2018 Strategic Water Supply Plan

City of Lubbock TEXAS

HDR

August 2018

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Prepared for

City of Lubbock
TEXAS

HDR

City of Lubbock TEXAS

2018 Strategic Water Supply Plan

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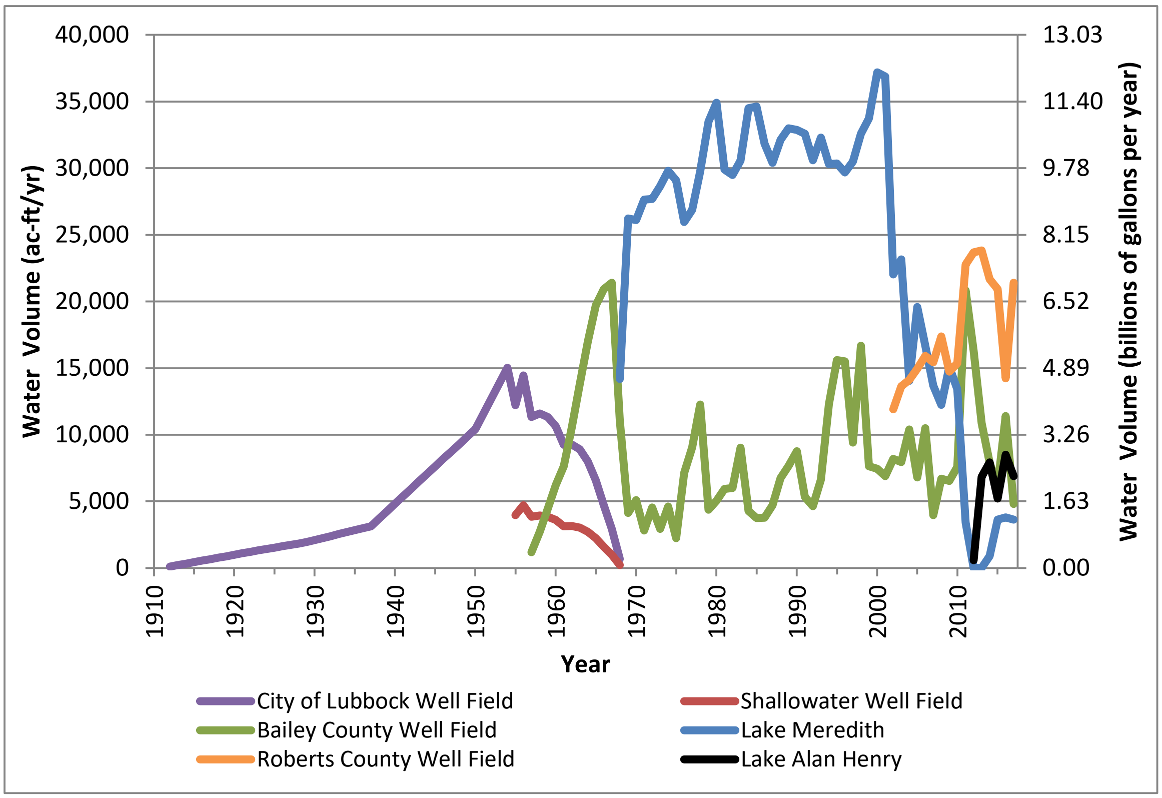
ES Executive Summary

The City of Lubbock (City) has actively planned for future water supplies through development of the City's Strategic Water Supply Plan (SWSP). The SWSP provides a "road map" to guide the development and implementation of cost-effective and sustainable water supplies over the next 100 years. This 2018 SWSP includes multiple strategies to diversity the City's water supply portfolio to minimize risk associated with variable climatic conditions while emphasizing conservation efforts to delay expensive water supply projects. This 2018 SWSP is a comprehensive update of the 2013 SWSP, and will be updated in the future as additional information about specific strategies becomes available or as conditions change.

ES.1 Historic Water Supplies

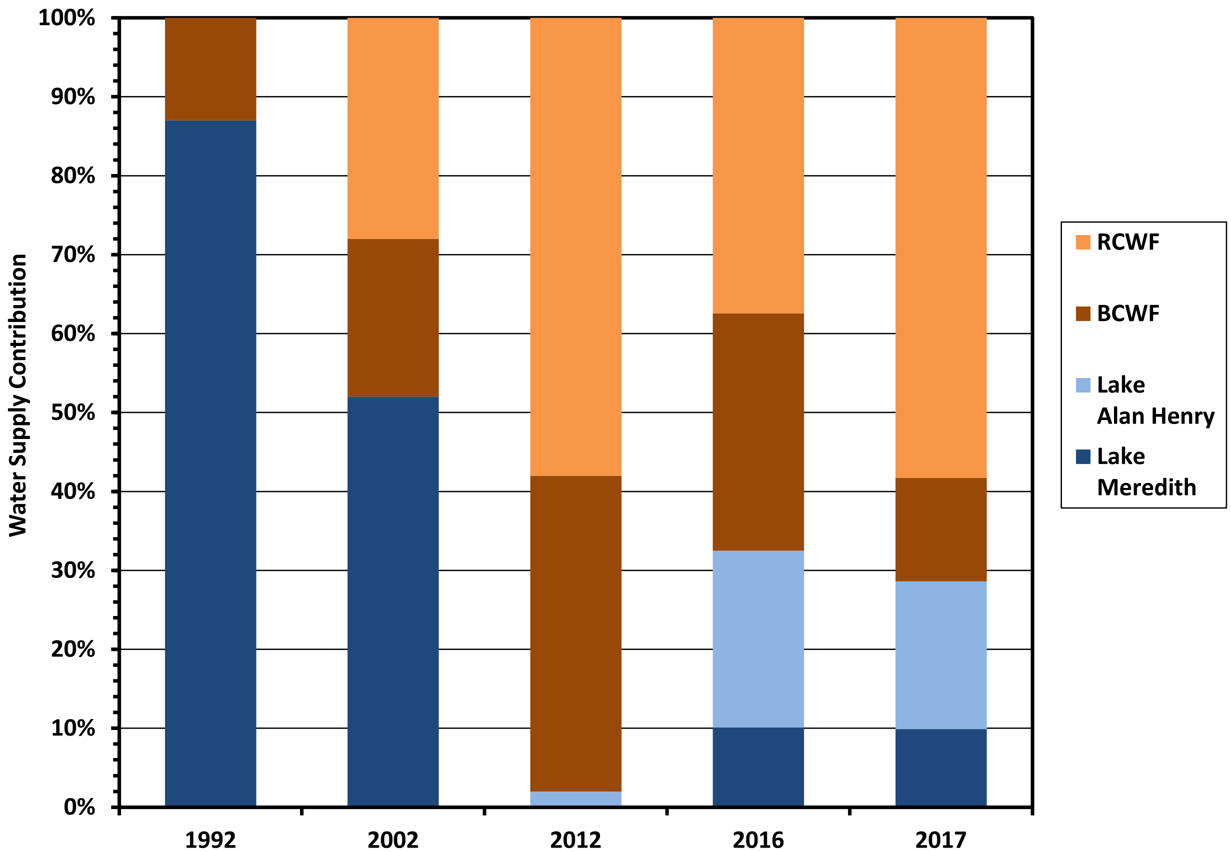
Historically, Lubbock's water supplies have varied between groundwater and surface water. Some water supplies have been discontinued due to diminished water quality, reduction in the water availability, and/or more stringent drinking water regulations. Lubbock's historic water supply usage is illustrated in Figure ES.1.

Figure ES.1. Lubbock's Historic Water Supply Usage



Lubbock currently enjoys a diverse water supply portfolio, consisting of two groundwater sources (Bailey County Well Field [BCWF] and Roberts County Well Field [RCWF]) and two surface water sources (Lake Meredith and Lake Alan Henry [LAH]). The City's utilization of those supplies varies from year to year, as illustrated in Figure ES.2. This dynamic water supply situation requires careful planning and adaptive management to meet the requirements of changing conditions.

Figure ES.2. Water Supply Contribution Comparison for 1992 and 2012



ES.2 Water Demand Projections

The planning process included in this document begins with projecting the City's water demand over a 100-year timeframe. Water demand projections are the driving force behind water supply decisions, and are dependent upon population and per capita consumption estimates. In Section 2, three important annual water demand scenarios are developed as follows:

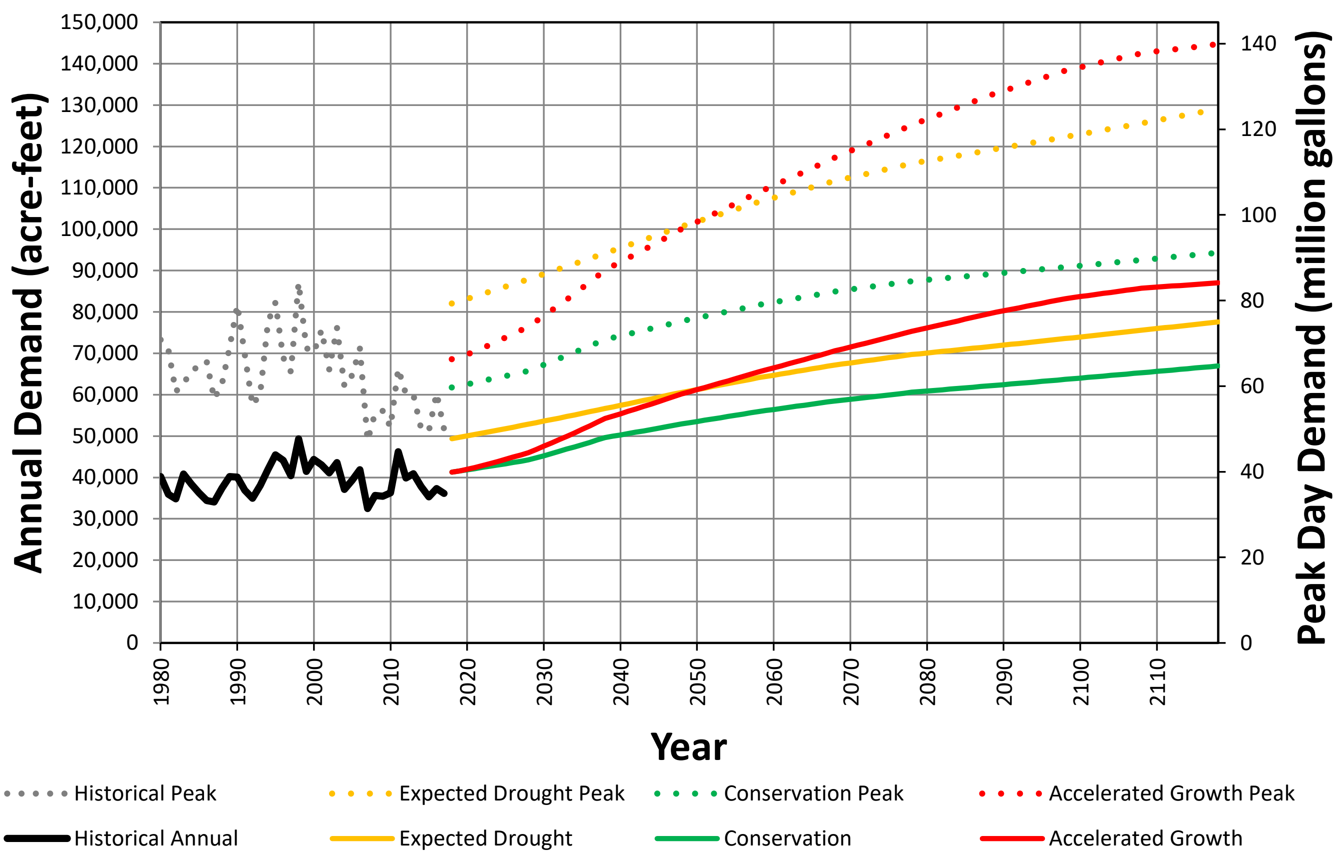
- Expected Drought Demand = Expected Population Growth x Drought Consumption
- Conservation Demand = Expected Population Growth x Conservation Consumption
- Accelerated Growth Demand = Accelerated Population Growth x Conservation Consumption

Peak day demand is also important to consider when planning for new water supplies. Satisfying peak demand can in some cases accelerate the need for a new water supply. Peak day water demand scenarios are developed as follows:

- Expected Peak Day = Expected Average Day Demand x Expected Peak Factor
- Conservation Peak Day = Expected Average Day Demand x Conservation Peak Factor
- Accelerated Peak Day = Accelerated Average Day Demand x Expected Peak Factor

Projections for these three scenarios for both Average Annual Demand and Peak Day Demand are shown in Figure ES.3.

Figure ES.3. Average Annual Demand and Peak Day Demand Projections



ES.3 Current Water Supplies

Lubbock's current water supply sources consist of the BCWF, the RCWF, Lake Meredith, and LAH, as discussed in Section 4, and shown in Figures ES.4 and ES.5. The City owns LAH and BCWF. The Lake Meredith and RCWF water supplies are owned and operated by the Canadian River Municipal Water Authority (CRMWA). RCWF and BCWF are groundwater supplies from the Ogallala Aquifer. As shown in the figures, groundwater production from the Ogallala well fields will decline over time if additional wells are not added periodically to maintain production capacity. Supplies from Lake Meredith are considered temporary, because lake levels as recently as 2011 prevented water from being supplied from the lake. However, LAH should be a renewable supply of water throughout the planning period as long as its yield does not change due to dramatic changes in the lake's environment.

