task Force that the targets included in their report should be voluntary targets rather than mandatory goals.

TCEQ Policy and Water Rights

Cancellation of Water Rights for Non-Use. The Texas Water Code [(8)] currently allows the Texas Commission on Environmental Quality to cancel any water right, in whole or in part, for ten consecutive years of non-use. This rule inhibits long-term water supply planning. Reservoirs are often constructed to fully utilize the yield available at a given site and are often constructed to meet needs far into the future. Many times, only part of the supply is used in the first ten years of the reservoir's operation, with the remainder allocated for future needs.

The water code should be changed to exempt certain projects from the cancellation for ten years of non-use rule. The exemption might include municipal water rights, water rights for steam electric power, water rights associated with major reservoirs, and water rights included as long-term supplies in an approved regional water plan.

Requirements for Interbasin Transfers Introduced in Senate Bill One. In 1997, Senate Bill One introduced a number of new requirements for applications for water rights permits to allow interbasin transfers. The requirements are found in Section 11.085 of the Texas Water Code [(9)]. The code includes many provisions that are not required of any other water rights, including:

- Analysis of the impact of the transfers on user rates by class of ratepayer
- Public meetings in the basin of origin and the receiving basin
- Extra notice to county judges, mayors, and groundwater districts in the basin of origin
- Extra notice to legislators in the basin of origin and the receiving basin
- TCEQ request for comments from each county judge in the basin of origin
- Proposed mitigation to the basin of origin
- Demonstration that the applicant has prepared plans that will result in the "highest practicable water conservation and efficiency achievable…"

Exceptions to these extra requirements placed on interbasin transfers were made for emergencies, small transfers (less than 3,000 acre-feet under one water right), transfers to an adjoining coastal basin, transfers to a county partially in the basin of origin, and transfers to a municipality whose retail service area is partially within the basin of origin.

The effect of these changes is to make obtaining a permit for interbasin transfer significantly more difficult than it was under prior law and thus to discourage the use of interbasin transfers for water supply. This is undesirable for several reasons:

- Interbasin transfers have been used extensively in Texas and are an important part of the state's current water supply. For example, current permits allow interbasin transfers of over 600,000 acre-feet per year from the Red, Sulphur, Sabine, and Neches Basins to meet needs in the Trinity Basin in Region C. This represents almost one-third of the region's reliable water supply.
- Current supplies greatly exceed projected demands in some basins, and the supplies already developed in those basins can only be used through interbasin transfers.
- Senate Bill One water supply plans for major metropolitan areas in Texas (Dallas-Fort Worth, Houston, and San Antonio) rely on interbasin transfers as a key component of their plans.
- Texas water law has always regarded surface water as belonging to the people of the state, to be used for the benefit of the state as a whole.

- The current requirements for permitting interbasin transfers provide an unnecessary barrier to development of the best, most economical, and most environmentally acceptable water supplies.
- Since no contested interbasin transfer permits have been granted under these new requirements, the meaning of some of the provisions and the way in which they will be applied by TCEQ are undefined.

The legislature should revisit the current law on interbasin transfers and remove some of the unnecessary and counterproductive barriers to such transfers that now exist.

Disposal of Brine Waste. Desalination projects result in a brine waste that must be disposed in an environmentally friendly fashion. Different regulations regarding the disposal of brine waste and different agencies govern those regulations. The brine resulting from water that is desalinated for municipal and industrial purposes is regulated by TCEQ and must be disposed according to much stricter standards than the brine resulting from petroleum development activities, regulated by the Railroad Commission. The way that brine is created should not affect the regulations that govern the disposal of the resulting brine. Region C recommends that the brine resulting from municipal and industrial desalination be disposed according to the same regulations as brine resulting from petroleum development activities.

Reuse of Treated Wastewater

Policies Limiting the Use of Treated Wastewater. The TCEQ has recently implemented policies, some in response to legislative requirements in Senate Bill One, that limit TCEQ's ability to permit projects for indirect reuse, in which water is returned to a reservoir or watercourse before being diverted for reuse. The policy of discouraging indirect reuse has a number of negative impacts on water suppliers in Region C and throughout the state:

- The policies are logically inconsistent with policies encouraging direct reuse of treated wastewater.
- The policies inhibit reuse for municipal purposes by prohibiting the most effective approach to municipal reuse, which incorporates "multiple barriers" between wastewater discharge and eventual reuse. Streams and reservoirs are among the most effective of such multiple barriers.
- The policies encourage reuse for irrigation and industrial purposes, where direct reuse is appropriate, while discouraging reuse to meet municipal needs, where indirect reuse is the preferred approach.

- It is poor public policy to discourage indirect reuse, which is a water supply alternative with relatively low environmental impacts.
- It is poor public policy to require the construction of infrastructure for direct reuse in cases when natural watercourses can deliver water much more economically.
- Indirect reuse of treated wastewater is an important element of water supply planning in Region C.

The legislature should revisit the issue of indirect reuse of treated wastewater using the bed and banks of state watercourses, with a view to reducing the obstacles to indirect reuse. The historical discharge of treated wastewater effluent should not make the indirect reuse of wastewater more difficult.

Reuse projects, both direct and indirect, are a significant portion of Region C's future water supplies. Large-scale indirect reuse projects are planned for Richland-Chambers Reservoir, Cedar Creek Reservoir, Lake Ray Hubbard, and Lake Lavon. TCEQ should clearly define the permitting process for large-scale indirect reuse projects to expedite the permitting process.

State and Federal Program – Water Supply Issues

Increased State Funding for Texas Water Development Board Loans and the State Participation Program. The Senate Bill One regional water planning studies show significant needs for future water supply projects. The Texas Water Development Board's loan and State Participation Programs have been important tools in the development of existing supplies. These programs should be continued and expanded with additional funding to assist in the development of the water management strategies recommended in the regional water plans to meet the future water needs in Texas.

