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.

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 P gives more details on non-cost evaluations for the strategies, and Appendix Q 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.)

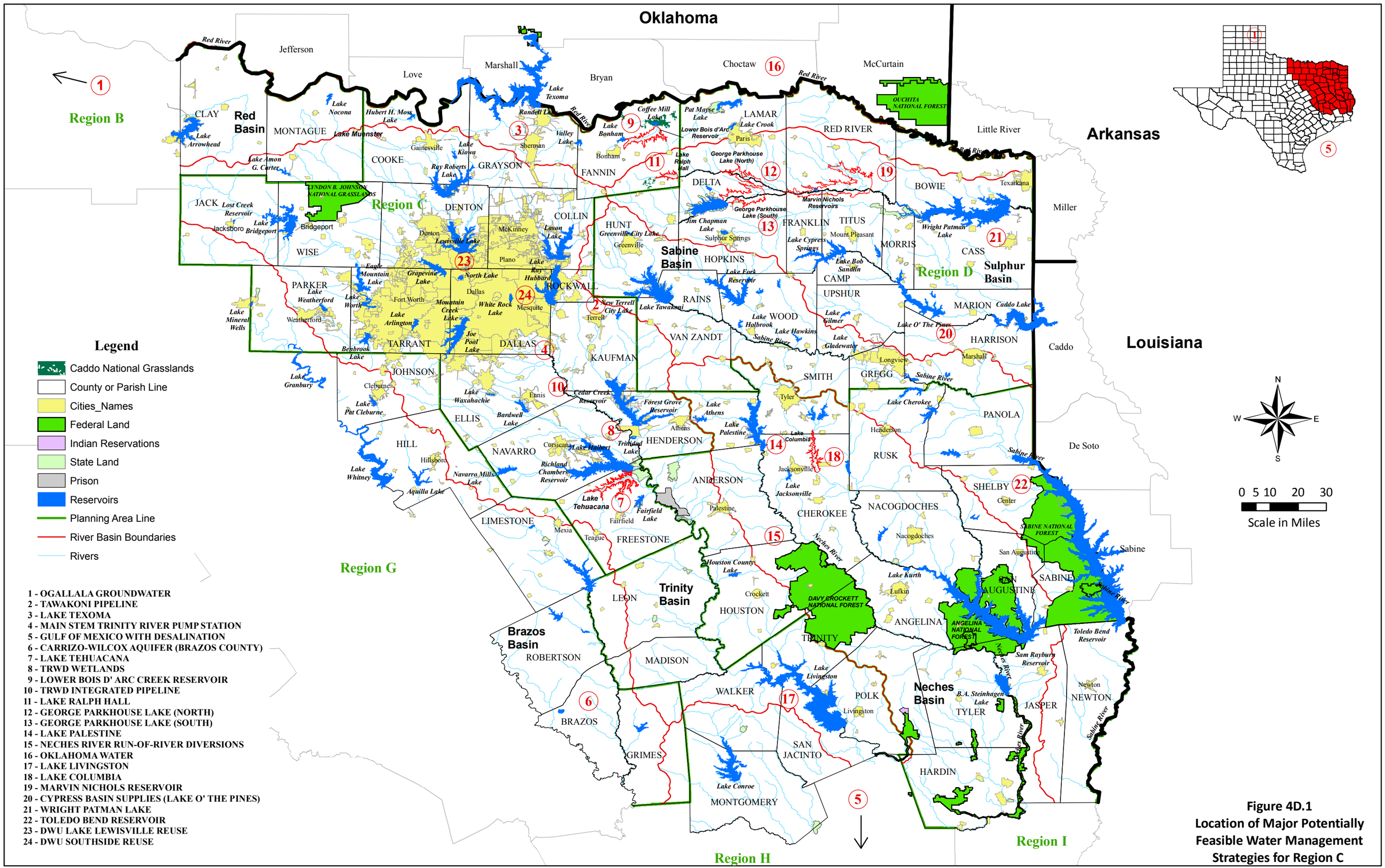
4D.1 Toledo Bend Reservoir

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)	1,190,200	N/A
Toledo Bend Reservoir	600,000	22
Gulf of Mexico with Desalination	Unlimited	5
Marvin Nichols Reservoir	489,840	19
Wright Patman Lake – System	390,000	21
Lake Texoma Not Yet Authorized - Blend	220,000	3
Lake Texoma Not Yet Authorized - Desalination	207,000	3
Lake Livingston	200,000	17
Ogallala Groundwater (Roberts County)	200,000	1
Wright Patman Lake - Raise Flood Pool	180,000	21
Oklahoma Water	165,000 or more	16
TRWD Integrated Pipeline	150,000	10
Lower Bois d'Arc Creek Reservoir	123,000	9
George Parkhouse Lake (North)	118,960	12
Lake Palestine (DWU Integrated Pipeline with TRWD)	114,337	14
Lake Texoma - Blend	113,000	3
Neches River Run-of-the-River Diversion	112,100	15
George Parkhouse Lake (South)	108,480	13
TRWD Wetlands	105,500	8
Lake Texoma - Desalination	105,000	3
Wright Patman Lake - Texarkana	100,000	21
Carrizo-Wilcox Groundwater (Brazos County)	100,000	6
Cypress Basin Supplies (Lake O' the Pines)	89,600	20