A comparison of the annual water demand and current supplies projections are shown in Figure ES.4. A comparison of the peak day demand and current peak day capacity projections are shown in Figure ES.5. If the "Expected Drought" curve is followed in these figures, it demonstrates that the City does not currently have sufficient supplies to meet annual or peak day demands. However, the City's actual water usage is currently more closely aligned with the "Conservation" curve in these figures. Based on these projections, if water consumption continues to exhibit the strong conservation trend, the City will have adequate supplies until at least 2032 (when Lake Meredith supplies are assumed to no longer be available). In addition, if Lake Meredith supplies can be sustained past 2032, the City can delay implementing an additional water supply project until about 2036. Following the "Accelerated Growth" curve in these figures, an additional water supply project would be necessary as early as 2028.

Figure ES.4. Annual Water Demand vs. Current Water Supply Projections

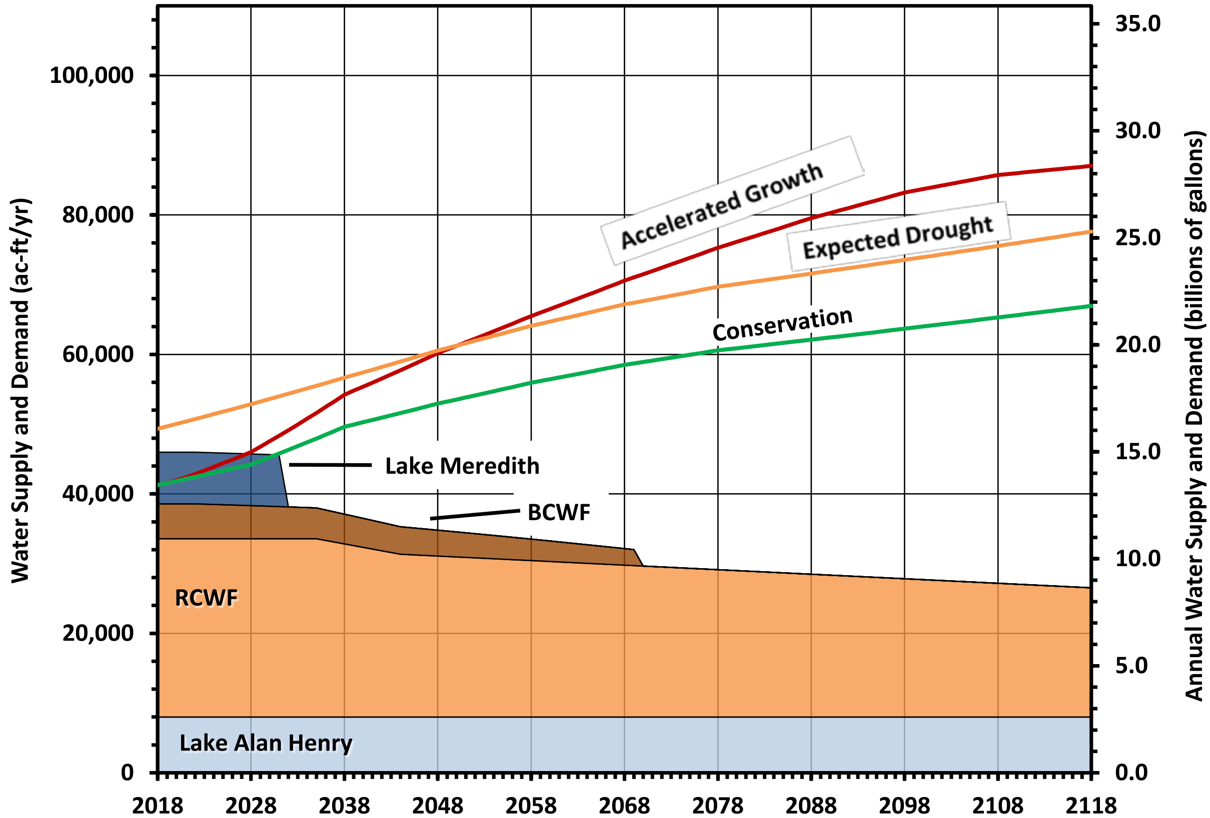
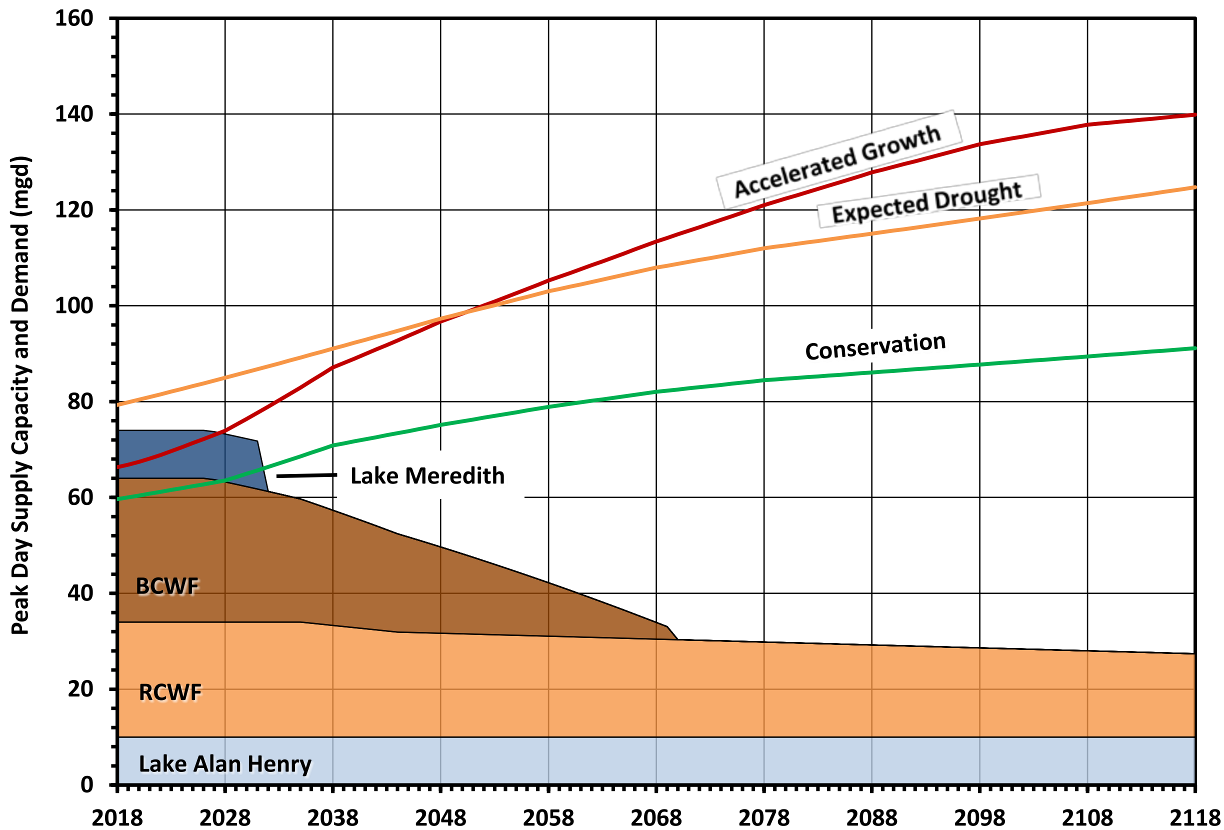


Figure ES.5. Peak Day Demand vs. Current Peak Day Capacity Projections



ES.4 Water Conservation Strategies

Water conservation is considered the least expensive supply of water that we possess. Projected Conservation demands lag projected Expected Drought demands by about 20 years, indicating that the City could potentially delay some future water supply projects by as much as 20 years by continuing to pursue its effective water conservation program. In Section 6, the conservation strategies discussed include public education and awareness, stringent seasonal watering restrictions, an increasing block rate structure, reducing unaccounted-for water losses, and additional measures to increase the efficiency of irrigation practices and commercial water use. The significant reduction in per capita consumption over the past few years can be directly attributed to the effectiveness of the City's conservation block rate structure, volume rates, and 2-day per week irrigation limitation on a year round basis.

ES.5 Potential Water Supply Strategies

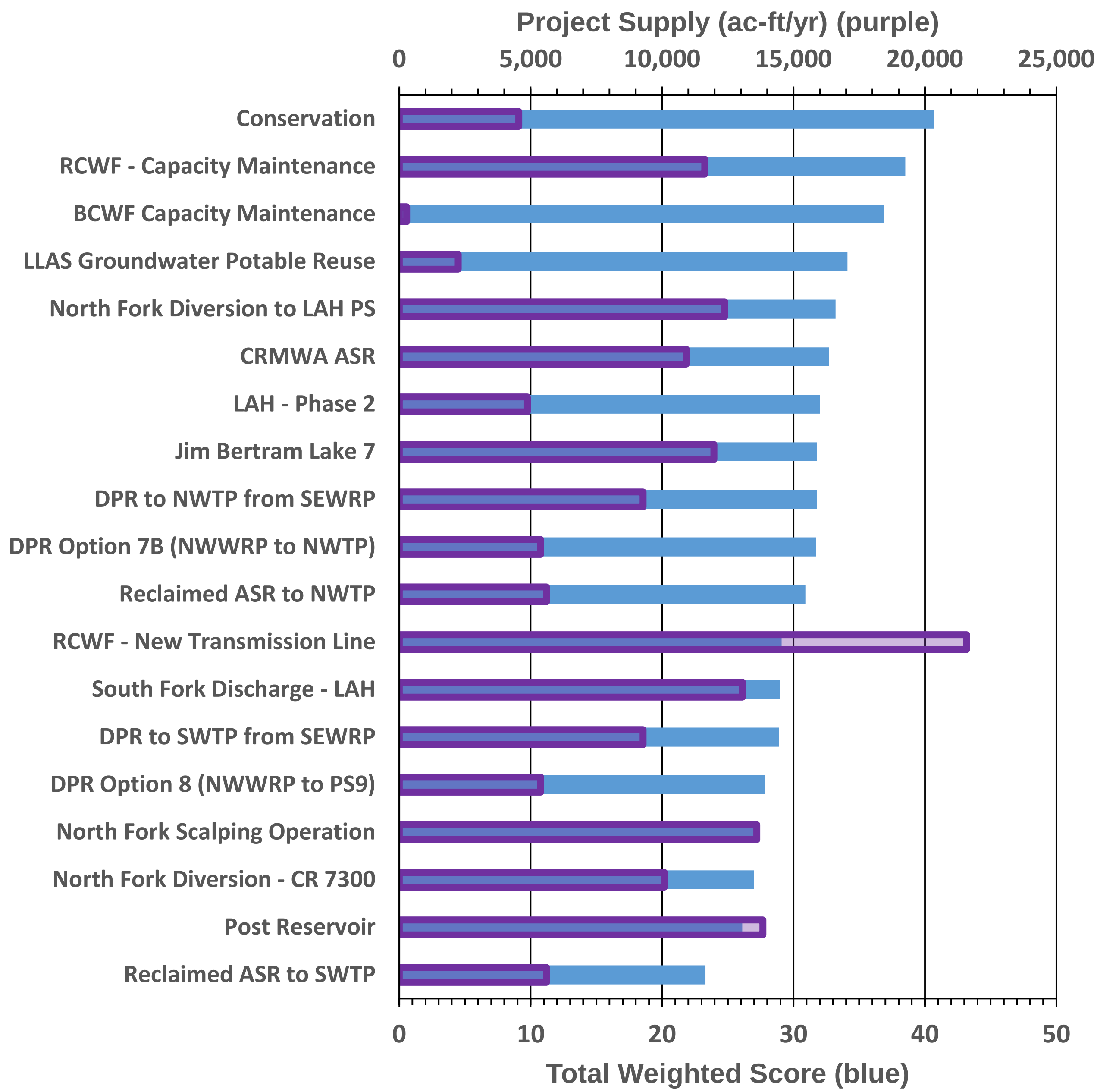
Table ES.1 provides a short explanation of each of the 17 non-conservation water supply strategies evaluated as part of this plan. These strategies, as described in Sections 7, 8, 9 and 10, are categorized as reclaimed water, groundwater, aquifer storage and recovery (ASR), and surface water, respectively. Other strategies considered but not evaluated fully are described in section 11.

In order to evaluate the strategies relative to one another, each strategy has been scored on a scale from 1 (low) to 5 (high) in 8 different criteria. Each criteria is weighted 0.5, 1.0, 1.5 or 2.0, depending on the criteria's importance. The range of possible total weighted scores is between 0 and 45. Section 12 describes the criteria and the scoring process in detail. Figure ES.6 summarizes the results of the scoring process and the relative amount of water that is available from each strategy. The amount of available water and the amount of time needed to implement each strategy are not factored into the scores. However, these two factors are used to determine the most cost effective way to satisfy future needs as demonstrated in each supply package scenario.