State Funding for Water Conservation Efforts. As a result of the policy recommendations in the 2001 regional water plans, the Texas Water Development Board established a water conservation task force and developed a state-wide water conservation campaign. The water conservation task force developed recommendations regarding best management practices for various types of water uses [(7)]. The conservation campaign [(10)] was released to the public on January 26, 2005.

The current TWDB regulations require that water conservation be considered as a water management strategy for each water shortage. In Region C, four model water conservation plans have been developed and are included in Appendices N and O of this plan. Programs should be developed to help local water suppliers achieve the conservation savings recommended in this regional water plan.

The legislature should provide funding to allow the Texas Water Development Board and other state agencies to undertake or expand the programs listed in Appendix X of this plan.

Funding for NRCS Structures as a Form of Watershed Protection. One key element of water supply planning is the protection of the quality and usability of supplies already developed. Over the past 50 years, the U.S. Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service) has built numerous small dams for sediment control and flood control in Texas. The NRCS reservoirs also improve water quality and prevent erosion in the watershed. The NRCS reservoirs provide water for livestock and increase streamflows during low flow periods. The design life for the majority of the NRCS watershed dams is 50 years. Most of the projects were built in the 1950s and 1960s and are nearing the end of their design life. Many of the NRCS structures are in need of maintenance or repair in order to extend the life of the dams.

The Dam Rehabilitation Act [(11)] funds the rehabilitation and upgrade of existing NRCS structures. Every year, the NRCS accepts applications for funding such projects and prioritizes them. The rehab program is a 65/35 split of federal funds to the sponsor's funds. Currently in the Region C area, ten NRCS structures are being planned, designed or constructed with funding through the dam rehabilitation act.

The Small Watershed Act [(12)] allocates federal funds for the development of new NRCS structures. The federal government provides 100% of the construction costs and the sponsor provides the land acquisition costs. Eight projects in Region C are being planned, designed, or constructed. Several of these projects are ready to construct, but the funding is not currently available.

The state should develop a program to provide funding for the development and rehabilitation of new and existing NRCS structures, as a form of watershed protection. Elements of such a program could include:

- State grants or matching funding for studies of NRCS structures
- Seminars on watershed protection.

The Region C Water Planning Group recommends that the State of Texas seek additional federal funding to improve and maintain NRCS structures. Region C also recommends that the state provide funding to the local sponsors to aid them in paying for their required 35% of the cost for the dam rehabilitation projects.

Funding Assistance for Desalination Projects. In December 2002, the TWDB completed a report [13] for Governor Perry recommending a large-scale demonstration seawater desalination project. This project will result in greater information available to Texas on the challenges involved in developing large-scale desalination projects. However, many smaller communities could make use of brackish groundwater or surface water if the treatment process was more affordable.

The Red River and Lake Texoma in Region C have high concentrations of salts. The water from these sources must either be blended with a less saline supply or desalinated for direct use. The smaller communities neighboring these water supplies could potentially use this water with help in funding the necessary desalination process. These sources would be more economical for the smaller communities than building small pipeline of great lengths to purchase water from a larger supplier. Region C recommends that the TWDB provide funding assistance for desalination projects for smaller communities. Region C also recommends that federal funds be sought for desalination projects.

Oversight of Groundwater Conservation District Rule Making. The Texas Legislature has established groundwater conservation districts across Texas, often without regard for aquifer boundaries. The groundwater conservation districts develop rules and regulations regarding the groundwater pumping within their districts. Often, the rules that have been developed by these districts are inconsistent from one district to the next, resulting in inconsistent regulation of the same aquifer. Although one-size-fits all regulations are inappropriate, the groundwater conservation districts need state oversight, particularly with regards to their rule-making policies. Region C recommends that the TWDB or TCEQ provide oversight for the current and future groundwater conservation districts.

CHAPTER 8
LIST OF REFERENCES

(1) Texas Water Development Board: *Chapter 357, Regional Water Planning Guidelines*, Austin, October 1999, amended July 11, 2001.

(2) Texas Parks and Wildlife Department, Ecologically Significant River and Stream Segments, Austin, [Online] Available URL: http://www.tpwd.state.tx.us/texaswater/sb1/rivers/unique/regions_text/regions_list/region_c.phtml, June 2003.

(3) Freese and Nichols, Inc., Alan Plummer Associates, Inc., Chiang, Patel & Yerby, Inc., and Cooksey Communications, Inc.: *Region C Water Plan*, prepared for the Region C Water Planning Group, Fort Worth, January 2001.

(4) U.S. Fish and Wildlife Service, *Texas Bottomland Hardwood Preservation Program*, Albuquerque, 1984.

(5) Texas Water Development Board: *Water for Texas – 2002*, Austin, January 2002.

(6) Chiang, Patel and Yerby, Inc.: *Draft 2005 Update to the City of Dallas Long Range Water Supply Plan*, Dallas, February 2005, and related presentations to the City Council and Council Committees.

(7) Texas Water Development Board and Water Conservation Implementation Task Force, *Report 362 Water Conservation Best Management Practices Guide*, Austin, [Online] Available URL: http://www.twdb.state.tx.us/assistance/conservation/TaskForceDocs/WCITFBMPGuide.pdf, November 2004.

(8) Texas Water Code, Chapter 11 Water Rights, Subchapter E, Section 11.173, Amended by Acts 2001, 77th Leg., ch. 966, § 2.12, eff. Sept. 1, 2001, Austin, [Online], Available URL: http://www.capitol.state.tx.us/statutes/wa.toc.htm, May 2005.

