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 2007 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

Major Water Management Strategies Implemented since the *2006 Region C Water Plan*

Region C water suppliers are diligently working to implement strategies that will meet the future water needs of Region C. This is evidenced by the following major strategies that have been implemented since the publication of the *2006 Region C Water Plan*:

- Dallas Water Utilities has developed agreements that allow it to use return flows in the Lake Lewisville watershed.
- Dallas Water Utilities has completed a pipeline from Lake Fork Reservoir to Lake Tawakoni that allows use of a portion of its supply from Lake Fork.
- North Texas Municipal Water District has received permits for additional reuse in Lake Lavon.
- North Texas Municipal Water District has developed the East Fork Reuse Project.
- North Texas Municipal Water District has connected to its Upper Sabine Basin supply.

- North Texas Municipal Water District has obtained additional water rights from Lake Texoma.
- Tarrant Regional Water District has completed the Eagle Mountain Connection to deliver East Texas water to Eagle Mountain Lake.
- Several suppliers have obtained water rights allowing for future development of reuse projects.

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 2008, pre-existing plans for future water supply in Region C included the following:

- Dallas Water Utilities was planning to connect its currently unused supply in Lake Palestine to its system, and expand its transmission system from Lake Tawakoni and Lake Fork Reservoirs.
- Tarrant Regional Water District was planning to expand its diversion of return flows from the Trinity River into Cedar Creek Reservoir and Richland-Chambers Reservoir to increase the yield of its system.
- North Texas Municipal Water District was planning to expand its existing reuse project and seek additional water supplies, including Lower Bois d'Arc Creek Reservoir.
- Several Region C water suppliers were considering the development of water supplies in the Sulphur River Basin to the east.
- 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 and Dallas Water Utilities are collaborating on joint facilities to deliver water from East Texas reservoirs.
- North Texas Municipal Water District, Dallas Water Utilities, and Tarrant Regional Water District have implemented major public information campaigns as part of overall conservation efforts.
- North Texas Municipal Water District and Upper Trinity Regional Water District plan to expand their regional water treatment and treated water delivery systems.
- Corsicana has completed construction of a pipeline to Richland-Chambers Reservoir and plans to complete a pump station and treatment plant to use this supply.
- Midlothian, Waxahachie, and Ennis are developing connections to obtain raw water from the Tarrant Regional Water District through the Trinity River Authority.

- Athens Municipal Water Authority has obtained a permit for indirect reuse through Lake Athens.
- The City of Muenster has constructed Lake Muenster.
- Many Region C suppliers have developed updated water conservation and drought contingency plans.
- As discussed in Chapter 6, several Region C water suppliers have received permits to allow reuse of return flows.
- 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.

Most Recent State Water Plan

Plans for Region C in the most recent state water plan, *Water for Texas – 2007* [1], were based on the *2006 Region C Water Plan* [6]. Table 4C.1 lists major water management strategies recommended in the *2006 Region C Water Plan.* 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
- Water right cancellation
- Aquifer storage and recovery

- New supply development
- Interbasin transfers
- Other measures.

Table 4C.1
Recommended Major Water Management Strategies
in the *2006 Region C Water Plan*

Strategy	Sponsor	Supply Available from Strategy in Acre-Feet per Year
Conservation	Multiple Entities	539,562
Marvin Nichols Reservoir	North Texas Municipal Water District, Tarrant Regional Water District, and Upper Trinity Regional Water District	489,840
Toledo Bend Reservoir	North Texas Municipal Water District, Tarrant Regional Water District	400,000
TRWD 3rd Pipeline and Reuse	Tarrant Regional Water District	188,765
Lower Bois d'Arc Creek Reservoir	North Texas Municipal Water District	123,000
Lake Fork Reservoir	Dallas Water Utilities	120,000
Oklahoma Water	North Texas Municipal Water District, Tarrant Regional Water District, and Upper Trinity Regional Water District	115,000
New Lake Texoma (Blend)	North Texas Municipal Water District	113,000
Lake Fastrill	Dallas Water Utilities	112,100
Wright Patman Lake - Flood Pool	Dallas Water Utilities	112,100
Lake Palestine	Dallas Water Utilities	111,460
East Fork Reuse Project	North Texas Municipal Water District	102,000
Return Flows above DWU Lakes	Dallas Water Utilities and Upper Trinity Regional Water District	79,605
Southside (Lake Ray Hubbard) Reuse	Dallas Water Utilities	67,253
Lewisville Lake Reuse	Dallas Water Utilities	67,253
Lake Ralph Hall and Reuse	Upper Trinity Regional Water District	50,740

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 O.