Table ES.1. Strategies Evaluated

Reclaimed Water	North Fork Diversion at County Road 7300	Reclaimed water discharged at Outfall 001 on the North Fork will be re-captured 2.7 miles downstream and pumped to the South Water Treatment Plant (SWTP) for further treatment.
	Direct Potable Reuse to the NWTP from SEWRP	Reclaimed water from the Southeast Water Reclamation Plant (SEWRP) will be treated and pumped to the North Water Treatment Plant (NWTP), and blended with other raw water supplies before further treatment.
	Direct Potable Reuse to the SWTP from SEWRP	Reclaimed water from the SEWRP will be treated and blended with other raw water supplies and pumped to the SWTP for further treatment.
	South Fork Discharge – LAH Supplement	The existing effluent pipeline to the Hancock Land Application Site will be extended to a tributary on the South Fork so that reclaimed water can be discharged and flow into Lake Alan Henry (LAH).
	North Fork Diversion to LAH Pump Station	Reclaimed water discharged at Outfall 001 will travel 67 miles downstream on the North Fork to the diversion site where it will be pumped directly to the LAH Pump Station.
	Direct Potable Reuse Option 7B (NWWRP to NWTP)	Reclaimed water from the Northwest Water Reclamation Plant (NWWRP) will be treated and pumped to the NWTP, and blended with other raw water supplies before further treatment.
	Direct Potable Reuse Option 8 (NWWRP to PS9)	Reclaimed water from the NWWRP will be treated to potable quality standards and introduced into the water distribution system at Pump Station 9.
Groundwater	RCWF – Capacity Maintenance	New wells will be installed to maintain the capacity of the existing Roberts County Well Field (RCWF).
	BCWF – Capacity Maintenance	New wells will be installed to maintain the capacity of the existing Bailey County Well Field (BCWF).
	RCWF New Transmission Line	Construction of additional wells and a second transmission line from the RCWF to the Canadian River Municipal Water Authority (CRMWA) Aqueduct will almost double Lubbock's CRMWA allocation and fill the aqueduct to capacity.
Aquifer Storage and Recovery (ASR)	Reclaimed ASR to NWTP	Reclaimed water from the SEWRP will be treated and pumped to an Aquifer Storage and Recover (ASR) facility near the NWTP, where it will be injected into the Ogallala Aquifer, recovered later and pumped to the NWTP for blending with other raw water supplies before further treatment.
	Reclaimed ASR to SWTP	Reclaimed water from the SEWRP would be treated and pumped to an ASR facility near the SWTP through the Hancock Land Application Site pipeline, where it will be injected into the Edwards-Trinity High Plains Aquifer, recovered about one mile downgradient to the east, and pumped to the SWTP for disinfection and blending with other treated water.
	CRMWA to ASR	Water received from CRMWA during winter months will be injected into the Ogallala Aquifer and recovered from the aquifer during summer months.
Surface Water	LAH Phase 2	Expansion of existing infrastructure will substantially increase the quantity of water that Lubbock can transport and treat from LAH.
	Jim Bertram Lake 7	A reservoir will be constructed on the North Fork upstream of Buffalo Springs Lake. Lake 7 water will be pumped to the NWTP for treatment.
	Post Reservoir	A reservoir will be constructed on the North Fork located east of Post in Garza County. Post Reservoir water will be pumped to the Post Pump Station and then to the SWTP for treatment.
	North Fork Scalping Operation	Stormwater on the North Fork will be captured and transported to LAH, increasing the lake's yield.

Figure ES.6. Supply Strategies Sorted by Score (Highest to Lowest)



ES.6 Supply Packages that Satisfy Future Needs

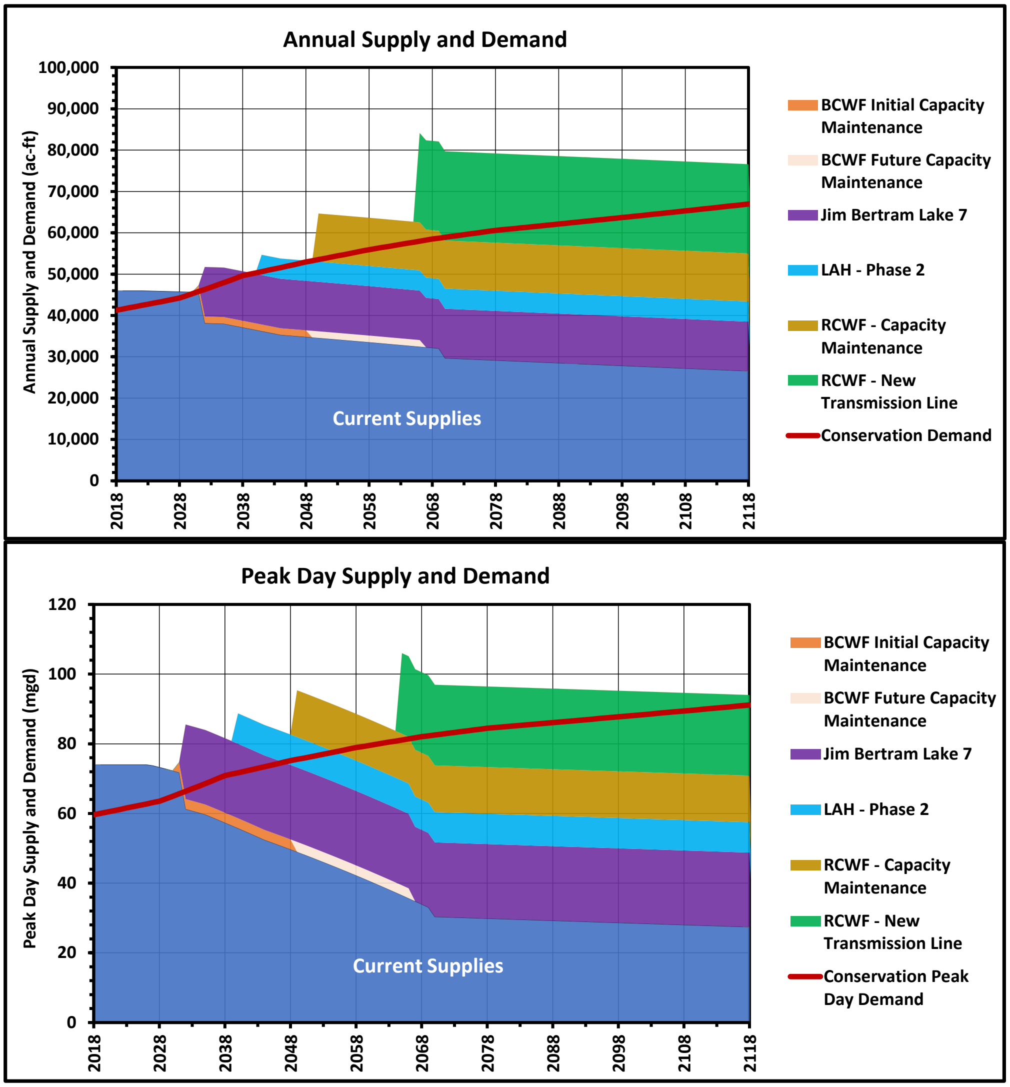
Combinations of supply strategies in conjunction with the various demand projections were used to develop five different supply packages that can potentially provide the City with water over the 100-year planning period. ***Many strategies used in these supply packages are interchangeable with other strategies that may not be included in the packages. Just because a strategy is not used in one of these examples, does not mean the strategy may not prove to be a more appropriate strategy in the future.*** Strategies were selected for inclusion in these packages based on a combination of meeting annual water volume needs and meeting peak day capacity needs. Many of the reuse strategies are not selected for inclusion in a package because they have limited capability to meet peak day capacity needs.

Section 13 describes these supply packages in greater detail. The five different supply packages developed are described below and presented in Figures ES.7 – ES.11. Table ES.2 compares strategy timelines and implementation dates for each of the five supply packages.

Supply Package 1 – Early Diversification

The Early Diversification supply package is intended to continue diversifying the City's water supplies so that the City is not overly dependent on a single source of supply. This supply package meets water demands under the Conservation demand scenario by maintaining and/or increasing supplies from the existing RCWF and BCWF and LAH, and also develops a new source of supply at a fairly early stage, Jim Bertram Lake 7. Because Lake 7 will utilize the City's reclaimed effluent as the primary portion of its yield, supply from Lake 7 will be relatively drought proof. Its proximate location to the City renders it somewhat less vulnerable to extended interruption than the City's existing supplies that are located much further away from Lubbock. Figure ES.7 illustrates the timing and supplies from this supply package.

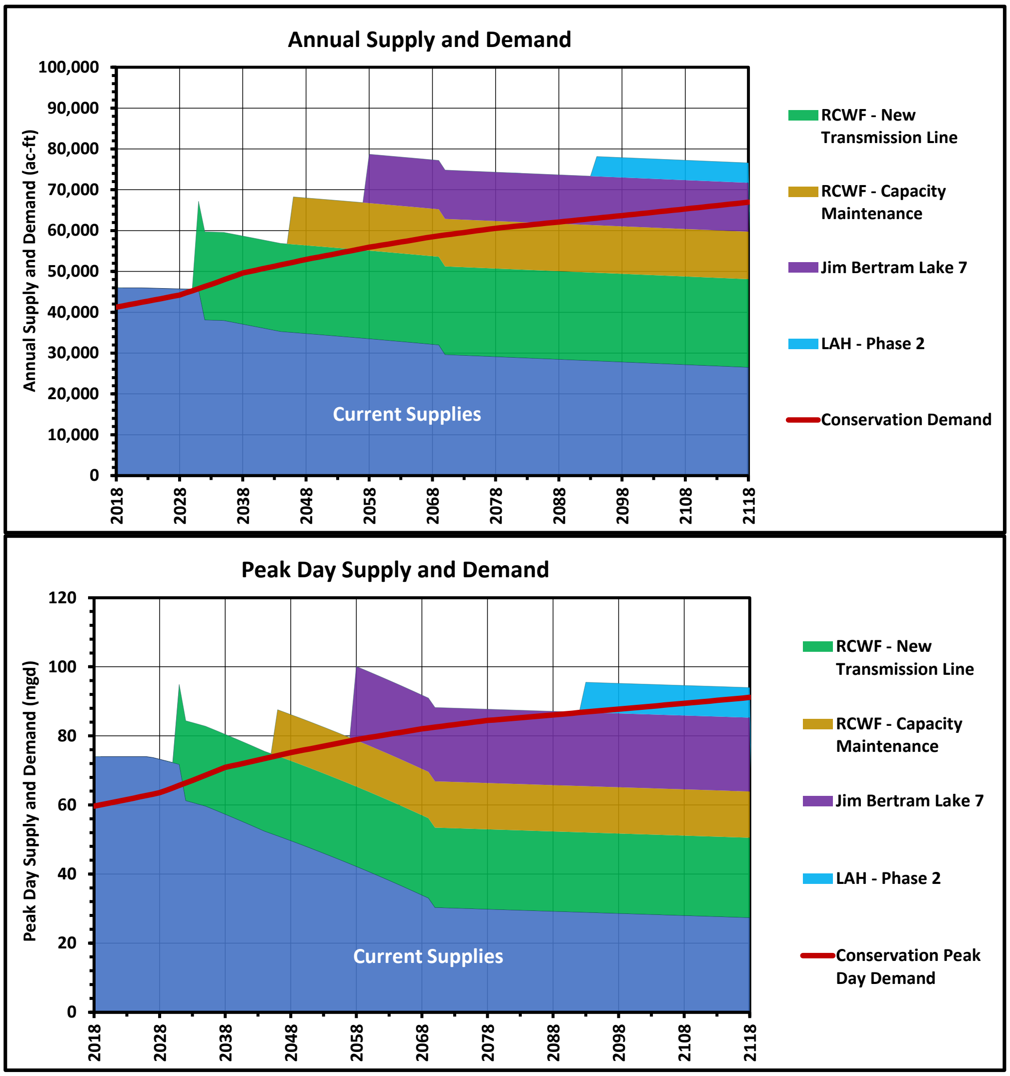
Figure ES.7. Early Diversification Supply Package



Supply Package 2 – Maximize RCWF

This supply package meets water demands under the Conservation demand scenario. The Maximize RCWF supply package is intended to, as much as possible, increase reliance on supplies from the RCWF, which is a drought proof, dependable supply that is easily maintained and expanded, and requires minimal water treatment. This supply package capitalizes on those characteristics early in the timeline. Expansion of surface water supplies (Lake 7 and LAH Phase 2) is delayed, and the BCWF is not maintained beyond its current configuration. Implementation of Lake 7 is needed by 2058 in order to meet peak day demands, but could be delayed until almost 2088 if annual supplies were the only consideration. Figure ES.8 illustrates the timing and supplies from this supply package.