(9) Texas Water Code, Chapter 11 Water Rights, Subchapter C, Section 11.085 Amended by Acts 2001, 77th Leg., ch. 1234, § 2.12, eff. Sept. 1, 2001, Austin, [Online], Available URL: http://www.capitol.state.tx.us/statutes/watoc.html, February 2005.

(10) Texas Water Development Board, Water IQ – Know Your Water, Austin, [Online], Available URL: http://www.water-iq.org/, May 2005.

(11) Based on information provided by Steven Bednartz of the Natural Resources Conservation Service, regarding NRCS Structures in Region C and the Dam Rehabilitation Act, February 10, 2005.

(12) Based on information provided by Steven Bednartz of the Natural Resources Conservation Service, regarding NRCS Structures in Region C and the Small Watershed Act, February 10, 2005.

(13) Texas Water Development Board, Large-Scale Demonstration Seawater Desalination in Texas, Report of Recommendations for the Office of Governor Rick Perry, Austin, [Online], Available URL: http://www.twdb.state.tx.us/Desalination/FINAL%2012-16-02.pdf, May 2005.

9. Infrastructure Funding Recommendations

This plan has identified over $14 billion in improvements (2002 dollars) needed by 2060 to meet the projected water demands in Region C. This plan also recommends that the State of Texas increase funding for water supply to assist with development of needed projects. In response to potentially significant increases in state and local financial contributions for water infrastructure projects, the Texas Legislature requested that an infrastructure financing survey be conducted as part of the regional water planning process to better assess the state's role in financing the identified water projects. This chapter identifies the portion of capital improvements recommended for Region C that will require outside financial assistance and identify potential financing sources.

9.1 Infrastructure Financing Questionnaires for Recommended Water Management Strategies

The infrastructure financing surveys were mailed 2005 to all municipal water user groups and wholesale water providers in Region C in July. Many of the proposed capital improvements recommended in this plan involve one or more of the wholesale water providers. Surveys were not mailed to aggregated water user groups: county-other, irrigation, livestock, manufacturing, mining, and steam electric power.

A total of 268 surveys were mailed, 233 to water user groups and 35 to wholesale water providers. Eighty-five surveys were mailed to entities with no identified capital costs in the Region C plan. Most of these water user groups were entities supplied by wholesale water providers and/or associated with regional projects in Cooke, Ellis, Fannin, and Grayson Counties. A few entities have sufficient supplies to meet the projected demands, but surveys were mailed to seek input on the assumed water conservation strategy.

Water User Groups (WUGs)

From the 233 water user groups surveyed, 168 submitted responses. Appendix Y includes a sample copy of the survey, along with a summary of the survey responses. The Region C Water Planning Group attempted up to two times to contact entities whose survey responses had not been received. The water user groups had an overall 73 percent participation rate in this survey.

A few respondents to the survey indicated that they had changes to the recommended strategies or strategy costs. The *Region C Initially Prepared Water Plan* [1] was amended to include the following strategies:

- A few entities indicated that they purchased water indirectly from the supplier we named in the summary table.
- Some entities had concerns that the population and/or water demands were too high or too low. We added these comments to Table 2.20.
- The City of Everman plans to drill an additional well in the Trinity aquifer within the next two years.
- The City of Irving plans to participate in the Marvin Nichols Reservoir project and would like that strategy included as an alternative.
- The City of Eustace plans to drill new wells sooner than originally recommended.
- The City of Arlington plans to develop two water treatment plant expansions, one prior to 2010 and one prior to 2020. The original report combined the two expansions into one recommendation in 2010.
- The City of Keller will pay for pipeline expansion from Fort Worth through increased water rates, not as a direct participant in the funding the capital costs.
- West Wise SUD plans to build a new water treatment plant instead of expanding the current plant.
- The City of Grand Prairie now buys directly from Fort Worth instead of indirectly through the Trinity River Authority. Grand Prairie also plans to develop a pipeline to Midlothian for a capital cost of $2.19 million.
- Bartonville WSC plans to drill more wells and purchase less water from Upper Trinity Regional Water District. The groundwater supply in Denton County is limited. Thus, the plan includes temporary overdrafting of the Trinity aquifer with new wells in 2010.
- The City of Frost does not currently use groundwater. They have wells for backup purposes only.
- The Danville WSC is planning to dissolve in the next five years. Celina, Prosper, and McKinney are planning to serve different portions of Danville’s service area.
- The City of Pelican Bay plans to drill two new wells.
- The City of Mabank serves a portion of Kaufman County-Other.
- The City of Forney responded that they do not plan to sell more reuse water to the power plant in Kaufman County beyond their current contractual obligation.
- Community Water Company responded that they do not plan to drill any more wells.
- Cash SUD plans to purchase additional water from the Sabine River Authority in the future.
- Mt. Zion WSC is currently a direct customer of the North Texas Municipal Water District.

- The City of Forest Hill plans to construct a 50 million gallon ground storage facility. This is an infrastructure improvement for distribution purposes, not additional water supply.
- The City of Aurora currently has groundwater supplies only.
- The pipeline from West Wise SUD to the City of Chico is large enough to handle the additional future supplies recommended in the plan.
- The City of Wortham is unlikely to pursue the purchase of water from the Tarrant Regional Water District.

Seventy-four water user groups plan to finance 100 percent of the capital costs for improvements identified in the survey. The remaining respondents reported being able to pay for a portion of the estimated capital improvements. For the portion of capital costs that the entities could not finance, respondents identified various possible funding mechanisms. A summary of the survey results for the water user groups is presented in Table 9.1.