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 *2006 Region C Water Plan* [6]. 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 O. 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 *2006 Region C Water Plan* [6]. The following regional systems were in the 2006 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
- 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.

Table 4C.2
Major Potentially Feasible Water Management Strategies for Connecting Existing Supplies

Strategy	Potential Sponsor(s) [a]	Maximum Supply Available to Region C from Strategy in Acre-Feet per Year	Recommended Included in 2006 Plan?
Toledo Bend Reservoir	SRA, NTMWD, TRWD, DWU, TRA and UTRWD	600,000	Yes
Gulf of Mexico with Desalination	DWU, NTMWD, and TRWD	Unlimited [b]	No
Wright Patman Lake – System	DWU, NTMWD, TRWD, and UTRWD	390,000	No
Lake Texoma Not Yet Authorized - Blend	DWU, NTMWD, TRWD, or UTRWD	about 220,000 (full use of Texas' share)	No
Lake Texoma Not Yet Authorized - Desalination	DWU, NTMWD, or TRWD	about 220,000 (full use of Texas' share)	No
Lake Livingston	DWU, NTMWD, or TRWD	200,000	No
Wright Patman Lake – Raise Flood Pool	DWU, NTMWD, TRWD, or UTRWD	180,000	Yes
Oklahoma Water	DWU, NTMWD, TRWD, UTRWD, and Denton	165,000 or more	Yes
Lake Texoma - Blend	NTMWD, DWU, and UTRWD	113,000	Yes
Lake Palestine	DWU	112,881	Yes
Lake Texoma - Desalination	NTMWD, DWU, or TRWD	105,000	No
Wright Patman Lake – Texarkana	DWU, NTMWD, TRWD, or UTRWD	100,000	No
Carrizo-Wilcox Groundwater (Brazos County)	TRWD, DWU or NTMWD	100,000	No
DWU Cypress River Basin Supplies (Lake O' the Pines)	DWU, NTMWD, or TRWD	89,600	No
LakeTawakoni Pipeline	DWU	77,994	Yes
GTUA Lake Texoma Already Authorized	GTUA	56,500	Yes
Ellis County Project	TRA / TRWD	53,189	Yes
Expanded NTMWD/GTUA Collin Grayson Municipal Alliance	Multiple	27,412	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.

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.

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 has already 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 requires environmental studies which were completed in May 2006 [7]. 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 [8]. 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.

A special study on the use of saline water in Region C was conducted as part of this round of planning. A summary of that report is in Section 4H of this report, and the complete text is in Appendix R of this report.

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 [9, 10]. 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 *2006 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 (has now been constructed)
- Lake Ralph Hall
- George Parkhouse Lake (North) George Parkhouse Lake (South) Marvin Nichols Reservoir
- Fastrill Reservoir
- Marvin Nichols Lake (South).

Since the completion of the *2006 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. 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 applications for a water right permit from the Texas Commission on Environmental Quality and a Section 404 permit from the U.S. Corps of Engineers.
- Dallas Water Utilities was considering supplies from Fastrill Reservoir in the Neches River Basin, but recent court rulings have caused this to no longer be considered a feasible strategy.
- North Texas Municipal Water District is considering supplies from Lower Bois d'Arc Creek Reservoir and has filed application for a water right permit from the Texas Commission on Environmental Quality and a Section 404 permit from the U.S. Corps of Engineers.
- Tarrant Regional Water District is considering supplies from Lake Tehuacana.

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, 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 2006 Plan?
Marvin Nichols Reservoir	DWU, NTMWD, TRWD, UTRWD, and Irving	489,840	Yes
George Parkhouse Lake (South)	NTMWD	135,600	No (alternate)
Lower Bois d'Arc Creek Reservoir	NTMWD	123,000	Yes
George Parkhouse Lake (North)	DWU, NTMWD, or UTRWD	118,960	No (alternate)
Tehuacana Reservoir	TRWD	56,800	No (alternate)
Lake Columbia	DWU	35,800	No (alternate)
Lake Ralph Hall	UTRWD	34,050	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 number of relatively small additional groundwater supplies as potentially feasible strategies, and these are listed in Appendix O. 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.