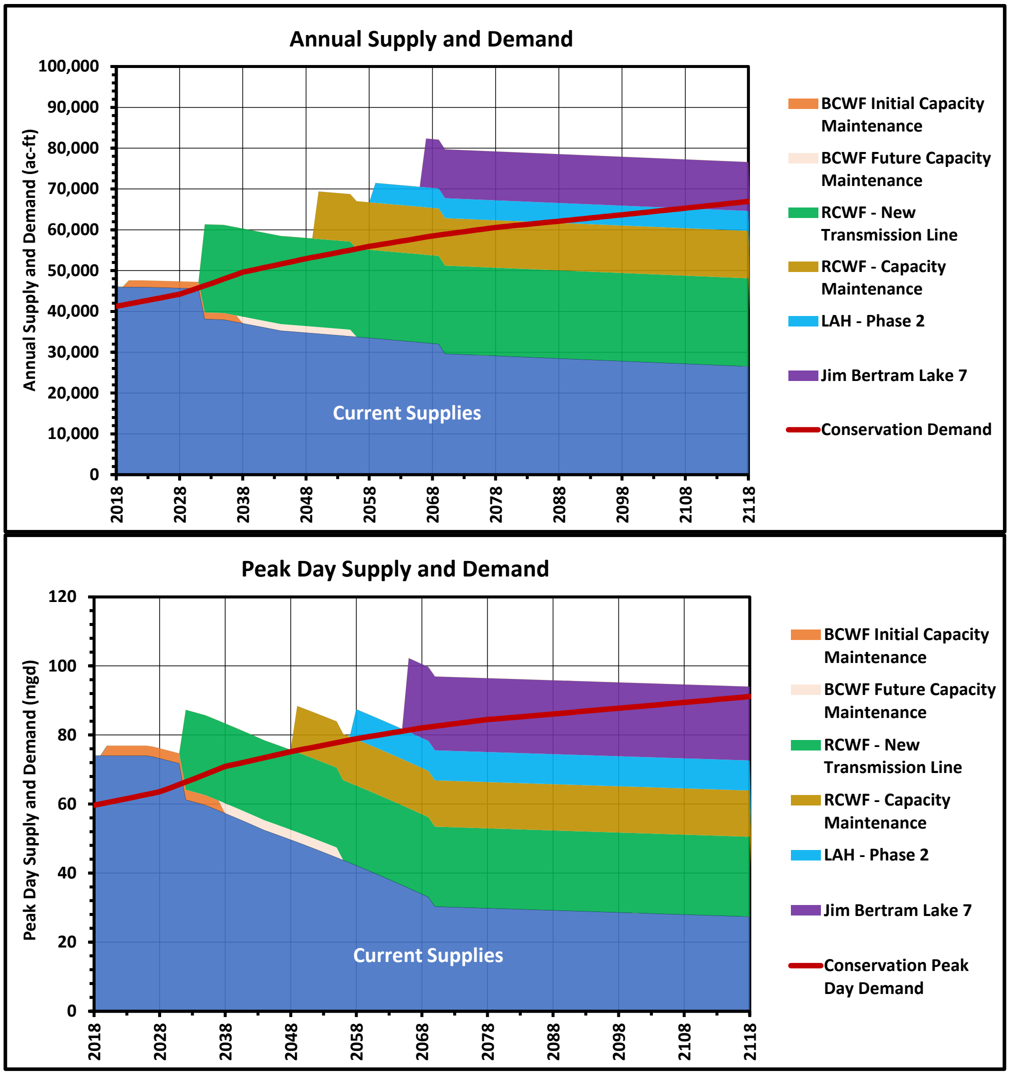
Figure ES.8. Maximize RCWF Supply Package



Supply Package 3 – Maximize Groundwater

This supply package meets water demands under the Conservation demand scenario. The Maximize Groundwater supply package is similar to the Maximize RCWF package, except that the BCWF continues to be expanded and maintained in order to retain its current 30 mgd peak day supply capacity, and the order in which the surface water supply projects (LAH Phase 2 and Lake 7) are implemented is reversed. Figure ES.9 illustrates the timing and supplies from this supply package.

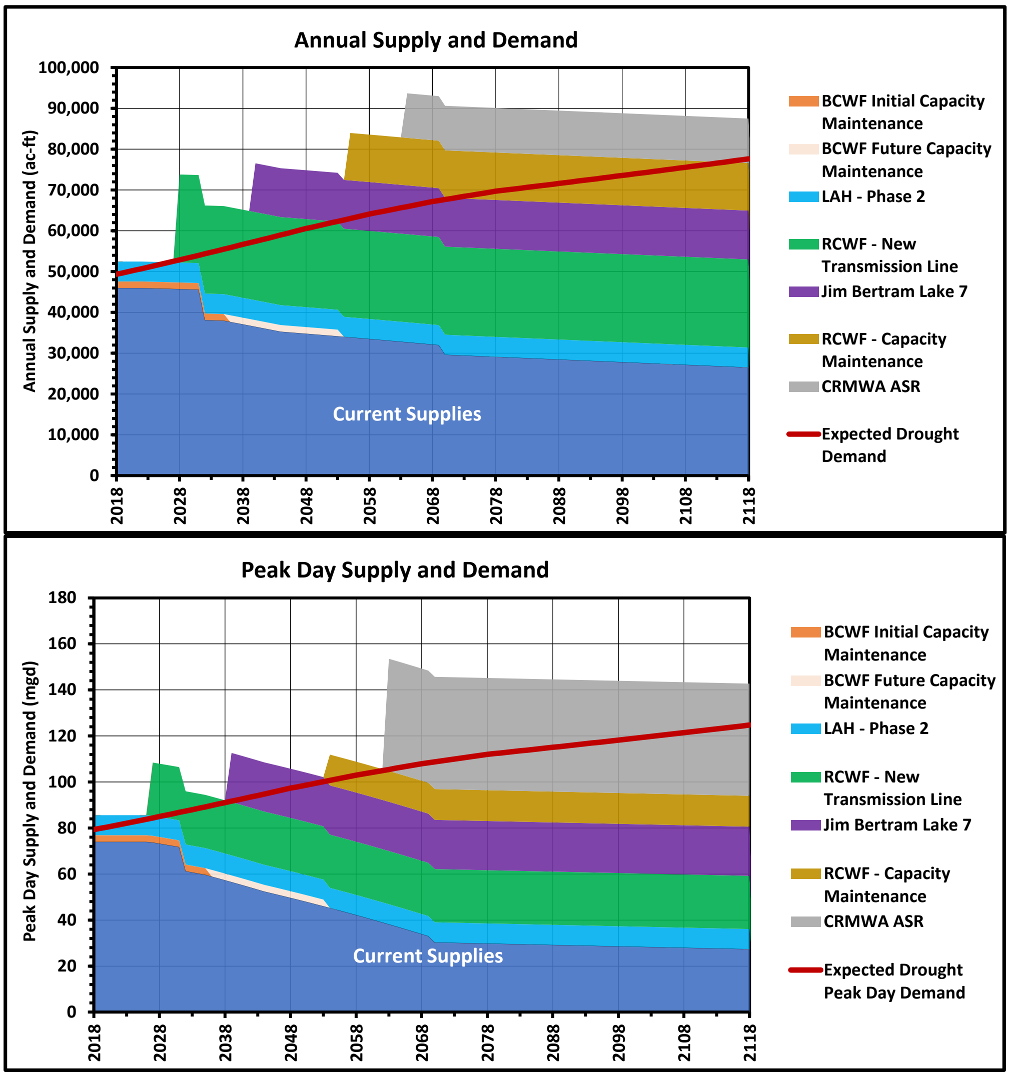
Figure ES.9. Maximize Groundwater Supply Package



Supply Package 4 – Expected Drought Demands

This supply package is intended to meet the larger water demands under the Expected Drought Demand scenario. Under the Expected Drought Demand scenario, population growth follows the Expected Growth progression, but water demands are not mitigated by successful conservation efforts and is what would be expected under severe drought conditions. The Drought Demands supply package initiates water supply strategies sooner than the previous packages. If peak day demands can be mitigated, then the CRMWA ASR project can be delayed or phased in more slowly over time during the later years. This supply package demonstrates the intensive water supply development that would be required if anticipated conservation savings are not realized. Figure ES.10 illustrates the timing and supplies from this supply package.

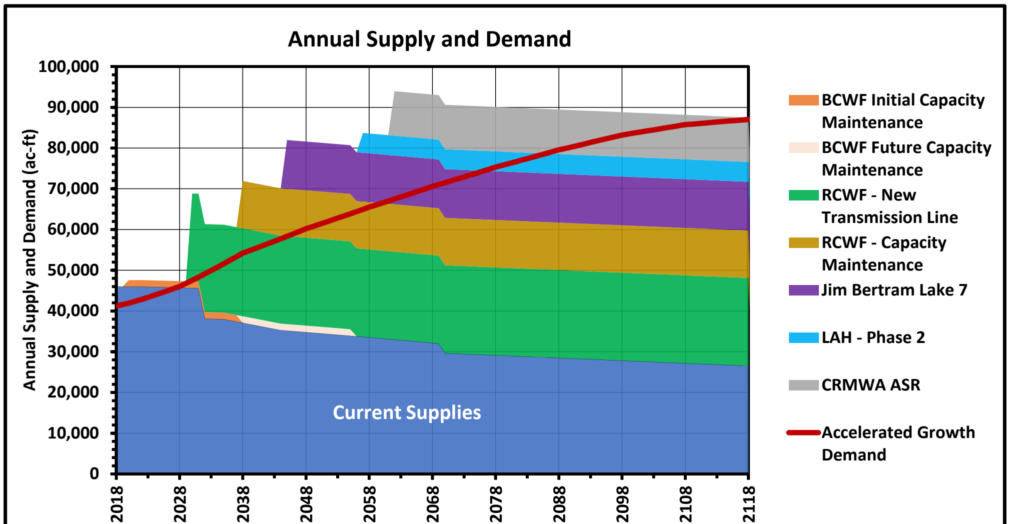
Figure ES.10. Drought Demands Supply Package



Package 5 – Accelerated Population Growth

The Accelerated Population Growth supply package is designed to meet water demands under a combination of faster than expected population growth, but with annual water demands mitigated by conservation savings. Under the Accelerated Population Growth scenario, annual water demands are actually smaller than the Expected Drought water demands met by the Expected Drought Demand water supply package in early years of the timeline because it is assumed that the accelerated population growth would necessitate more immediate water conservation savings. However, this scenario assumes that peak day reduction efforts are not as effective, and the timing of most of this package is driven by the need to meet future peak day demands. Figure ES.11 illustrates the timing and supplies from this supply package.

Figure ES.11. Accelerated Population Growth Supply Package



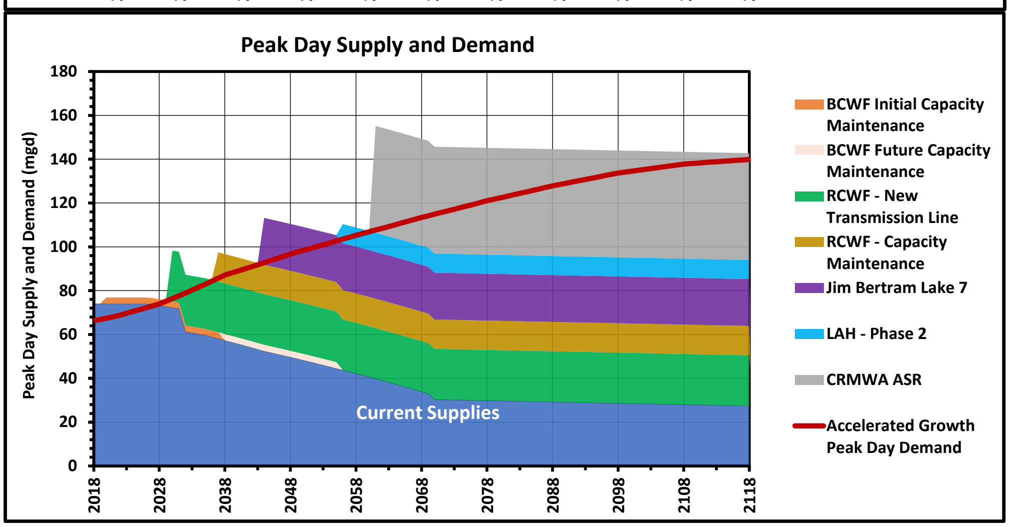


Table ES.2. Comparison of Supply Packages

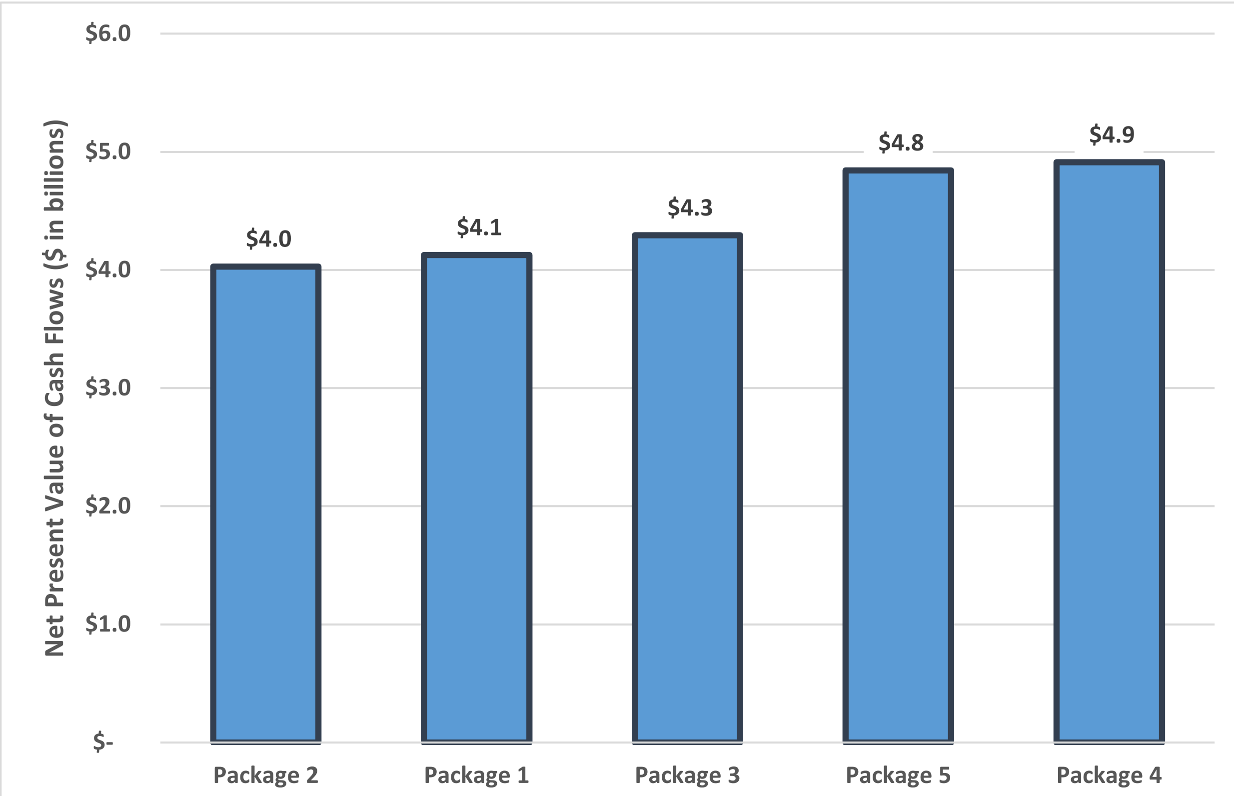
Supply Package 1 Early Diversification	Supply Package 2 Maximize RCWF	Supply Package 3 Maximize Groundwater	Supply Package 4 Drought Demands	Supply Package 5 Accelerated Population Growth
2018				
		2020: BCWF ICM 2026: BCWF CM-1	2018: BCWF ICM 2018: LAH Phase 2 2024: BCWF CM-1	2020: BCWF ICM 2026: BCWF CM-1
2028				
2031: BCWF ICM 2032: Jim Bertram Lake 7 2037: BCWF CM-1	2031: RCWF New Transmission	2032: RCWF New Transmission 2032: BCWF CM-2	2027: RCWF New Transmission 2030: BCWF CM-2	2032: BCWF CM-2 2030: RCWF New Transmission
2038				
2040: LAH Phase 2 2043: BCWF CM-2	2046: RCWF ICM	2038: BCWF CM-3 2044: BCWF CM-4	2036: BCWF CM-3 2039: Jim Bertram Lake 7 2042: BCWF CM-4	2037: RCWF ICM 2038: BCWF CM-3 2044: BCWF CM-4 2044: Jim Bertram Lake 7
2048				
2049: BCWF CM-3 2049: RCWF ICM 2055: BCWF CM-4		2049: RCWF ICM 2050: BCWF CM-5	2048: BCWF CM-5 2054: RCWF ICM	2050: BCWF CM-5 2056: LAH Phase 2
2058				
2061: BCWF CM-5 2065: RCWF New Transmission	2058: Jim Bertram Lake 7	2058: LAH Phase 2 2066: Jim Bertram Lake 7	2063: CRMWA ASR	2061: CRMWA ASR 2067: RCWF CM-1
2068				
	2076: RCWF CM-1			
2078				
2079: RCWF CM-1		2079: RCWF CM-1	2084: RCWF CM-1	
2088				
	2093: LAH Phase 2			2097: RCWF CM-2
2098				
	2106: RCWF CM-2			
2108				
2109: RCWF CM-2		2109: RCWF CM-2	2114: RCWF CM-2	
2118				