Table 9.1
Summary of Water User Groups Financing Needs in Region C

Total Costs of Strategies - WUGs Surveyed	**$842,911,000**
Total Costs of Strategies - IFR Responses	**$672,128,000**
Amount Likely to be Funded by Cash Reserves	$48,227,000
Amount Likely to be Funded by Bonds	$412,387,000
Amount Likely to be Funded by Loans	$43,728,000
Amount Likely to be Funded by Federal Programs	$27,923,000
Amount Likely to be Funded by State Programs	$56,380,000
Amount Likely to be Funded by Other Programs	$25,300,000
Amount from Entities Unsure of Percentage Breakdown	$24,202,000
Amount from Entities Indicating "Not Applicable" to Project Costs	$7,568,000
Amount from Entities Not Providing Information on Costs	$26,413,000
Sum of Survey Response	**$672,128,000**
Amount Respondents CANNOT Afford	**$170,783,000**

Note: Eight water user groups indicated agreement with the recommended strategies. However, these entities did not know what percentage to indicate regarding the various types of funding. All said that they would use some form of state funding. These entities represent a total capital cost of $17,286,000, some of which would likely be funded by state programs.

Wholesale Water Providers (WWPs)

Thirty wholesale water providers responsed to the financing surveys, resulting in an 86 percent response rate. Ten reported that it is likely they can finance a portion of the total capital improvements, but that state participation would also be required, especially for region-wide projects. These providers also reported that the ability of the participants to pay for regional projects would vary depending on circumstances and negotiations at the time of development. Responses from twenty WWPs stated that each provider intends to finance 100 percent of the identified capital improvements, but that final decisions regarding financing will be made just before the project is begun. These providers also stated that the users of the proposed projects might seek to use state programs if the funding helps the project and the project meets the criteria for funding.

Twenty-one entities reported that they could fund approximately 91 percent of the estimated capital costs with current revenue sources. The remainder of the capital costs will require grant assistance from the state or additional rate adjustments that will need approval by city council. Summaries of the wholesale water provider responses are included in Appendix Y. Table 9.2 provides the financing needs for the wholesale water providers based on the survey results.

Table 9.2
Summary of Wholesale Water Providers Financing Needs in Region C

Total Costs of Strategies - WWPs Surveyed	**$12,720,522,000**
Total Costs of Strategies - IFR Responses	**$12,695,047,000**
Amount Likely to be Funded by Cash Reserves	$283,143,000
Amount Likely to be Funded by Bonds	$11,345,628,000
Amount Likely to be Funded by Loans	$0
Amount Likely to be Funded by Federal Programs	$168,681,000
Amount Likely to be Funded by State Programs	$797,521,000
Amount Likely to be Funded by Other Programs	$92,506,000
Amount from Entities Indicating "Not Applicable" to Project Costs	$0
Amount from Entities Not Providing Information on Costs	$7,568,000
Sum of Survey Response	**$12,695,047,000**
Amount Respondents CANNOT Afford	**$25,475,000**

9.2 Wholesale Water Provider and Water User Group Preferred Funding Mechanisms

Based on the survey responses, the water users in Region C can afford to pay for approximately 75 percent of the capital costs identified for water supply infrastructure. However, the survey responses represent only some of the total capital improvement costs recommended for Region C, and the capital costs needing financial assistance may differ. To bridge the gap between what the water users can afford and what is needed, there are numerous funding programs available for municipal and non-municipal water users with local, state and/or federal sponsors. Many of the programs target municipal entities through loan and grant programs. There are also several agricultural assistance programs that administer funds for rural and agricultural users. Some of the funding options require a political subdivision to take the lead and establish benefits to non-municipal water users. Other programs are not open to non-municipal users, but non-municipal users (particularly manufacturers) may benefit from these funding programs through purchasing water from eligible municipalities.

The current primary mechanisms for funding infrastructure projects in Region C are financing through local bank loans and municipal bonds that are repaid through increased fees and revenues. This funding mechanism places the burden of paying for the capital improvements on the beneficiaries of the project. It also provides for local control in the implementation and timing of the needed improvements. While local financing will continue to be an integral component for financing water projects in this region, other funding sources through state and federal sponsors have been utilized in the region and may be accessed more frequently in the future as the region looks to develop new water resources.

The following are potential funding mechanisms that may be available for infrastructure projects in Region C. These funding sources are discussed in more detail in Appendix Y and summarized in Table 9.3. Table 9.4 shows the potential funding sources for non-municipal water users.

- Market financing (taxable and tax-exempt)
- Texas Water Development Board programs
- U.S. Department of Agriculture programs
- Texas Department of Agriculture programs
- U.S. Department of Commerce Economic Development Administration Public Works Program
- U.S. Small Business Administration programs
- Texas Department of Economic Development programs
- Corps of Engineers Sponsorship
- Local economic development incentives.

Table 9.3
Summary of Funding Programs for Water Users in Region C

Program	State/ Federal / Local	Agency [a]	Type	Eligible Water Supply Projects
Private Financing	N/A	N/A	All	All
Fees and Tax Increases	Local	N/A	All	All
Municipal Bonds	Local	N/A	All	All
Drinking Water State Revolving Fund	State	TWDB	Loans	Water supply and source water protection
Water and Wastewater Loan Program	State	TWDB	Loans	Planning, acquisition and construction of water related infrastructure
Clean Water State Revolving Fund Program	State	TWDB	Loans	Wastewater recycling and reuse facilities
State Participation Program	State	TWDB	Loans	Regional wastewater recycling and reuse facilities
Agriculture Water Conservation Loan	State	TWDB	Loans	Install efficient irrigation equipment on private property
Water Infrastructure Fund	State	TWDB	Loans	Water management strategies recommended in state or regional water plans
Rural Water Assistance Fund	State	TWDB	Loans	Development or regionalization of rural water supplies
Farm Ownership Program	Federal	USDA	Loans, loan guarantees	Water conservation
Rural Utilities Service Water and Waste Disposal Loans and Grants	Federal	USDA	Grants, loans, loan guarantees	Drinking water, wastewater collection and treatment facilities in rural areas
Watershed Protection and Flood Prevention Program	Federal	USDA / NRCS	Grants	Plan and install watershed-based projects on private land
Texas Capital Fund Infrastructure Development Fund	State	TDA	Grants	Water and sewer infrastructure improvements