Tawakoni Pipeline	77,994	2
DWU Southside (Lake Ray Hubbard) Reuse	67,253	24
DWU Lake Lewisville Reuse	67,253	23
Main Stem Trinity River Pump Station[(a)]	66,512/41,029	4
Tehuacana Reservoir	56,800	7
Lake Ralph Hall and Reuse	52,437	11
Lake Columbia	35,800	18

Note: The maximum supply of 66,512 acre-feet per year includes temporary supplies. The long term supply is 41,029 acre-feet per year.



Legend

- Caddo National Grasslands
- County or Parish Line
- Cities_Names
- Federal Land
- Indian Reservations
- State Land
- Prison
- Reservoirs
- Planning Area Line
- River Basin Boundaries
- Rivers

1 - OGALLALA GROUNDWATER
2 - TAWAKONI PIPELINE
3 - LAKE TEXOMA
4 - MAIN STEM TRINITY RIVER PUMP STATION
5 - GULF OF MEXICO WITH DESALINATION
6 - CARRIZO-WILCOX AQUIFER (BRAZOS COUNTY)
7 - LAKE TEHUACANA
8 - TRWD WETLANDS
9 - LOWER BOIS D' ARC CREEK RESERVOIR
10 - TRWD INTEGRATED PIPELINE
11 - LAKE RALPH HALL
12 - GEORGE PARKHOUSE LAKE (NORTH)
13 - GEORGE PARKHOUSE LAKE (SOUTH)
14 - LAKE PALESTINE
15 - NECHES RIVER RUN-OF-RIVER DIVERSIONS
16 - OKLAHOMA WATER
17 - LAKE LIVINGSTON
18 - LAKE COLUMBIA
19 - MARVIN NICHOLS RESERVOIR
20 - CYPRESS BASIN SUPPLIES (LAKE O' THE PINES)
21 - WRIGHT PATMAN LAKE
22 - TOLEDO BEND RESERVOIR
23 - DWU LAKE LEWISVILLE REUSE
24 - DWU SOUTHSIDE REUSE