Note: ICM = Initial Capacity Maintenance, CM-1 = Capacity Maintenance-1, CM-2 = Capacity Maintenance-2, etc.

ES.7 Financial Impact of the Water Supply Packages

Each water supply package represents a substantial capital investment by the City, which will vary based upon the actual timing of when specific projects are implemented. In order to illustrate the costs and provide a comparison between the packages, the net present value of each package was determined based upon the implementation schedule proposed for each package. Figure ES.12 presents the net present value of each water supply package. In addition, the future debt service was determined for each package, which is presented in Section 13.

Figure ES.12. Net Present Value Comparison of Supply Packages



Supply Packages 1, 2 and 3 have the smallest net present values and are based on satisfying the Conservation Demands projection. Supply Packages 4 and 5 are the most costly and are based on meeting the greater Expected Demands and Accelerated Growth Demands projections.

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Acronyms and Abbreviations

Term	Definition
210 Authorization	30 Texas Administrative Code Chapter 210
AAD	Average Annual Day
ac-ft/yr	acre-feet per year
AOP	advanced oxidation process
APAI	Alan Plummer Associates, Inc.
ASR	aquifer storage and recovery
ATP	advanced treatment plant
AWC	average winter consumption
AWD	Annual Water Demand
AWWA	American Water Works Association
BCWF	Bailey County Well Field
BNR	biological nutrient removal
BRA	Brazos River Authority
CCL	Candidate Contaminate List
cfs	cubic feet per second
City	City of Lubbock, Texas
CM	Capacity Maintenance
CR	County Road
CRMWA	Canadian River Municipal Water Authority
DBS&A	Daniel B. Stephens & Associates
DFC	Desired Future Conditions
DPR	Direct Potable Reuse
ECC	Emerging Constituents of Concern
EID	Environmental Information Document
EPS	effluent pumping stations
ETHP	Edwards-Trinity High Plains
FM	Farm-to-Market Road
GAC	Granular Activated Carbon
GAM	Groundwater Availability Model
GCD	Groundwater Conservation District
GMA	Groundwater Management Area
gpcd	gallons per capita per day

Term	Definition
gpf	gallons per flush
gpm	gallons per minute
HET	high-efficiency toilet
HLAS	Hancock Land Application Site
Hp	horsepower
HPUWCD	High Plains Underground Water Conservation District No. 1
ICI	industrial, commercial and institutional
IFAS	Integrated Fixed-film Activated Sludge
JBLS	Jim Bertram Lake System
kwh	kilowatt-hour
LAH	Lake Alan Henry
LAHPS	Lake Alan Henry Pump Station
LLAS	Lubbock Land Application Site
µS/cm	microSiemens per centimeter
mg	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
NFD-LAHPS	North Fork Diversion to Lake Alan Henry Pump Station
NFDMF	North Fork of the Double Mountain Fork of the Brazos River
NPV	net present value
NTU	Nephelometric Turbidity Units
NWTP	North Water Treatment Plant
NWWRP	Northwest Water Reclamation Plant
PDD	Peak Day Demand
PF	Peaking Factor
PPCP	pharmaceuticals and personal care products
PPS	Post Pump Station
PS	Pump Station
RCWF	Roberts County Well Field
Region A	Panhandle Water Planning Area or Group
Region O	Llano Estacado Water Planning Area or Group
RO	reverse osmosis
ROI	Return on Investment
RWA	Reclaimed Water Availability
SB3	Senate Bill 3

Term	Definition
SCADA	Supervisory Control and Data Acquisition
SEWRP	Southeast Water Reclamation Plant
SLPS	Southland Pump Station
SWSP	Strategic Water Supply Plan
SWTP	South Water Treatment Plant
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TDS	total dissolved solids
TPDES	Texas Pollutant Discharge Elimination System
TWDB	Texas Water Development Board
USACE	United States Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
UV	ultraviolet
WAM	Water Availability Model
WET	Water Education Team
WRMWD	White River Municipal Water District

1 Introduction

1.1 History

The City of Lubbock, Texas (the City) city council approved an initial Strategic Water Supply Plan (SWSP) in July 2007. The goal of the Water Utilities Department is to update the Plan every five years in order to keep planning information as current as possible. Prior to the 2007 Plan, other water planning documents were prepared as needed by the City or by consultants hired by the City. Excerpts from these documents are referenced in the 2007 Plan[1] and summarized in Table 1.1.

Table 1.1. Studies referenced during the development of the Lubbock 2007 SWSP

Study Name	Study Date	Author
2004 City of Lubbock Strategic Water Plan	2004	Water Texas
2001 City of Lubbock Water Supply Evaluation	2001	Black & Veatch
1999 City of Lubbock 50-Year Water Plan	1999	City water staff
1992 Comprehensive Groundwater Management Study for the City of Lubbock	1992	Geraghty & Miller, Inc
1975 Plan for Additional Water Supply- Lubbock, Texas	1975	Freese & Nichols
1971 Report on Water Supply – Lubbock, Texas	1971	Freese, Nichols & Endress
1968 Interim Report on Water Supply – Lubbock, Texas	1968	Freese, Nichols & Endress

In 2013, the City prepared a comprehensive 100-year Strategic Water Supply Plan (2013 SWSP), which evaluated the City's projected population growth and associated water demands through year 2113, summarized the City's current water supplies, and evaluated various water supply strategies for meeting projected water supply shortages. The 2013 SWSP combines those strategies into several packages, any of which can be pursued to meet the City's goals. These packages take into account the City's annual water supply volume needed, as well as the City's maximum, or peak, day demands. Since development of the 2013 SWSP, the City has evaluated several water supply strategies in greater detail and developed additional information regarding the strategies, including cost and implementation issues. This 2018 SWSP is an update of the 2013 SWSP, and takes into account the results of strategy evaluations since 2013.

In addition to Lubbock's planning efforts, the State of Texas passed legislation in 1999 which required the creation of 16 Regional Water Planning Areas across the State. Regional Water Planning Groups were appointed for each area, and are tasked with developing water supply plans for their respective areas. Lubbock is located within the Llano Estacado (Region O) Water Planning Area as depicted in Figure 1.1 and is currently represented by the Director of

[1] 2007 Strategic Water Supply Plan for the City of Lubbock, Section 4.0.

Water Utilities on the Region O Water Planning Group. The first regional plans were completed in 2001 with subsequent updates to the plans in 2006, 2011 and 2016. All of the regional plans are incorporated into the State Water Plan which is released one year later (i.e. 2002, 2007, 2012, and 2017). The Region O Plan includes water management strategies for Lubbock and surrounding communities as well as for agriculture, mining, and industry.

1.2 Purpose

The City of Lubbock will continuously refine and implement its 100-year strategic water supply plan. Continual updates are essential in order to ensure that a sufficient water supply is available at the time that it is needed. The purpose of this Plan is to provide the framework for the City to develop sustainable water sources that can be implemented within appropriate time frames and in the most cost efficient manner. This Plan will also be utilized to support the City's position in the on-going regional water planning process. The City's goals include:

- Providing a roadmap to development and implement cost-effective and sustainable water supplies over the next 100-years;
- Diversifying the City's water supply portfolio to minimize risk associated with variable climate conditions and weaknesses associated with each water supply. Diversification strategies include implementing multiple groundwater, surface water and reclaimed water supplies to create a more reliable, sustainable, and resilient system; and
- Emphasize water conservation efforts to delay expensive water supply projects.

1.3 Description

The following steps are involved in the water supply planning process:

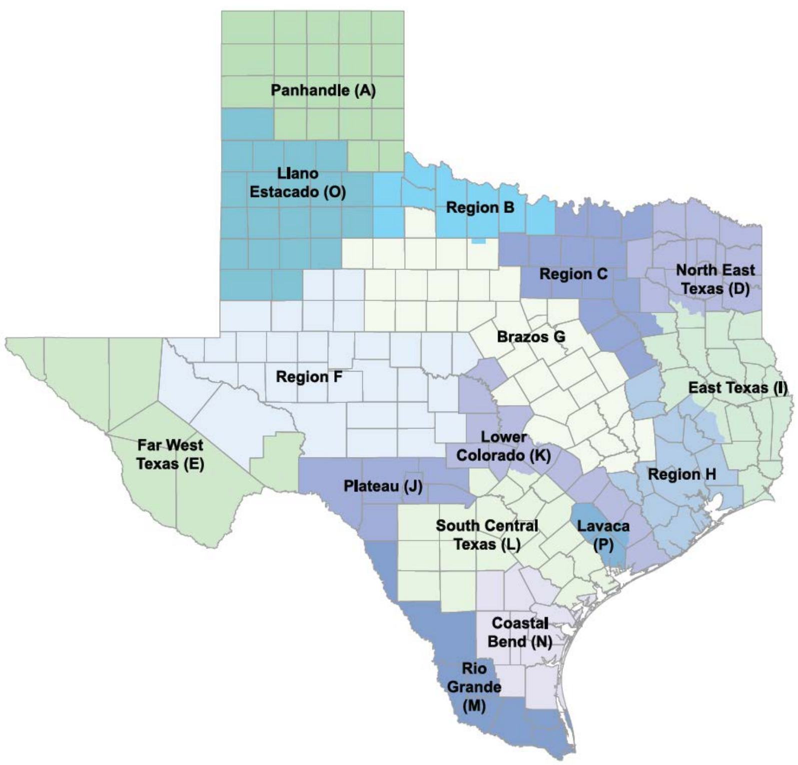
- Step 1 – Estimate Water Demand
- Step 2 – Calculate Long-term Yield of Current Water Supplies
- Step 3 – Determine When Water Deficits Begin to Occur
- Step 4 – Evaluate the Role of Water Conservation
- Step 5 – Identify Water Supply Strategies
- Step 6 – Evaluate and Rank Water Supply Strategies
- Step 7 – Create Supply Packages to Satisfy Future Needs
- Step 8 – Calculate the Financial Impact
- Step 9 – Implement the Plan
- Step 10 – Continuously Analyze and Refine the Plan

This Plan follows Steps 1 through 8. Steps 9 and 10 are dynamic steps that will evolve year by year. The planning horizon in this document includes the next 100 years. Projections have been made with the following three planning periods in mind:

Short Range Planning	12 years	2018 – 2030
Medium Range Planning	50 years	2031 – 2068
Long Range Planning	100 years	2069 – 2118

Potential water conservation strategies with associated costs are evaluated. In addition, potential water supply strategies are grouped into four categories: reclaimed water, groundwater, surface water and aquifer storage and recovery (ASR). These strategies include estimated volumes of available water and costs to implement each strategy. The 18 water supply strategies are evaluated, ranked, and subsequently packaged to meet future needs. Various strategies are placed into five supply packages to demonstrate ways to meet expected conservation demand, expected drought demand, and accelerated drought demand scenarios. Supply packages are presented for planning purposes only. Many strategies are interchangeable with flexible implementation schedules based upon a variety of unpredictable variables including climate conditions, population, per capita consumption, industry need, changes in regulatory environments, etc. Each package of strategies includes a net present value financial analysis.