Table 9.3, Continued

Program	State/ Federal / Local	Agency*	Type	Eligible Water Supply Projects
Linked Deposit Program	State	TDA	Interest buy-down	Water conservation, stock tanks, brush control, and dam construction
Rural Development Finance Program	State	TDA	Loans, loan guarantees	Non-specific, includes water and wastewater systems, municipal infrastructure projects
Loan Guaranty Program	State	TDA	Loan guarantees	Non-specific
Young Farmer Loan Guarantee Program	State	TDA	Loan guarantees	Non-specific
Public Works Program	Federal	USDC	Grants	Water and sewer systems for industrial use
7a Loan Guaranty Program	Federal	SBA	Loan guarantees	Non-specific
Certified Development Company (504) Program	Federal	SBA	Loans	Improvements, utilities
Texas Capital Access Fund	State	TDED	Reserve account	Non-specific
Texas Industrial Bond Revenue Program	State	TDED	Bonds	Non-specific
Texas Enterprise Zone Program	State	TDED	Tax refunds, credits	Non-specific
Corps of Engineers	Federal	COE	Cost sharing	Those that meet a federal purpose, such as multi-purpose reservoirs, ecosystem restoration projects
Local economic development incentives	Local	N/A	Tax abatements, etc.	Non-specific

Note: a. TWDB = Texas Water Development Board, USDA = U.S. Department of Agriculture, NRCS = National Resources Conservation Service, TDA = Texas Department of Agriculture, USDC = U.S. Department of Commerce, SBA = U.S. Small Business Administration, and TDED = Texas Department of Economic Development.

Table 9.4
Applicable Funding Programs for Non-Municipal Users

Program	State/ Federal / Local	Agency*	Non-Municipal Users Eligible to Apply**	Type	Eligible Water Supply Projects	Water Users with Potential to Receive Funding				
						Manufact-uring	Mining	Irrigation	Livestock	Steam Electric Power
Private Financing	N/A	N/A	Yes	All	All	x	x	x	x	x
Clean Water State Revolving Fund Program	State	TWDB	No	Loans	Wastewater recycling and reuse facilities	x	x	x		x
State Participation Program	State	TWDB	No	Loans	Regional wastewater recycling and reuse facilities	x	x	x		x
Agriculture Water Conservation Loan	State	TWDB	Indirect	Loans	Install efficient irrigation equipment on private property			x		
Water Infrastructure Fund	State	TWDB	No	Loans	Water management strategies recommended in state or regional water plans	x	x	x	x	x
Rural Water Assistance Fund	State	TWDB	No	Loans	Development or regionalization of rural water supplies	x		x	x	x
Farm Ownership Program	Federal	USDA	Yes	Loans, loan guarantees	Water conservation			x	x	
Rural Utilities Service Water and Waste Disposal Loans and Grants	Federal	USDA	No	Grants, loans, loan guarantees	Drinking water, wastewater collection and treatment facilities in rural areas	x	x	x	x	x
Watershed Protection and Flood Prevention Program	Federal	USDA/ NRCS	Indirect	Grants	Plan and install watershed-based projects on private land	x	x	x	x	

Table 9.4, Continued

Program	State/ Federal / Local	Agency*	Non-Municipal Users Eligible to Apply**	Type	Eligible Water Supply Projects	Water Users with Potential to Receive Funding				
						Manufact-uring	Mining	Irrigation	Livestock	Steam Electric Power
Texas Capital Fund Infrastructure Development Fund	State	TDA	No	Grants	Water and sewer infrastructure improvements	x	x	x	x	x
Linked Deposit Program	State	TDA	Yes	Interest buy-down	Water conservation, stock tanks, brush control, and dam construction			x	x	
Rural Development Finance Program	State	TDA	Yes	Loans, loan guarantees	Non-specific	x	x			x
Loan Guaranty Program	State	TDA	Yes	Loan guarantees	Non-specific			x	x	
Young Farmer Loan Guarantee Program	State	TDA	Yes	Loan guarantees	Non-specific			x	x	
Public Works Program	Federal	USDC	No	Grants	Water and sewer systems for industrial use	x	x			x
7a Loan Guaranty Program	Federal	SBA	Yes	Loan guarantees	Non-specific	x	x	x	x	
Certified Development Company (504) Program	Federal	SBA	Yes	Loans	Improvements, utilities	x	x	x	x	
Texas Capital Access Fund	State	TDED	Yes	Reserve account	Non-specific	x	x	x	x	
Texas Industrial Bond Revenue Program	State	TDED	Indirect	Bonds	Non-specific	x	x			x

CHAPTER 9
LIST OF REFERENCES

(1) Freese and Nichols, Inc., Alan Plummer Associates, Inc., Chiang, Patel, and Yerby, Inc., and Cooksey Communications, Inc.: *Initially Prepared 2006 Region C Water Plan*, prepared for the Region C Water Planning Group, May 2005.

10. Plan Approval Process and Public Participation

This section describes the plan approval process for the Region C Water Plan and the efforts made to inform the public and encourage public participation in the planning process. Special efforts were made to inform the general public and water suppliers and others with special interest in the planning process and to seek their input.