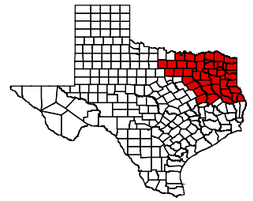
Interbasin Transfers

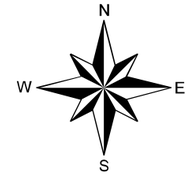
Table 4C.4 shows the potentially feasible strategies for Region C that would require interbasin transfer permits. (Under Texas law, interbasin transfer permits are required to transfer surface water from one river basin to another. They are not required for the transfer of groundwater.) Several of the strategies listed in Table 4C.4 have already been granted interbasin transfer permits, including Dallas' Lake Tawakoni pipeline and connection to Lake Palestine and NTMWD's supply from Lake Texoma. Existing sources with the potential to provide supply to Region C that would require interbasin transfer permits include the Brazos River Authority system, Wright Patman Lake, Toledo Bend Reservoir, 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 Columbia, and Lake Ralph Hall. Overall water supplies in the Trinity and Brazos River Basins are mostly or completely allocated, while the Red, Sulphur, Cypress Creek, Sabine, and Neches Basins may have supplies in excess of their 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





0 5 10 20 30

Scale in Miles

Trinity Basin

Red Basin

Sulphur Basin

Sabine Basin

Neches Basin

Brazos Basin

Trinity Basin

Lake Texoma

Hubert H. Moss Lake

Randell Lake

Coffee Mill Lake

Lake Bonham

Lower Bois D' Arc Creek Reservoir

Valley Lake

Lake Muenster

COOKE

Gainesville

Sherman

Lake Kiowa

Bonham

FANNIN

GRAYSON

Ray Roberts Lake

George Parkhouse Lake (North)

Marvin Nichols Reservoirs

Lake Ralph Hall

Lost Creek Reservoir

Lake Bridgeport

WISE

DENTON

COLLIN

Lewisville Lake

Jacksboro

Bridgeport

JACK

Lavon Lake

Jim Chapman Lake

George Parkhouse Lake (South)

Wright Patman Lake

Grapevine Lake

Eagle Mountain Lake

North Lake

White Rock Lake

ROCKWALL

Lake Ray Hubbard

Lake Fork Reservoir

Lake Mineral Wells

Lake Weatherford

TARRANT

Lake Worth

Lake Arlington

Mountain Creek Lake

Forney

Terrell Lake

Lake Tawakoni

PARKER

Lake Granbury

Benbrook Lake

Joe Pool Lake

DALLAS

KAUFMAN

Cedar Creek Reservoir

ELLIS

Lake Waxahachie

Bardwell Lake

Lake Palestine

Forest Grove Reservoir

Athens

Trinidad Lake

Lake Halbert

NAVARRO

HENDERSON

Navarro Mills Lake

Lake Columbia

Richland Chambers Reservoir

Lake Tehuacana

Fairfield Lake

Fairfield

Teague

FREESTONE

Lake Fastrill

Toledo Bend Reservoir

1

2

3

4

5

6

7

Legend

- County Line
- River Basin Boundaries
- Rivers & Streams
- Reservoirs
- Proposed Reservoirs

POTENTIALLY FEASIBLE RESERVOIRS

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

Figure 4C.1
Existing and Potentially Feasible Reservoirs

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 2011 Region C Plan

Source	Basin of Origin	Receiving Basin	Maximum Amount (Ac-Ft/Yr)	Comments
Lake Palestine	Neches	Trinity	112,881	Already permitted
Lake Tawakoni Pipeline (additional Fork Reservoir water)	Sabine	Trinity	77,994	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
Forest Grove Reservoir	Trinity	Neches	2,500	Connection of Existing Supply
Gulf of Mexico Desalination	Gulf of Mexico	Trinity	unlimited	Connection of Existing Supply, 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
Marvin Nichols Reservoir	Sulphur	Trinity	489,840	New Surface Water
Lower Bois d'Arc Creek Reservoir	Red	Trinity	123,000	New Surface Water
Lake Ralph Hall	Sulphur	Trinity	34,050	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

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 four active groundwater conservation districts in Region Cand three newly created districts that have not yet begun operation. These 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. Participation in 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 becoming active participants in groundwater conservation districts in areas of heavy groundwater use.

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 reservoirs in Region C, there is a projected reduction in reservoir yield of 37,000 acre-feet per year over the 50-year period from 2010 to 2060. For reservoirs outside Region C that supply water to Region C, there is a projected reduction in yield of 16,000 acre-feet per year over the same period.