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

Figure 4D.2
Unit Costs of Potentially Feasible Major Strategies for Region C

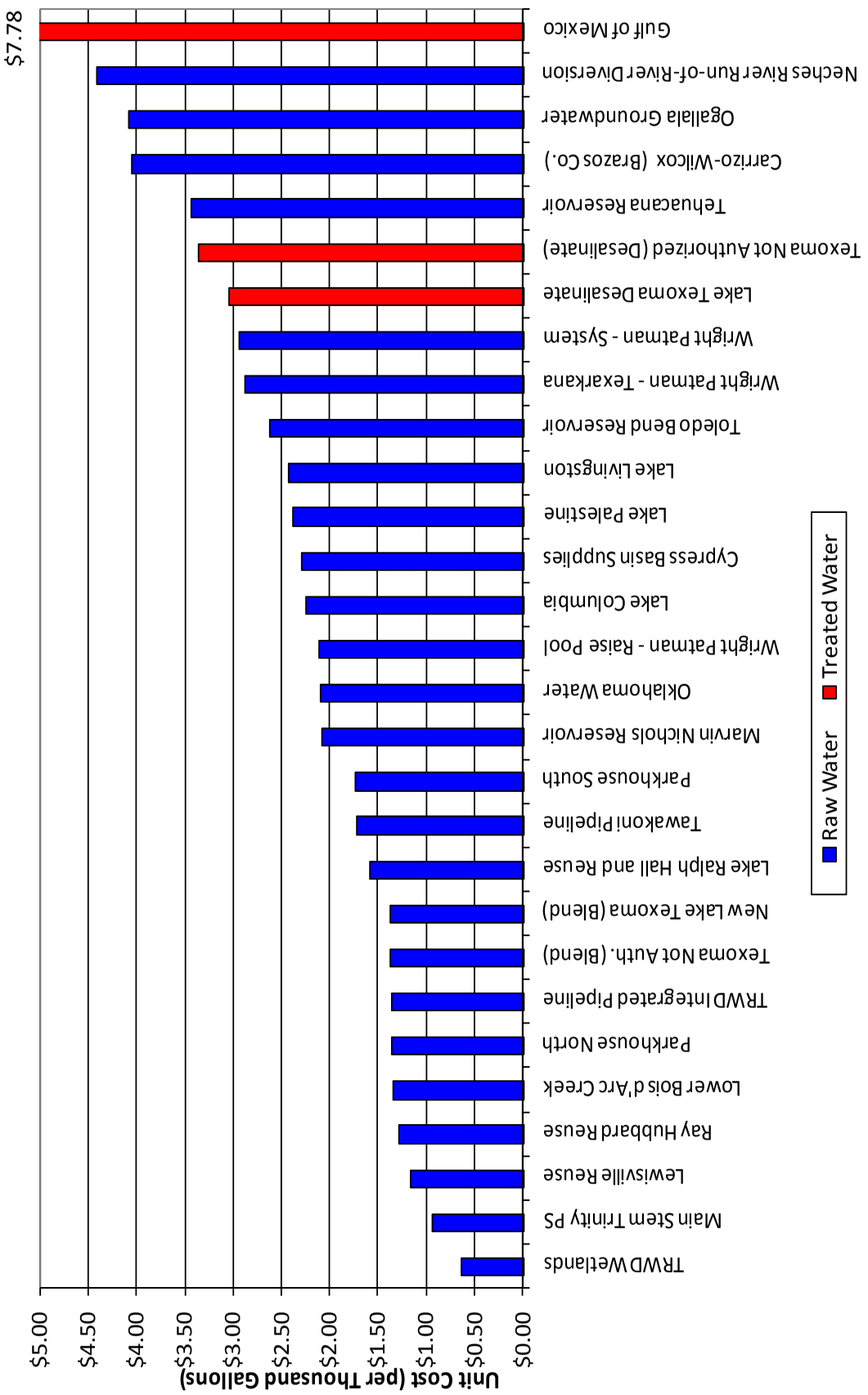


Table 4D.2
Summary of Costs and Impacts of Major Potentially Feasible Strategies for Region C