10.1 Regional Water Planning Group

The legislation for Senate Bill One and the Texas Water Development Board (TWDB) planning guidelines establish regional water planning groups to control the planning process [1]. The regional water planning groups were to include representatives of eleven specific interests:

- General public
- Counties
- Municipalities
- Industrial
- Agricultural
- Environmental
- Small businesses
- Electric generating utilities
- River authorities
- Water districts
- Water utilities

Table 10.1 lists the members of the Region C Water Planning Group, the interests they represent, and the counties in which they reside. At the beginning of this second round of planning, Terrace Stewart was the Chairman of the Region C Water Planning Group. When Mr. Stewart took another position out of state, Jim Parks was elected the Chairman of the group with Robert Johnson as the Vice-Chairman and Roy Eaton as the Secretary. In January 2005, Roy Eaton stepped down as Secretary but remained on the planning group. Paul Zweiacker was elected the new Secretary. When their terms expired in 2003, Judge Tom Vandergriff and Leroy Burch did not run for reelection to the Region C Water Planning Group. G.K. Maenius and

Russell Laughlin were elected to those positions. George Shannon passed away in November of 2005, just as this report was being finalized.

Table 10.1
Members of the Region C Water Planning Group

Member	Interest	County
James Parks, Vice-Chairman	Water Districts	Collin
Robert Johnson, Vice-Chairman	Municipalities	Dallas
Paul Zweiacker, Secretary	Electric Generating Utilities	Dallas
Brad Barnes	Agricultural	Jack
Russell Laughlin	Industries	Tarrant
Jerry W. Chapman	Water Districts	Grayson
Roy F. Eaton	Small Businesses	Wise
Dale Fisseler	Municipalities	Tarrant
G. K. Maenius	Counties	Tarrant
Howard Martin	Municipalities	Denton
Jim McCarter	Water Utilities	Navarro
Elaine Petrus	Environmental	Tarrant
Paul Phillips	Municipalities	Parker
Irvin M. Rice	Public	Dallas
Robert O. Scott	Environmental	Tarrant
George Shannon	Water Districts	Tarrant
Connie Standridge	Water Utilities	Freestone
Danny Vance	River Authorities	Tarrant
Mary E. Vogelson	Public	Dallas

10.2 Outreach to Water Suppliers, Water User Groups, and Regional Planning Groups

The Region C Water Planning Group made special efforts to contact water suppliers and water user groups in the region and neighboring regional water planning groups to obtain their input in the planning process. Water suppliers and water user groups were surveyed on a number of occasions to solicit information on their current situation and their future water plans. Region C coordinated with Regions D, G, H, and I regarding shared resources and water user groups that were located in multiple regions.

Five of the largest wholesale water providers in the region (Dallas Water Utilities, Tarrant Regional Water District, North Texas Municipal Water District, Fort Worth, and Trinity River Authority) were represented on the water planning group. In addition, the planning group encouraged the Region C consultants to keep in touch with the wholesale water providers and other water suppliers as planning proceeded. Water suppliers were included on the mailing list for Region C newsletters (discussed below under outreach to the public). Other specific measures to obtain input from water suppliers and from other regional water planning groups are discussed below.

Questionnaires

Five questionnaires have been sent to the Region C water user groups and wholesale water providers. Appendix C includes copies of the questionnaires that were mailed in September 2002 to all Region C county judges, cities with populations over 500, regional water suppliers, and retail water suppliers (supplying over 0.25 mgd). The questionnaires sought information on population projections and water planning issues. The overall response rate for the population and water planning issues questionnaire was 67 percent.

The second questionnaire presented information on the projected water demands and is included in Appendix E of this plan. The questionnaire was mailed in January 2003 to all Region C county judges, cities with populations over 500, regional water suppliers, and retail water suppliers (supplying over 0.25 mgd). The overall response rate for the demand projection questionnaires was 68 percent.

The third questionnaire was emailed and mailed in April 2004 to water user groups, wholesale water providers, county judges, and groundwater conservation districts in Region C. The questionnaire presented summary information including the adopted population and demand projections, the recommended strategies in the 2001 Plan, and the proposed strategies being considered for the 2006 Plan. The questionnaires are included in Appendix S of this plan. The overall response rate to this questionnaire was 57 percent.

The fourth questionnaire involved questions regarding current water conservation practices being implemented in Region C. The questionnaires are included in Appendix K of this plan. The water conservation questionnaires were mailed to water user groups and wholesale water providers in July 2004. This survey provided useful information in determining what additional water conservation measures ought to be included in the basic and expanded water conservation packages discussed in Chapter 6. The overall response rate to this questionnaire was 54 percent.

The fifth questionnaire was mailed to water user groups and wholesale water providers in July 2005. This questionnaire sought input regarding the recommended water management strategies and the financing options each entity will likely pursue to develop these strategies. The results of this survey are discussed in Chapter 9 and included in Appendix Y. The overall response rate to this questionnaire was 74 percent.

Following the deadline for each questionnaire, the consultants spent a considerable amount of time calling each entity whose survey response had not been received. The consultants attempted to call each of these entities up to two times. The follow-up phone calls resulted in increased participation rate and additional information acquired.

Meetings with Wholesale Water Providers and Other Suppliers

The consultants met in person with most of the wholesale water providers and with water user groups that were interested in meeting. The consultants spoke with wholesale water providers by phone when the provider thought that an in-person meeting was not necessary.

In the spring of 2003, the consultants met with the following water suppliers to discuss current water supplies, current customers, TWDB-approved population projections, draft per capita water use projections, recommendations in the 2001 Plan, future water supplies, and additional wholesale customers:

- Corsicana
- Dallas Water Utilities
- Fort Worth
- Greater Texoma Utility Authority
- North Texas Municipal Water District
- Tarrant Regional Water District
- Trinity River Authority
- Upper Trinity Regional Water District.