Figure 1.1. Regional Water Planning Areas



Source: Texas Water Development Board. http://www.twdb.texas.gov/publications/shells/RegionalWaterPlanning.pdf

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2 Water Demand Projections

Water demand projections are the driving force behind water supply decisions and are dependent upon population and per capita consumption estimates. In this section, the 2018 Strategic Water Supply Plan (SWSP) (or “2018 Plan”) projections are compared with former projections from the City’s 2013 SWSP[1] and the 2021 Llano Estacado (Region O) Regional Water Plan.[2] It is important to note that the 2021 Region O Water Plan projections extend only to the year 2070, whereas the City’s 2013 SWSP extends to 2113, and this 2018 Plan extends to 2118. Where applicable, at least 35 years of historic data are presented to provide context for future projections.

2.1 Population

The population projections in this 2018 Plan are based on the 2010 Federal Census data[3] and the City Planning Department’s historical population information. This Plan projects population for the following four communities that receive water from the City of Lubbock Water System (2010 Census populations included):

- City of Lubbock (229,573 people)
- City of Shallowater (2,484 people)
- Town of Ransom Canyon (1,096 people)
- Buffalo Springs Lake (453 people)

The smaller communities make up less than 2% of Lubbock’s total population, which is well within the margin of error for population projections.

The two following population scenarios are presented in this 2018 Plan.

Expected Growth – This scenario depicts the expected population growth in the City and closely corresponds to the City Planning Department’s projections for the first 20 years. The Expected Growth projection consists of a 1.20% per year growth rate through 2038.[4] After this period, the growth rate drops to 0.80% per year and declines 0.10% every decade until 2079, at which point it remains constant at 0.40% per year growth. This scenario is comparable to the Probable Population scenario from the 2013 Plan.

Accelerated Growth – This scenario depicts what would occur if the City experiences accelerated growth over the next 20 years. The rate for the Accelerated Growth projection starts at 1.20% per year and increases by 0.10% per year until it reaches 1.70% per year and

[1] Strategic Water Supply Plan. City of Lubbock. February 2013: Section 2.3 Annual Water Demand.

[2] Llano Estacado (Region O) 2021 Regional Water Plan. DRAFT Population and Water Demand Projections.

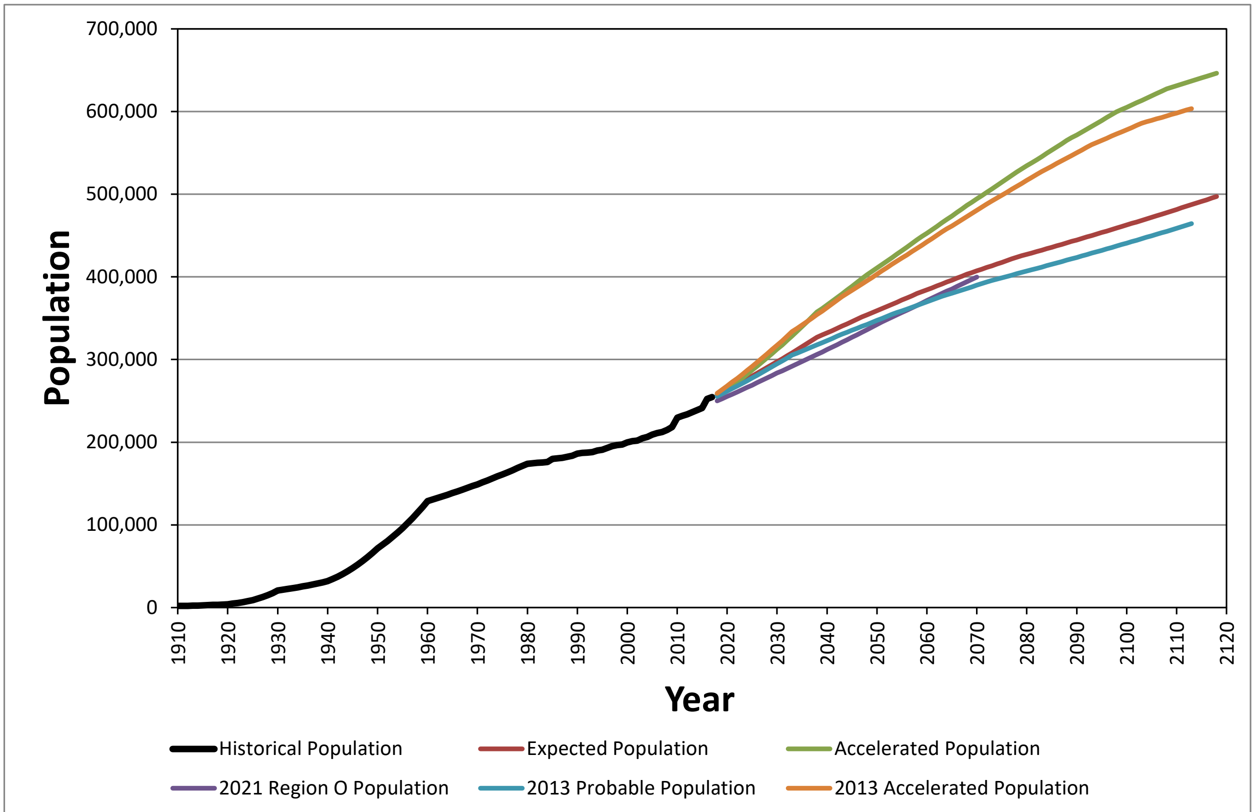
[3] United States Census Bureau Quick Facts United States. Address: https://www.census.gov/quickfacts/table/PST045216/4845000,48.

[4] In comparison, the City of Lubbock Planning Department projects a 1.12% annual growth rate from 2010-2040. The Planning Department has not generated population projections beyond 2040.

remains constant through 2038. After 2038, the growth rate declines to 1.20% per year for a decade, 1.00% per year for the following decade, and then declines 0.10% per decade from 2058 through 2098. For the last two decades, the growth rate declines by 0.15% per decade.

Figure 2.1 compares the population projections from these two scenarios with the projections utilized in the 2013 SWSP and those planned for use in the 2021 Region O Plan. Historic and projected population tables are included in Appendix A.1 and A.2, respectively.

Figure 2.1. Historical and Projected Population



The Expected Growth scenario for this 2018 Plan projects the following populations for the City of Lubbock and three customer cities:

- 290,258 in the year 2028
- 403,152 in the year 2068
- 497,140 in the year 2118

2.2 Per Capita Consumption

The State of Texas Water Conservation Task Force has established municipal per capita consumption goals, urging cities to implement measures that lower their per capita consumption each year. The Water Conservation Task Force has recommended a per capita consumption goal of 140 gallons per capita per day (gpcd).[5] The recommendation is for entities above 140 gpcd to implement management practices that reduce annual consumption by one percent of the total gpcd, based upon a five-year rolling average until the entity achieves a total gpcd less than 140.[6] The Llano Estacado Regional Water Planning Group considers the one percent annual reduction to be too aggressive for municipalities in the region and has recommended a more conservative 0.5 percent annual gpcd reduction based on a five-year rolling average until the goal of 140 gpcd is met. A slower reduction in consumption will assist water utilities to maintain revenue stability.[7]

For this 2018 Plan, two per capita consumption scenarios were developed. Both reflect the more stringent goal of 140 gpcd set by the Water Conservation Task Force, but the scenarios differ in terms of the time in which this is accomplished. The two consumption scenarios are described below.

Drought Consumption – This scenario starts at 171 gpcd. The gpcd was calculated from the gpcd of 178 in 2011 (the driest year on record) and declines at a 0.54% per year to have a starting value of 171 gpcd in 2018. The consumption continues to decline at 0.50% per year until 2038, when it reaches a gpcd of 155. Over the next 80 years, the per capita consumption declines at a slower rate of 0.13% per year, reaching 139 gpcd in 2118.

Conservation Consumption – This scenario demonstrates the effect on water demand if the City continues focusing on their water conservation efforts. The Conservation Consumption scenario starts at 143 gpcd in 2018 (Lubbock's five-year rolling average per capita consumption from 2012 to 2016). Note that the City's water conservation efforts have lowered the gpcd below the goals set forth in the City of Lubbock's Water Conservation Plan[8] of 150 gpcd by 2019 and 147 gpcd by 2024. By 2022, the gpcd reaches 140, the goal set by the Water Conservation Task Force. After this period, the per capita consumption declines at a slower rate of 0.149% per year, reaching 120 gpcd in 2118.

The drought consumption and conservation consumption scenarios from this 2018 Plan and the 2013 Plan are compared with the consumption values to be used in the draft 2021 Region O Plan in Figure 2.2, which also includes historical consumption values since 1980. Historic and projected per capita consumption tables are included in Appendix A.1 and A.3 respectively.

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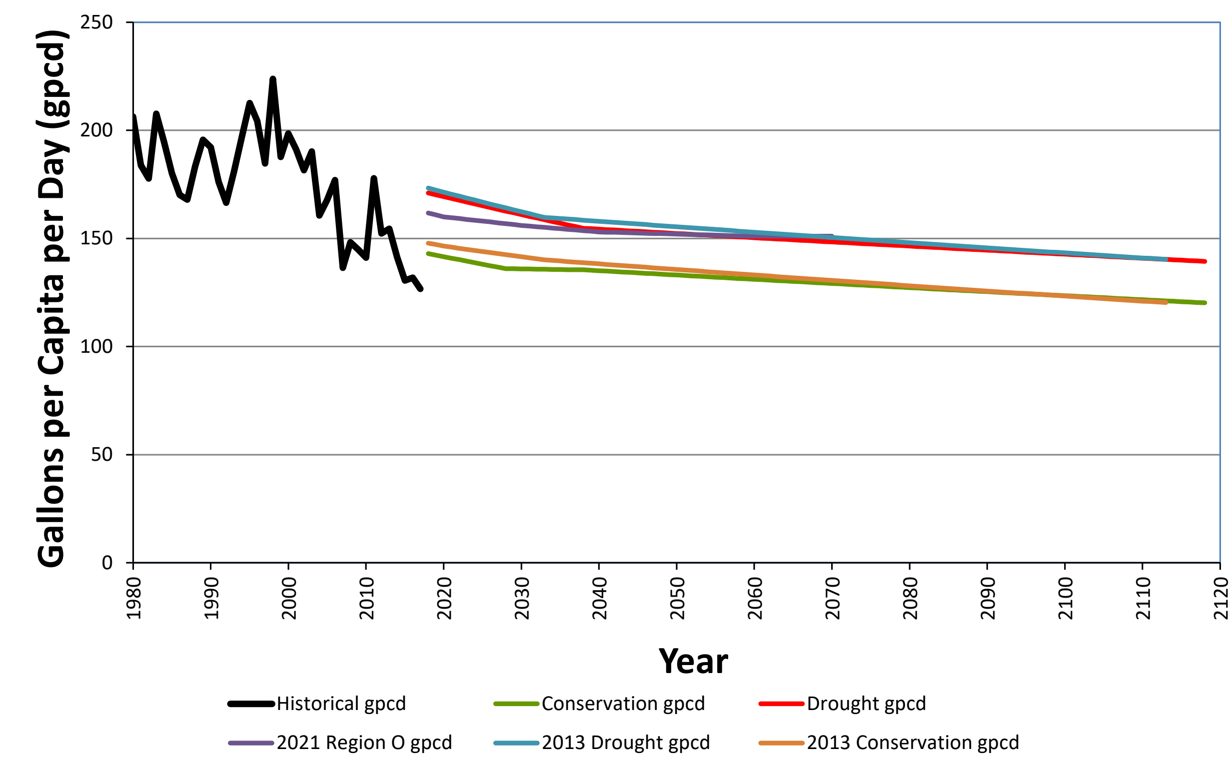
[5] Texas Water Development Board Special Report: Report to the 79th Legislature. Water Conservation Implementation Task Force. Austin, TX. November 2004: 31-33.

[6] 2016 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. December 2015: Section 5.2.1.

[7] 2016 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. December 2015: Section 5.2.1.

[8] Water Use Management Plan – Water Conservation Plan. City of Lubbock. Ordinance 2010-O0055 adopted 7/22/2010; Ordinance 2014-O0167, sec. 3, adopted 12/18/2014.

Figure 2.2. Historical and Projected Per Capita Water Consumption



2.3 Annual Water Demand

Lubbock's Annual Water Demand (AWD) projections consist of three scenarios, which were developed from different combinations of the two population scenarios described in Section 2.1 and the two per capita consumption scenarios described in Section 2.2. The AWD scenarios are as follows.

Expected Drought Demand – (Expected Growth x Drought Consumption) – This scenario represents the expected demand during times of drought since it includes the expected population and drought consumption projections. This scenario is comparable to the Probable Drought scenario from the 2013 Plan.

Conservation Demand – (Expected Growth x Conservation Consumption) – This scenario is included to provide an understanding of the impact that aggressive water conservation efforts will continue to have on future water demands.

Accelerated Growth Demand – (Accelerated Growth x Conservation Consumption) – This water demand projection reflects an accelerated population growth combined with conservation consumption. If population growth rates exceed the Expected projections, then this scenario assumes that conservation efforts will be implemented to offset the increased demands of the faster population growth. Note that these Accelerated Growth Demands are smaller than the Expected Drought Demands during the earlier years of the plan, but exceed the Expected Drought Demands beginning in year 2051. This indicates that aggressive conservation efforts alone will not be able to meet future needs if population grows substantially faster than expected.