Strategy	Potential Supplier(s)	Potential Region C Supply (Acre-Feet per Year)	Region C Share of Capital Cost	Unit Cost for Region C ($/1,000 Gal.)		Reliability	Environ-mental Factors	Agricultural/ Rural Impacts	Other Natural Resources	3rd Party Impacts	Key Water Quality Parameters	Consistency		Implementation Issues	Comments
				With Debt Service	After Debt Paid							Suppliers	Other Regions		
Toledo Bend Reservoir	DWU, NTMWD, SRA, & TRWD	600,000	$4,504,906,000	$2.61	$0.94	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)	$4,367,727,000	$7.78	$2.91	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	$3,300,565,000	$2.08	$0.57	High	High	High	Medium high	High	Medium	Yes	Not inconsistent	Requires new water rights permit and IBT. Known public opposition.	Costs are weighted average for all five potential participants.
Wright Patman - System	DWU, NTMWD, and TRWD	390,000	$3,085,722,000	$2.93	$0.85	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 or TRWD	220,000 (Costs for 113,000 acre-feet per year)	$551,378,000	$1.37	$0.32	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)	$925,918,000	$3.37	$1.41	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.
Lake Livingston	DWU, NTMWD, or TRWD	200,000	$1,321,975,000	$2.42	$0.91	High	Low	Low	Low	Medium low	Low	No (alternate)	Unknown	Requires contract with TRA.	May be competing interest in supply in other region. Cost is the average of costs for the three suppliers.
Ogallala Groundwater (Roberts County)	DWU, NTMWD, or TRWD	200,000	$2,850,685,000	$4.07	$0.88	High	Medium low	Medium	Medium	Medium low	Medium	No (alternate)	Not inconsistent	Requires additional water rights.	Assumes 400,000 acres of water rights. Seller will need additional rights. Cost is the average of costs for the three suppliers.
Wright Patman - Raise Flood Pool	DWU, NTMWD, or TRWD	180,000	$1,197,468,000	$2.11	$0.63	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, NTMWD, TRWD, Irving, and/or UTRWD	165,000 or more (costs based on 115,000)	$756,044,000	$2.09	$0.64	High	Low	Low	Low	Medium low	Medium low	Yes	N/A	Oklahoma has moritorium for export of water out of state.	
TRWD Integrated Pipeline	TRWD	179,000 (based on 200 mgd capacity, 1.25 peaking)	$702,008,046	$1.36	$0.48	High	Low	Low	Low	Medium low	Low	Yes	N/A		Pipeline delivers existing supplies.