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 O includes a listing of potentially feasible water management strategies for Region C for Wholesale Water Providers and for all Water User Groups by County. Table 4C.5 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 P. 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.5
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 2006 Plan?
Conservation and Reuse (Including reuse projects listed below)	Multiple	1,190,200	Yes
Toledo Bend Reservoir	SRA, NTMWD, TRWD, DWU, and UTRWD	600,000	Yes
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 (alternate)
Lake Texoma - Desalination	NTMWD	207,000	No
Lake Livingston	DWU, NTMWD, or TRWD	200,000	No (alternate)
Ogallala Groundwater (Roberts County)	DWU, NTMWD, or TRWD	200,000	No (alternate)
Wright Patman Lake – Raise Flood Pool	DWU, NTMWD, or TRWD	180,000	Yes
Oklahoma Water	DWU, NTMWD, TRWD, UTRWD, and Denton	165,000 or more	Yes
Lower Bois d'Arc Creek Reservoir	NTMWD	123,000	Yes
George Parkhouse Lake (North)	DWU, NTMWD, or UTRWD	118,960	No (alternate)
Lake Texoma - Blend	NTMWD	113,000	Yes
Lake Palestine (Integrated Pipeline with TRWD)	DWU	112,881	Yes
George Parkhouse Lake (South)	DWU, NTMWD, or UTRWD	108,480	No (alternate)
TRWD Integrated Pipeline and Reuse	TRWD	105,500	Yes
Lake Texoma Desalination	NTMWD	105,000	No (alternate)
Wright Patman Lake – Texarkana	DWU, NTMWD, TRWD, or UTRWD	100,000	No
Carrizo-Wilcox Groundwater (Brazos County)	TRWD, DWU or NTMWD	100,000	No (alternate)

Table 4C.5, Continued

Strategy	Potential Sponsor(s)	Maximum Supply Available to Region C in Acre-Feet per Year	Recommended in 2006 Plan?
Carrizo-Wilcox Groundwater (Brazos County)	TRWD and NTMWD	100,000	No (alternate)
DWU Cypress River Basin Supplies (Lake O' the Pines)	DWU, NTMWD, or TRWD	89,600	No
Lake Tawakoni Pipeline	DWU	77,994	Yes
DWU Southside (Lake Ray Hubbard) Reuse	DWU	67,253	Yes
DWU Lewisville Lake Reuse	DWU	67,253	Yes
Main Stem Trinity River Pump Station	DWU and NTMWD	66,512	No
Tehuacana Reservoir	TRWD	56,800	No (alternate)
GTUA Lake Texoma Already Authorized	GTUA	56,500	Yes
Ellis County Water Supply Project	TRA/ TRWD/Ellis County Suppliers	53,189	Yes
Lake Ralph Hall and Reuse	UTRWD	52,437	Yes
Lake Columbia	DWU	35,800	No
TRA Contract with Irving for Reuse	TRA and Irving	28,000	No
NTMWD/GTUA Collin Grayson Municipal Alliance	Multiple	27,412	Yes

Factors Considered in Evaluation

Table 4C.6 sets out the factors specifically considered by the Region C Water Planning Group in the evaluation of potential water management strategies. As required, 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.

Consistency with plans of Region C water suppliers is an important factor in the evaluation of strategies. It is 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 P gives more details on the evaluation of potentially feasible water management strategies for Region C.

Table 4C.6
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

Environmental Evaluation

The environmental evaluation of potentially feasible management strategies is summarized in Appendix P. 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.6. 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 Q 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 Q. For equitable comparison of the water management strategies, capital costs for all strategies were assumed to be financed by 30–year bonds. The discounted present value of each potentially feasible strategy will be calculated by the Texas Water Development Board. The costs shown in Appendix Q are the unit costs during and after payment of debt service.

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.6 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

(1) Texas Water Development Board: *Water for Texas – 2007*, Austin, adopted November 14, 2006.

(2) Texas Water Development Board: *Chapter 357, Regional Water Planning Guidelines*, Austin, September 2008.

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

(4) Alan Plummer Associates, Inc.: *City of Dallas 5-Year Strategic Plan for Water Conservation*, Dallas, April 2005.

(5) Alan Plummer Associates, Inc.: *Recycled Water Implementation Plan*, Dallas, August 2005. https://www.twdb.state.tx.us/RWPG/rpgm_rpts/2003483486_Recycled_Water_Implementation_Plan_Vol_I.pdf

(6) Freese and Nichols, Inc., Alan Plummer Associates, Inc., Chiang, Patel & Yerby, Inc., and Cooksey Communications, Inc.: *2006 Region C Water Plan*, Fort Worth, January 2006.

(7) U.S. Army Corps of Engineers, Tulsa District, *Final Environmental Assessment, Lake Texoma Storage Reallocation Study, Lake Texoma, Oklahoma and Texas*, Tulsa, May 2006. Available URL: http://www.swt.usace.army.mil/library/Lake%20Texoma%20Reallocation%20Study/2006/FINAL%20LAKE%20TEXOMA%20EA%20060106.pdf

(8) Texas State Soil and Water Conservation Board, *State Brush Control Plan,* Temple, [Online], Available URL: http://www.tsswcb.state.tx.us/reports/brushplan2001.pdf, 2002.

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

(10) 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.

TABLES

FIGURES