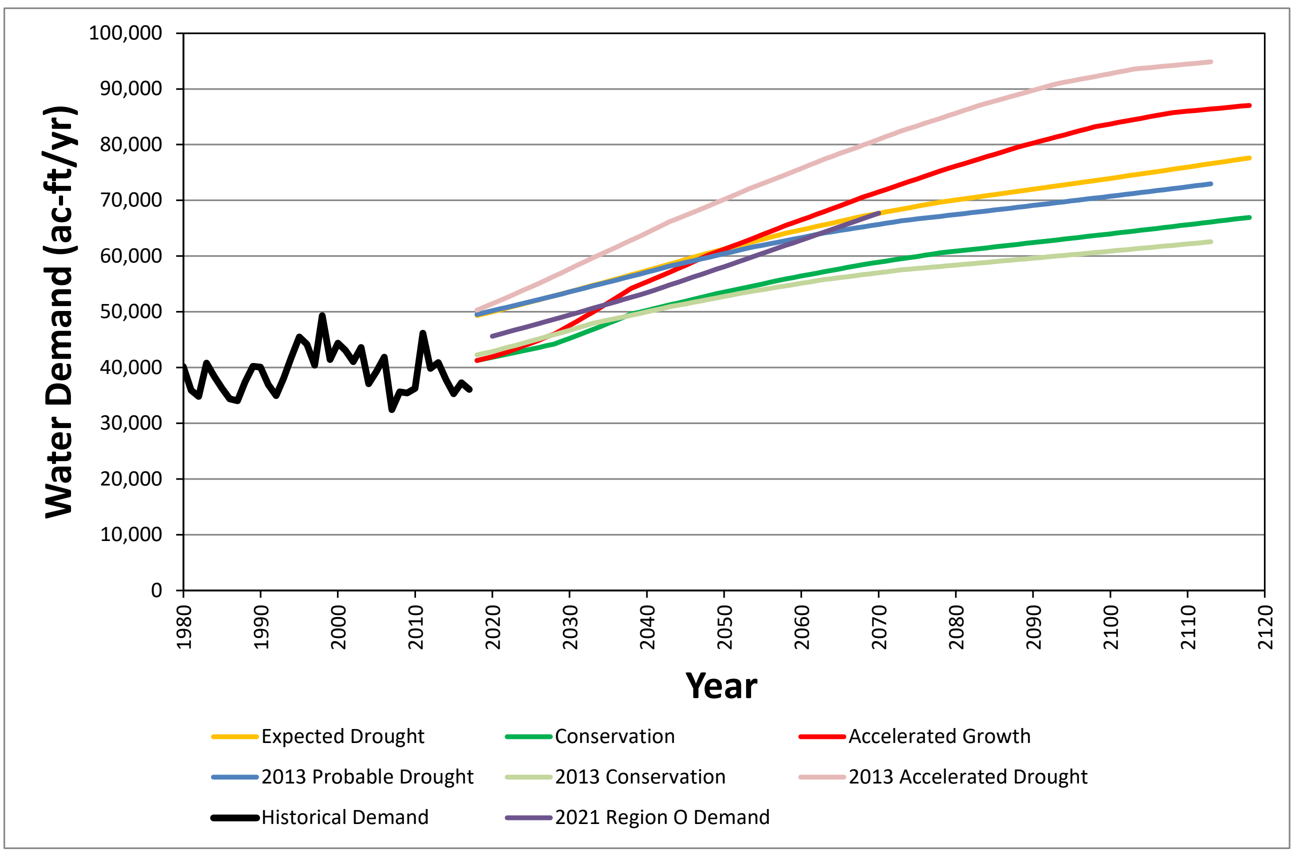
Historic and projected tables of AWD are included in Appendix A.1 and A.3 respectively, and are summarized in Table 2.1. A comparison of this Plan's AWDs to the 2021 Region O Plan and the City's 2013 Plan is shown in Figure 2.3. Historical and Projected Annual Water Demands. The demand curves for the expected population growth scenarios are similar to those utilized for Probable and Conservation scenarios in the 2013 Plan, except that the 2018 Plan demands exceed those from the 2013 Plan starting between years 2040 and 2050. The Accelerated Demands are not similar between the two plans because of the aggressive conservation assumed for the Accelerated Growth scenario in the 2018 Plan.

Table 2.1. Annual Water Demand Projections

Scenario	2018	2028	2068	2118
Expected Drought	49,344	52,878	67,180	77,625
Conservation	41,266	44,221	58,498	66,954
Accelerated Growth	42,266	45,999	70,587	87,044

Note: measurements are in acre-feet per year (ac-ft/yr). One ac-ft is 325,851 gallons.

Figure 2.3. Historical and Projected Annual Water Demands



2.4 Peak Day Water Demand

Peak Day Demand (PDD) must be considered when planning and designing water systems, and is used in this Plan to determine the size of infrastructure necessary to support expected maximum daily demands on the water system. The PDD typically is associated with outside water use during summer months, and will vary from year to year as precipitation patterns and temperatures fluctuate. The PDD is based on the AWD discussed in Section 2.3. Projections for PDD are calculated as follows:

Average Annual Day (AAD) in million gallons (mg) = AWD / 365 days

PDD in mg = AAD x Peaking Factor (PF)

The PF is a constant determined using historically observed daily water production records. Table 2.2 shows highlighted years for Lubbock's historic PDD, ADD and PF. Appendix A.1 includes a more comprehensive table of historical PFs.

Table 2.2. Historic Peak Day Data

Year	Historic PDD (mg)	Historic AAD (mg)	Historic PF
Historic Reference			
1980	70.85	35.89	1.97
1985	65.18	32.41	2.01
1990	79.00	35.79	2.21
1995	79.54	41.32	1.92
2000	67.82	39.51	1.72
2005	62.54	35.09	1.78
Last 10 Years			
2008	53.66	31.85	1.69
2009	54.23	31.63	1.71
2010	50.40	32.38	1.56
2011	64.12	41.25	1.55
2012	58.07	35.59	1.63
2013	57.96	36.51	1.59
2014	50.04	33.76	1.48
2015	49.56	31.51	1.57
2016	58.37	33.29	1.75
2017	49.94	32.24	1.55

Notes: PDD = Peak Day Demand; mg = million gallons; AAD = Average Annual Day; PF = Peaking Factor

For planning purposes, the following two PFs have been developed.

Expected PF – A common rule of thumb employed in the water planning industry is to assume a PF of 2.0. However, over the last 10 years, the City of Lubbock's PF has been much lower than 2.0. Therefore, an Expected PF of 1.8 is used in this Plan. This number is derived from evaluating the previous 10 years and identifying the maximum PF, which was 1.75 in 2016, rounded to 1.80. The City is projecting that the amount of water used on a peak day will be 1.8 times greater than on an "average" day. This is comparable to the Probable scenario from the 2013 Plan.

Conservation PF – The Conservation PF shows the reduction in PDD that may be achieved if the City adopts more aggressive water conservation policies. The conservation PF begins at 1.62 (the average PF from the previous 10 years) and then decreases from 1.62 to 1.52 over the 100-year planning period.

These two PFs were used to create three PDD scenarios. The Expected PF was combined with the Expected Drought AWD to produce the Expected Drought PDD and with the Accelerated Growth AWD to produce the Accelerated Growth PDD. The Conservation PF was multiplied by the Conservation AWD to produce the Conservation PDD. The resulting PDDs are summarized in Table 2.3.

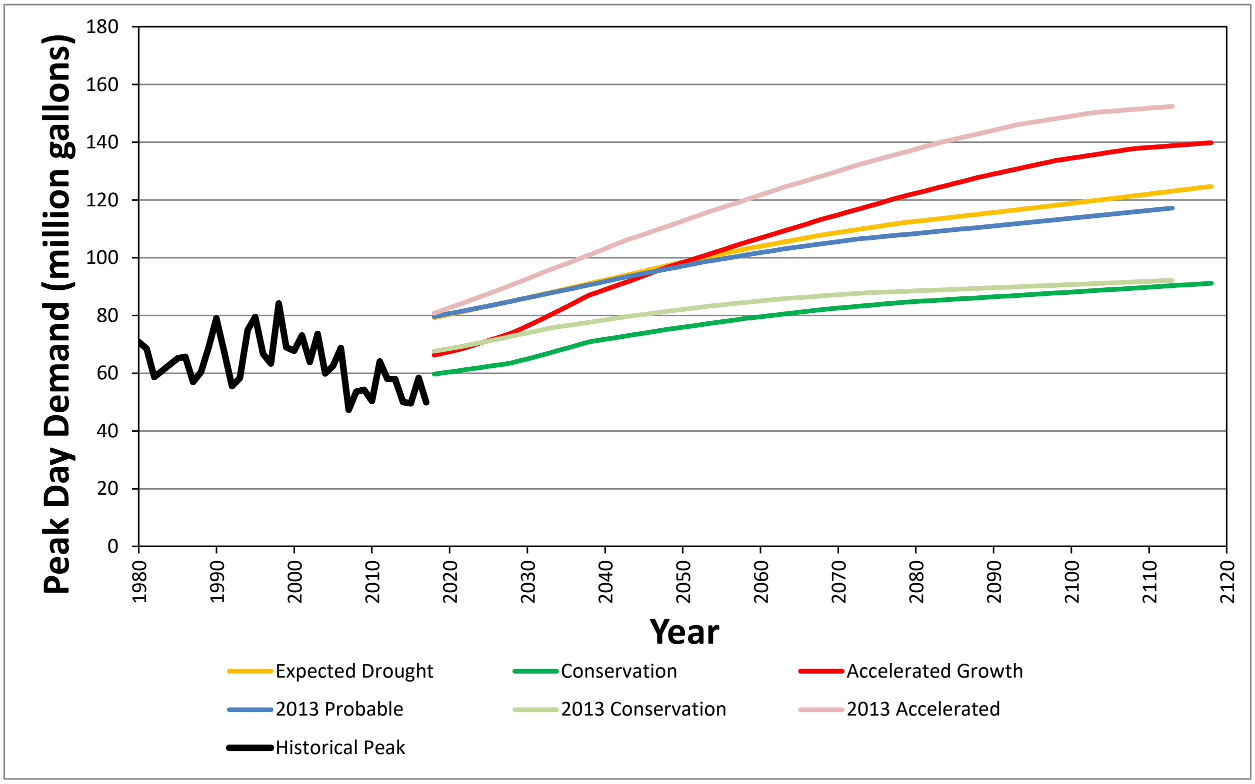
Table 2.3. Peak Day Water Demand Projections

Scenario	2018	2028	2068	2118
Expected Drought	79.29	84.97	107.95	124.74
Conservation	59.64	63.53	82.05	91.14
Accelerated Growth	66.31	73.92	113.43	139.87

Note: measurements in million gallons per day (mgd)

A comparison of this Plan's PDD to the 2013 Plan is provided in Figure 2.4 (see Appendix A.1 and A.4). The 2021 Region O Plan does not include PDD information, although a PF of 2.0 typically is used to size new infrastructure in the regional plans.

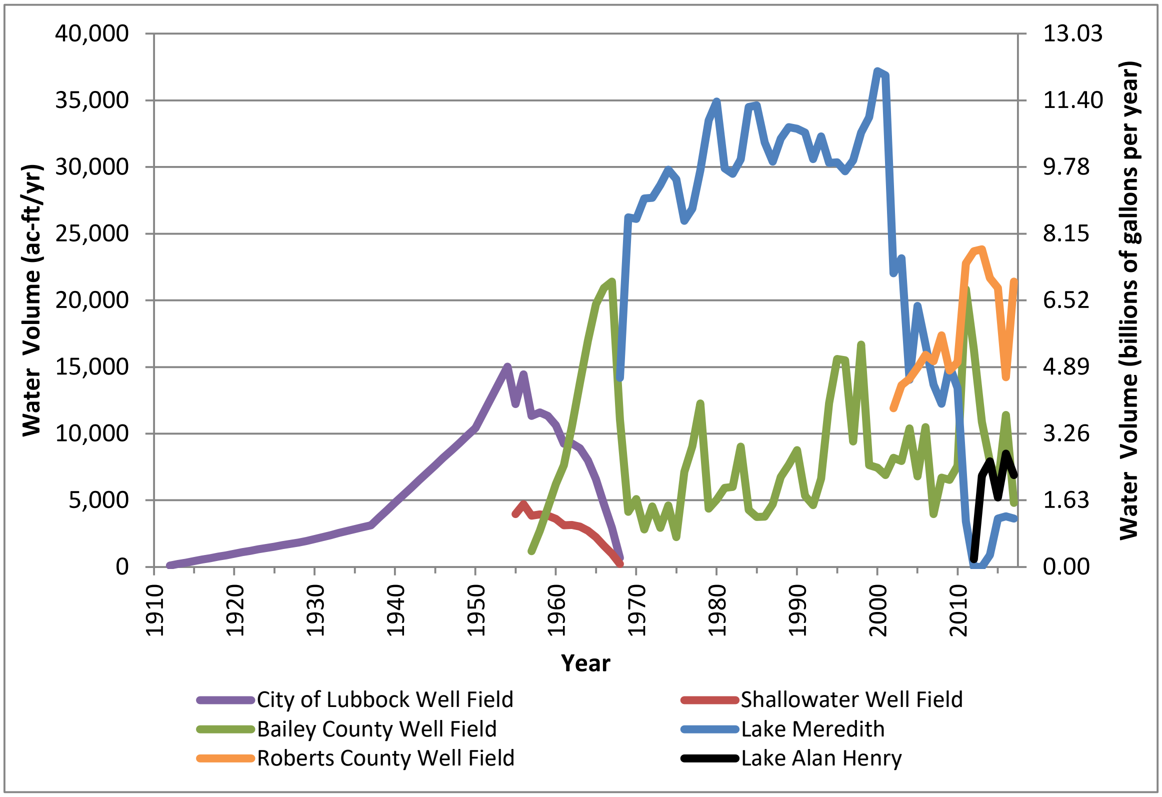
Figure 2.4. Historical and Projected Peak Day Demands



3 Decommissioned Water Supplies

Water supplies are dynamic natural resources. Over a period of decades, a once productive and cost effective water supply can become less desirable for a variety of reasons. Undesirable changes that can occur in a water supply include decreases in water quality, a decline in the sustainable yield, a depletion of the source of water, or a shift in the regulations governing water. Figure 3.1 depicts the City's historic water supply usage since the establishment of the City in 1911.