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 ($/1,000 Gal.)		Reliability	Environ-mental Factors	Agricultural/ Rural Impacts	Other Natural Resources	3rd Party Impacts	Key Water Quality Parameters	Consistency		Implementation Issues	Comments
				With Debt Service	After Debt Paid							Suppliers	Other Regions		
Lower Bois d'Arc Creek Reservoir	NTMWD	123,000	$615,498,000	$1.33	$0.21	High	Medium high	High	Medium	Medium	Low	Yes	N/A	Requires new water rights permit and IBT.	
George Parkhouse Lake North	DWU, NTMWD, and/or UTRWD	118,960	$518,083,000	$1.35	$0.35	High	Medium high	Medium high	Medium	Medium	Low	No (alternate)	Not inconsistent	Requires new water rights permit and IBT.	Costs are the average of NTMWD and DWU.
Lake Palestine (DWU Integrated Pipeline with TRWD)	DWU	114,337	$887,954,087	$2.37	$0.60	High	Low	Low	Low	Medium low	Low	Yes	Yes	DWU has IBT permit.	
New Lake Texoma (Blend)	NTMWD	113,000	$531,378,000	$1.37	$0.32	High	Medium low	Low	Medium low	Medium low	Medium	Yes	N/A	Requires contract with USACE.	NTMWD has received a water right and is negotiating with USACE.
Neches River Run-of-River Diversion	DWU	112,100	$1,980,278,000	$4.41	$1.13	High	Medium high	Medium	Medium high	Medium	Medium	Yes	Not inconsistent	Requires new water rights permit and IBT.	
George Parkhouse Lake (South)	NTMWD and/or UTRWD	108,480	$669,360,000	$1.73	$0.39	High	Medium high	Medium high	Medium	Medium	Low	No (alternate)	Not inconsistent	Requires new water rights permit and IBT.	
TRWD Wetlands	TRWD	105,500	$212,416,000	$0.63	$0.18	Low	Low	Low	Low	Low	Medium	Yes	N/A	TRWD has permit for reuse.	
Lake Texoma Desalinate	NTMWD	105,000	$736,391,000	$3.05	$1.36	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.
Lake Wright Patman - Texarkana	DWU, NTMWD, or TRWD	100,000	$842,003,000	$2.87	$0.99	High	Low	Low	Low	Medium low	Medium low	No (alternate)	Not inconsistent	Requires agreement with Texarkana and IBT.	Costs are the average for the three suppliers.
Carrizo-Wilcox Groundwater (Brazos County and vicinity)	DWU or NTMWD	100,000	$857,398,000	$4.05	$1.66	High	Medium	Medium	Medium high	Medium	Low	No (alternate)	No	Requires coordination with local groundwater districts. Competing uses for water.	Costs are the average for DWU and NTMWD.
Cypress Basin Supplies (Lake O' the Pines)	DWU, NTMWD, or TRWD	89,600	$564,157,000	$2.28	$0.86	High	Low	Low	Low	Medium low	Low to medium low	No (alternate)	Not inconsistent	Requires IBT, renegotiating exsting contracts, and contract with NETMWD.	Costs are the average for the three suppliers.
Tawakoni Pipeline	DWU	77,994	$496,243,000	$1.71	$0.29	High	Low	Low	Low	Low	Low	Yes	Yes		
DWU Southside (Lake Ray Hubbard) Reuse	DWU	67,253	$292,327,000	$1.27	$0.30	High	Low	Low	Medium low	Low	Medium	No	N/A	DWU has water right permit.	
DWU Lake Lewisville Reuse	DWU	67,253	$282,453,000	$1.15	$0.21	High	Low	Low	Medium low	Low	Medium	No	N/A	DWU has water right permit. Difficult construction through urban area.	
Main Stem Trinity River Pump Station [(a)]	DWU and NTMWD	66,512/41,029 [(a)]	$142,567,000	$0.94	$0.16	High	Low	Low	Low	Low	Medium	Yes	N/A	Requires water right permit amendment.	
Tehuacana Reservoir	TRWD	56,800	$746,345,000	$3.43	$0.50	High	Medium high	Medium high	Medium	Medium	Low	No (alternate)	N/A	Requires new water rights permit.	
Lake Ralph Hall and Reuse	UTRWD	52,437	$316,756,000	$1.58	$0.23	High	Medium high	Medium	Medium	Medium	Medium	Yes	N/A	Requires new water right and IBT.	
Lake Columbia	DWU	35,800	$294,119,000	$2.24	$0.41	High	Medium high	Medium	Medium	Medium	Medium	No (alternate)	Yes	Requires contract with ANRA and IBT.	

Note: (a) The Main Stem Trinity River Pump Station supplies up to 66,512 acre-feet per year including interim supplies. The long term supplies are 41,029 acre-feet per year. Long term supplies are used for unit costs.

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 $3.18 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 cost of desalination and 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 recommended strategy for Region C in the 2001 and 2006 *Region C Water Plans* [1,12]. 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.)

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 $3.43 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 as well as a contract with Texarkana.

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 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 $896,478,000. 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.

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 purchasing 100,000 of the 150,000 acre-feet of storage for Texas and has received 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, which is purchasing storage and has received a Texas water right for the supply.

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 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 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.

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.7 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 $4.07 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.8 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, Tarrant Regional Water District, and Upper Trinity Regional Water District in the *2006 Region C Water Plan* [12]. The strategy was also recommended in the in the 2001 *Region C Water Plan* [1]. At the present time, the Oklahoma Legislature has established a moratorium on the export of water from the state. The Tarrant Regional Water District and the City of Irving have both filed suits in Federal court seeking to overturn the moratorium. In the long run, Oklahoma remains a promising source of water supply for Region C.

Raw water from Oklahoma would cost about $2.09 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 Irving (25,000 acre-feet per year), 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 $941,080,000. It is an alternative strategy for Dallas Water Utilities and Irving.