As the planning process progressed, the list of wholesale water providers increased. The consultants added these providers to the list of entities with whom they met. In the spring of 2004, the consultants met with the following wholesale water providers to review the current supplies, current customers and the related source(s) of supply, TWDB-approved demand projections, water treatment plant capacity and planned expansions, future water sources, and potential future customers:

- Corsicana
- Dallas Water Utilities
- Denton
- Fort Worth
- Garland
- Greater Texoma Utility Authority
- North Texas Municipal Water District
- Sabine River Authority
- Tarrant Regional Water District
- Trinity River Authority
- Upper Neches River Municipal Water Authority
- Upper Trinity Regional Water District
- Weatherford.

In the spring of 2005, the consultants met with the following wholesale water providers to review the current supplies, current customers and the related source(s) of supply, TWDB-approved demand projections, water treatment plant capacity and planned expansions, future water sources, alternative water management strategies, potential future customers, and additional questions related to the planning process:

- Corsicana
- Dallas Water Utilities
- Denton
- Fort Worth
- Garland
- Greater Texoma Utility Authority
- Irving (not a wholesale water provider)
- North Texas Municipal Water District
- Tarrant Regional Water District
- Trinity River Authority

- Upper Trinity Regional Water District
- Walnut Creek SUD
- Weatherford.

The meetings with the providers listed above provided a better understanding of the current water supplies and the manner in which they are used, the current customers, current infrastructure limitations, potential future customers, and planned water supply and infrastructure improvement projects. These meetings were useful in determining recommended strategies for the Region C Water Plan.

10.3 Outreach to the Public

Newsletters

The Region C Water Planning Group published newsletters throughout the second round of the Regional Water Planning process to keep the public informed on the progress of the planning process, as well as to educate the public about water management strategies under consideration, water conservation issues and other water-related topics. The newsletters were sent to:

- Water right holders
- County judges
- Mayors and officials of cities in the region
- Other water planning regions
- Texas Water Development Board staff
- Approximately 675 media representing more than 200 media outlets in North Central Texas
- Any person who requested to be on the mailing list.

A total of seven newsletters have been distributed on behalf of the Region C Water Planning Group during the second round of water planning, with another newsletter scheduled for distribution in January 2006. Appendix Z includes copies of the Region C newsletters, as well as a brochure on the regional water planning process produced by Texas Water Development Board.

Media Outreach

The media outreach plan for Region C called for using a number of communication vehicles to keep the media, and hence the public, informed of the progress and activities of the Region C Water Planning Group:

- **Newsletters.** Newsletters were sent to approximately 675 media representing more than 200 media outlets in North Central Texas, as well as to members of the general public on the mailing list.
- **Media-Only briefing.** Members of the media with an interest in water planning issues were invited to a media-only lunch briefing in August 2004 at the Trinity River Authority Central Wastewater Treatment Plant. During the meeting, media heard from the RCWPG chair, vice-chair, secretary and lead consultants on key water management strategies under consideration, projected water needs and supplies, steps involved in the water planning process and other critical issues. Media were invited to participate in a question-and-answer session following the presentation. Approximately ten local media attended, representing some of the primary media outlets in Region C.
- **Public hearings.** The media were invited through printed public meeting notices and press releases to attend the public hearings regarding the approval of the scope of work, two amendments to the 2001 plan, and the Initially Prepared Plan.
- **Press materials.** A complete press kit on Region C's water planning effort was developed in 2003 and distributed to the media later that year. The kit materials were also translated into Spanish and made available to Hispanic media. All materials were also posted on the Region C Web site. The press kit included frequently asked questions and answers, a summary of the planning process, list of key water management strategies under consideration, "Did You Know?" fact sheet, list of RCWPG members and contact information, copy of the newsletter(s), and a press release on the state's mandated water planning.
- **Press releases and media advisories.** Press releases and/or media advisories were issued prior to every meeting of the RCWPG during the second round of regional water planning. These notices alerted the media of the opportunity to attend and cover these public meetings, as well as requesting the media to include meeting notices in their public calendars to encourage public attendance and participation.
- **Ongoing media relations.** Among other key media outlets, reporters from *The Dallas Morning News*, including Staff Writer Jim Getz and Associate Editorial Editor William McKenzie, have been proactive in attending the board meetings and have diligently covered the issues and activities surrounding the Region's water planning efforts. Neil Strassman is an Environmental Reporter for the *Fort Worth Star-Telegram* and has also spent a great amount of time covering Region C activities. Significant coverage of Region C water planning efforts has also appeared in the *Plano Star-Courier* and other community newspapers.
- **Editorial board meetings.** Editorial board meetings were held with *The Dallas Morning News* and *Fort Worth Star-Telegram* at the end of June after the Initially Prepared Plan was

made available for public review. The purpose of the editorial board meetings was to encourage the media to write editorials about the importance of regional water planning. Such articles might encourage attendance and public participation at the July 18, 2005 public hearing on the Initially Prepared Plan.

The Region C Water Planning Group and its efforts have netted a significant amount of press coverage since the second round of water planning began. The following are some of the media outlets that have produced stories on the Region C planning process in the last few years:

- *Allen American*
- Alliance Regional Newspapers
- *Arlington Star-Telegram*
- *Athens Daily Review*
- *Azle News*
- *Bonham Daily Favorite*
- *Bridgeport Index*
- *Cedar Creek Pilot*
- *Cedar Hill Today*
- *Colleyville Courier*
- *Colleyville Times*
- *Coppell Gazette*
- *Corsicana Daily Sun*
- *Dallas Business Journal*
- *Dallas Morning News*
- *Denton Record-Chronicle*
- *DeSoto Today*
- *Flower Mound Leader*
- *Flower Mound Messenger*
- *Fort Worth Business Press*
- *Fort Worth Star-Telegram*
- *Gainesville Daily Register*
- *Greenville Herald Banner*
- *Inside Collin County Business*
- KRLD 1080 AM

- *Lancaster Today*
- *Lewisville Leader*
- *McKinney Messenger*
- *Lufkin Daily News*
- *Nacogdoches Daily Sentinel*
- *Oak Cliff Tribune*
- *Plano Star-Courier*
- *Sanger Courier*
- *Sherman Herald-Democrat*
- *Southlake Journal*
- *Southlake Times*
- *Texarkana Gazette*
- WBAP 820 AM
- *Wise County Messenger*
- *Wylie News.*

Region C Web Site

In order to make the *Initially Prepared 2006 Region C Water Plan* more accessible to the public, the draft plan was made available on the Region C web site, www.regioncwater.org, in June 2005. The web site has been used extensively throughout the second round of regional water planning, with all key documents uploaded to the site for public review. The site has also provided updates on upcoming meetings and key dates in the water planning process, as well as contact information for RCWPG members and consultants.