4D.9 Tarrant Regional Water District and Dallas Integrated Pipeline

The Tarrant Regional Water District (TRWD) and Dallas Water Utilities (DWU) are cooperating to construct the Integrated Pipeline, which will deliver water to Tarrant and Dallas Counties from Lake Palestine, Cedar Creek Lake, and Richland-Chambers Reservoir. The pipeline will have a capacity of about 350 mgd, with about 200 mgd for TRWD and 150 mgd for Dallas. Dallas's share of the project will deliver water from Lake Palestine and is discussed in Section 4D.12 below. TRWD's share will deliver about 179,000 acre-feet per year from Cedar Creek Lake and Richland-Chambers Lake (assuming a 1.25 peaking factor). The project is a recommended water management strategy for TRWD and DWU, and TRWD's share of the capital cost is $812,305,000.

4D.10 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 and 2006 *Region C Water Plans* [1,12]. 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." NTMWD has applied for a water right permit, an interbasin transfer permit, and a Federal Section 404 permit for the project. 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 $615,489,000, including water transmission facilities.

4D.11 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 Upper Trinity Regional Water District, and Irving.

4D.12 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. DWU's share of the yield of Lake Palestine will provide a supply of 111,766 in 2020, decreasing to 107,347 in 2060 due to sedimentation. 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 as part of the Integrated Pipeline Project being developed jointly with Tarrant Regional Water District. 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 $910,831,000.

4D.13 Neches River Run-of-the-River Diversion

Lake Fastrill was a recommended water management strategy in the approved 2006 Region C Water Plan [12] and the 2007 State Water Plan [14] and was designated by the Texas Legislature as a unique site for reservoir development. The lake was intended to meet projected water supply needs for the Dallas and water user groups in Anderson, Cherokee, Henderson, and Smith Counties in Region I. A decision of the United States Supreme Court on February 22, 2010 not to hear the appeals of the State of Texas and Dallas has effectively supported the creation of the Neches River National Wildlife Refuge (NRNWR) and rendered the development of Lake Fastrill extremely unlikely.

The Neches Run-of-the-River Diversion strategy is one potential alternatives to Lake Fastrill. It would involve run-of-the-river diversions from the Neches River in Anderson and Cherokee Counties downstream of Lake Palestine and the Neches River National Wildlife Refuge and upstream of the Weches Dam site. The run-of-the-river diversions would be subject to senior water rights and environmental flow restrictions and would not be available at all times. Hence, the run-of-the-river project would include one or more "off-channel" storage reservoirs located on tributaries of the Neches River in Anderson and Cherokee Counties which would be refilled during periods when water is available for diversion from the Neches River. Based on an off-channel storage capacity of about 540,000 acre-foot firm water supplies of approximately 134,500 acre-foot per year would be available from the off-channel reservoirs to meet Dallas and Region I needs. A firm supply of 112,100 acre-feet per year would be delivered from off-channel storage to the proposed pump station at Lake Palestine and then on to Dallas and firm supplies of 22,400 acre-feet per year from the off-channel storage for Region I [13].

4D.14 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 Dallas Water Utilities, the North Texas Municipal Water District, the Upper Trinity Regional Water District, and Irving.

4D.15 Tarrant Regional Water District Wetlands Project

The Tarrant Regional Water District has 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. Full development of the project will provide 115,500 acre-feet per year of new supply for TRWD. TRWD has already developed 10,000 acre-feet per year of this supply, leaving 105,500 acre-feet per year of additional supply as a water management strategy for future development.

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 to TRWD is $212,416,000.

4D.16 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 $4.05 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.17 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.18 Tawakoni Pipeline

Dallas Water Utilities has substantial water supplies in Lake Tawakoni and Lake Fork Reservoir in the Sabine Basin. The currently available supplies from these two sources are limited to about 224,000 acre-feet per year (200 mgd) by the capacity of the existing 84-inch and 72-inch pipelines from Lake Tawakoni to Dallas. DWU is planning to replace these lines with a 144-inch pipeline, making the full supply from the two reservoirs available. This will increase supplies for DWU by about 78,000 acre-feet in 2020. The capital cost of this project is estimated as $496,240,000.

4D.19 Southside (Lake Ray Hubbard) Reuse

The *2006 Region C Water Plan* [12] 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 strategy is not recommended in this plan. It has been replaced by the main stem pump station discussed below in Section 4D.20.

4D.20 Lewisville Lake Reuse

Indirect reuse through Lewisville Lake was analyzed in Dallas Water Utilities' 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 strategy would be difficult to implement because of the need for pipeline development through an urbanized area. This is not a recommended strategy in this round of regional water planning. Reuse in Lake Lewisville will be developed on the basis of return flows from wastewater treatment plants in the watershed.

4D.21 Main Stem Trinity River Pump Station

The Main Stem Trinity River Pump Station will divert water from the Trinity River for delivery to the North Texas Municipal Water District (NTMWD) East Fork Wetlands. By agreement between DWU and NTMWD, DWU will then retain return flows from NTMWD wastewater treatment plants discharging in the Lake Ray Hubbard and Lake Lewisville watersheds and develop indirect reuse through the lakes. This project will provide an additional 41,029 acre-feet per year from Lake Ray Hubbard for DWU by 2060. The project will also provide an interim supply for NTMWD. This is a recommended strategy for both DWU and NTMWD.

4D.22 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 and 2006 *Region C Water Plans* [1,12]. 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.23 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 34,050 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 18,387 acre-feet per year. Developing Lake Ralph Hall and the related reuse is a recommended strategy for the Upper Trinity Regional Water District.

4D.24 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 most 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.25 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 12 recommended major strategies, supplying a total of 1.77 million acre-feet per year to Region C at a capital cost of $12.15 billion.

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

Strategy	Supplier	Supply (Ac-Ft/Yr)	Supplier Capital Cost	Supplier Unit Cost ($/1000 gal.)	
				With Debt Service	After Debt Paid
Toledo Bend Reservoir	NTMWD	200,000	$1,239,762,000	$2.24	$0.86
	TRWD	200,000	$1,937,420,000	$3.43	$1.27
Marvin Nichols Reservoir	NTMWD	174,840	$830,894,000	$1.45	$0.39
	TRWD	280,000	$2,371,116,000	$2.63	$0.74
	UTRWD	35,000	$225,628,000	$1.99	$0.56
TRWD Integrated Pipeline	TRWD	179,000*	$702,008,000	$1.36	$0.48
Lower Bois d'Arc Creek Reservoir	NTMWD	123,000	$615,498,000	$1.33	$0.21
Oklahoma Water	NTMWD	50,000	$208,624,000	$1.43	$0.49
	TRWD	50,000	$441,548,000	$2.77	$0.79
	Irving	25,000	$194,825,000	$2.49	$0.75
	UTRWD	15,000	$96,083,000	$2.04	$0.61
Lake Palestine	DWU	111,776	$887,954,000	$2.37	$0.60
New Lake Texoma (Blend)	NTMWD	113,000	$336,356,000	$0.93	$0.27
Wright Patman Lake - Raise Flood Pool	DWU	112,100	$896,478,000	$2.34	$0.56
TRWD Wetlands	TRWD	105,500	$212,416,000	$0.63	$0.18
Tawakoni Pipeline	DWU	77,994	$496,243,000	$1.71	$0.29
Lake Ralph Hall and Reuse	UTRWD	52,437	$316,756,000	$1.58	$0.23
Main Stem Trinity River Pump Station	DWU and NTMWD	41,029	$142,567,000	$0.94	$0.16
Region C Total		**1,766,676**	**$12,152,176,000**		

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. * The TRWD Integrated Pipeline is not a new supply to the region and is not included in the Region C Total supply.

SECTION 4D
LIST OF REFERENCES

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(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.

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

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(10) Chiang, Patel and Yerby, Inc.: *2005 Update - Long Range Water Supply Plan*, Dallas, December 31, 2005.

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

(12) Freese and Nichols, Inc., Alan Plummer Associates, Inc., Chiang, Patel & Yerby, Inc., and Cooksey Communications, Inc.: *2006 Region C Water Plan*, prepared for the Region C Water Planning Group, Fort Worth, January 2006.

(13) HDR, Inc.: "Neches River Run-of-the-River Diversions Project Preliminary Technical Information for 2011 Region C Regional Water Plan," Austin, March 2010.

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