Members of the public have had the opportunity to sign up for the newsletter mailing list through the web site, and to view current and past issues of the RCWPG newsletter. Members of the press have also been able to access press kit materials and submit requests for press kits or interviews via the web site.

10.4 Public Meetings and Public Hearings

Initial Public Hearing

As required by Senate Bill One rules, the Region C Water Planning Group held an initial public hearing to discuss the planning process and the scope of work for the region on July 10, 2001. The scope of work was approved by the Region C Water Planning Group. The public were notified by the notice that was published in accordance with Texas Water Development Board (TWDB) guidelines [(1)].

Regular Public Meetings

The Region C Water Planning Group held regular meetings during the development of the plan, receiving information from the region's consultants and making decisions on planning efforts. These meetings were open to the public, and proper notice was made under Senate Bill One guidelines [(1)]. All but two of the Region C Water Planning Group meetings were held at the Trinity River Authority (TRA) Central Wastewater Treatment Plant in Grand Prairie, a central location in the region. The two meetings held elsewhere included one meeting at the City of Arlington and another meeting at the North Texas Municipal Water District in Wylie. Both meetings were moved from the TRA location due to temporary security concerns at the treatment plant. The water planning group met regularly, approximately every six to eight weeks. The committee held three meetings in 2002, six meetings in 2003, and eight meetings in 2004, and has held seven meetings during 2005.

Public Hearings on Amendments to the 2001 *Region C Water Plan*

First Public Hearing for Amendment. The RCWPG held a public hearing on June 23, 2003, to consider a set of amendments [(2)] to the 2001 *Region C Water Plan*. The following topics were included in the amendment:

- Supplying the City of Anna from a proposed pipeline bringing surface water from the City of Sherman (through Greater Texoma Utility Authority)
- Adding additional groundwater well(s) for the City of Anna as an alternative water management strategy

- Adding an additional water management strategy to the City of Melissa and Collin County-Other to participate in the pipeline project bringing Lake Texoma water from Sherman to the southern portion of Grayson County and northern portion of Collin County
- Adding reuse and the purchase of unused water in Forest Grove Reservoir to the water supply for the City of Athens (through the Athens Municipal Water Authority).
- Adjusting the firm yield of Lake Athens based on the Water Availability Model (WAM).

Second Public Hearing for Amendment. The RCWPG held another public hearing on December 6, 2004, to consider another amendment [3] to the 2001 *Region C Water Plan*. The second amendment included the addition of the East Fork Reuse Project for the North Texas Municipal Water District.

The public were notified of both public hearings by the posting of public notice in accordance with the TWDB guidelines. Region C also produced a press release and media advisory for media throughout Region C and the potentially-affected areas, as well as posting information the Region C web site.

Both sets of amendments were adopted by the Region C Water Planning Group and were submitted to the Texas Water Development Board for approval. The Texas Water Development Board approved all of the Region C amendments to the 2001 Plan and adjusted the statewide plan to reflect the approved amendments.

Public Hearing on Initially Prepared Plan

The public hearing on the *Region C Initially Prepared Water Plan* was held on July 11, 2005, at the Bob Duncan Community Center in Arlington. Official public notice was posted in accordance with the TWDB requirements [1]. Thirty nine people signed up to provide oral comments at the public hearing, 23 opposing to the plan and 16 supporting the plan. In addition to those speakers, attendees were allowed the opportunity to support or oppose the plan for the record without making oral comments. Ten people went on record opposed to the plan and eleven people went on record in support of the plan. The opposition to the plan was primarily based on the inclusion of new reservoirs as recommended water management strategies.

Public Input

The Region C Water Planning Group encouraged the public to participate in the planning process by providing an opportunity for the public to speak to the group. The public was allowed to address the planning group on each action item prior to the group taking action. The public was also invited to speak on any topic prior to the conclusion of each meeting. Summaries of the public comments were posted on the Region C web site following each meeting.

The public was invited to speak to the planning group at all of the public hearings. Oral comments at the public hearing regarding the Initially Prepared Plan were recorded by a court stenographer and are available on the Region C web site. These comments were summarized and included in Appendix BB of this report, along with the planning group's response to each speaker. Written comments were also accepted by the planning group. Written comments on the Initially Prepared Plan have been included in Appendix AA of this plan. Responses to the written comments are found in Appendix BB.

CHAPTER 10
LIST OF REFERENCES

(1) Texas Water Development Board: *Chapter 357, Regional Water Planning Guidelines*, Austin, October 1999, amended July 11, 2001.

(2) Freese and Nichols, Inc., Alan Plummer Associates, Inc., Chiang, Patel, and Yerby, Inc., and Cooksey Communications, Inc.: *Amendments to the 2001 Region C Water Plan*, prepared for the Region C Water Planning Group, July, 2003.

(3) Freese and Nichols, Inc., Alan Plummer Associates, Inc., Chiang, Patel, and Yerby, Inc., and Cooksey Communications, Inc.: *Amendment to the 2001 Region C Water Plan*, prepared for the Region C Water Planning Group, January, 2005.