Figure 3.1. Lubbock's Historic Water Supply Usage

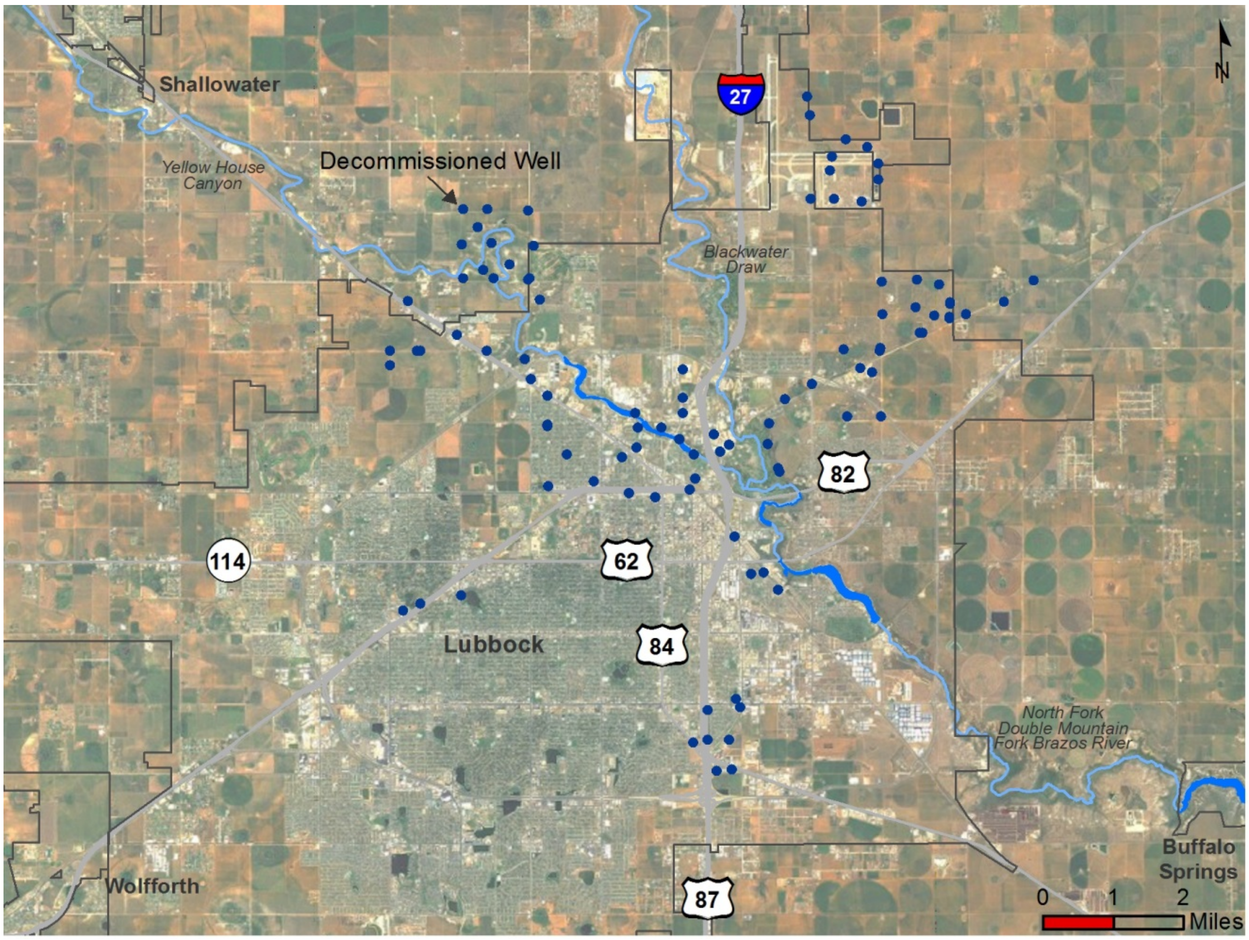


As shown on the graph, two of the City's past water supplies (City and Shallowater Well Fields) were used for a period of time and later decommissioned. A brief history of each of these decommissioned supplies is presented in this section.

3.1 City of Lubbock Well Field

When the first municipal water system was constructed for the City in 1911, it consisted of one well installed at a depth of 206 feet near the current intersection of 5th Street and Avenue J. From 1911 to 1954, the City owned 5.0 acres of water rights in and adjacent to the city limits. The City gradually expanded the number of wells it used. Groundwater pumped from well fields near the City was the only water supply for the City until the late 1950s when the Shallowater and Bailey County (Sandhills) Well Fields began to be used. Local well fields owned and operated by the City included the Northeast Well Field, the Airport Well Field, Pump Station #3 Well Field, Pump Station #6 Well Field, and Pump Station #7 Well Field. Figure 3.2 shows the location of the wells in the City Well Field.

Figure 3.2. City Well Field Locations



At its peak, the City Well Field included 61 wells. In the mid-1950s, the City began reducing the City Well Field production as the Shallowater Well Field and subsequently the Bailey County Well Field became operational. The City discontinued the use of the City Well Field when Lake Meredith water became available in 1968. The only local wells that were in operating condition and could potentially produce water for the City in the 1990s were the eight wells associated with Pump Station #6. At that time, it was estimated the combined production of these wells was 8 million gallons per day (mgd).[1]

The City eventually decided to decommission the City Well Field due to changes in the water quality of the groundwater under the City as Lubbock became more populated and urban sources of contamination impacted the groundwater supply. In addition, some of the naturally occurring minerals (such as fluoride) could not meet the increasingly stringent water quality standards set by regulatory agencies. These local wells that were once used for potable purposes are no longer part of the City's water supply. By 2012, all of the inactive City potable water supply wells had been plugged and abandoned.

3.2 Shallowater Well Field

In 1953, the City purchased 2,060 acres of water rights in Hockley and Lubbock counties, about 12 miles northwest of the City of Lubbock, and subsequently constructed the Shallowater Well Field.[2] The well field was used by the City from 1955 until 1968 when Lake Meredith became the main source of drinking water for the City. It appears that the City stopped using the Shallowater Well Field in the 1960s due to water quality issues. Furthermore, the production capacity of the Ogallala Aquifer near the well field had declined rapidly due to heavy agricultural irrigation surrounding the well field over the past century.

The Shallowater Well Field consists of 17 wells, which cover the entire water rights acreage. The well field location and infrastructure are depicted in Figure 3.3.

In 2011, City staff evaluated whether the well field should be rehabilitated or decommissioned, and recommended that the well field be decommissioned for the following reasons:[3]

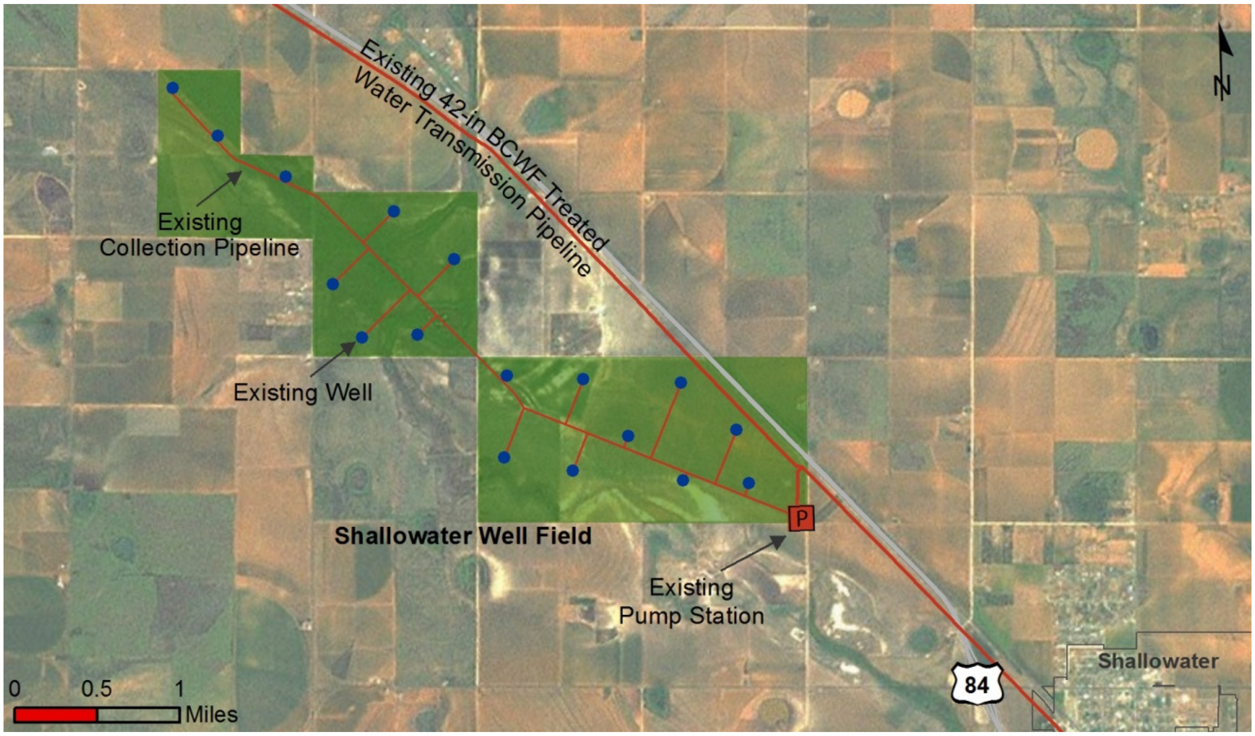
- Production capacity of the Shallowater Well Field is poor (average well capacity is 20 gallons per minute [gpm]);
- Ogallala Aquifer groundwater underlying the well field is of poor quality; and
- Existing water system infrastructure in the well field is in very poor condition.

1 Comprehensive Groundwater Management Study for the City of Lubbock. Geraghty & Miller, Inc. April 1992: Vol. 1, 57.

2 City of Lubbock Water Advisory Commission; Orientation Manual. September 18, 2003.

3 Shallowater Well Field Decommissioning Evaluation Memorandum. April 8, 2011.

Figure 3.3. Shallowater Well Field



It was estimated that it could cost more than $8,000,000 to replace all of the wells and upgrade the related infrastructure to meet current regulatory standards. These estimates did not include the cost of advanced water treatment facilities to correct water quality problems. Overall, the cost per recoverable acre-foot of groundwater for the Shallowater Well Field was determined to be at least seven times more expensive than expansions associated with the Roberts County (John C. Williams) and Bailey County (Sandhills) Well Fields.

4 Existing Water Supplies

The City of Lubbock (City) has relied upon a combination of both surface and groundwater for the last half century. Currently, the City's main water supplies consist of the following sources:

Canadian River Municipal Water Authority (CRMWA):

- Lake Meredith
- Roberts County Well Field (RCWF)

City-Owned:

- Bailey County Well Field (BCWF)
- Lake Alan Henry (LAH)

These four raw water supply sources and transmission facilities are shown in Figure 4.1. The current and future estimates of Lubbock's existing supplies presented in this section assume no expansion or maintenance over the 100-year planning period.

As depicted in Figure 4.1, Lubbock's closest existing water supply source is LAH, which is over 60 miles southeast of Lubbock. Lake Meredith and the RCWF are Lubbock's most distant water supply sources, located over 150 miles northeast of Lubbock. Their supplies must be transported through the CRMWA transmission pipeline and aqueduct.

Prior to 1968, groundwater withdrawals from the BCWF and local well fields were sufficient to meet the City's total water demand. In 1968, with the availability of surface water from Lake Meredith, groundwater withdrawals were reduced substantially. By the 1980s, Lake Meredith provided up to 90% of the City's water demand. However, Lake Meredith's yield began declining in the 1990's and by the end of 2001, groundwater was being used to replace a portion of Lake Meredith's supply. By September 2011, Lake Meredith's water level dropped to a point where CRMWA could no longer provide water from the reservoir to its member cities. From the Fall of 2011 until the Fall of 2012, the City met its water demand with 100% groundwater from the RCWF and the BCWF. Water from LAH became available in the Fall of 2012. LAH provided the City with 17% of its annual supply in 2013. In 2015, CRMWA began drawing water from Lake Meredith again. By 2017, Lake Meredith represented 11% of Lubbock's water supply used to meet demand.

Lubbock's water supplies have constantly changed over time depending on the demand and availability of surface water or groundwater supplies. Within the last 25 years, the profile of Lubbock's water supply has changed dramatically, as depicted in Figure 4.2.

- In 1992, Lubbock received 87% of its water supply from Lake Meredith, and the RCWF did not exist.
- By 2012, Lake Meredith was no longer a supply, and RCWF provided 58% of Lubbock's water supply.

- In 2016, a pipeline break forced the City to utilize additional supplies from the BCWF and less from the RCWF, but reliance on the BCWF was reduced in 2017 following repairs.
- In 2016 and 2017, surface water from Lake Meredith and LAH made up about 30 percent of the City's supply as all four sources were utilized.

As a result, continuous planning is essential to maximize the City's dynamic water supply situation.

4.1 Canadian River Municipal Water Authority Supplies

CRMWA was created by the Texas Legislature in 1953 to provide a source of municipal and industrial water for its eleven member cities located in the Texas Panhandle and South Plains. The CRMWA headquarters is located at Sanford Dam (Lake Meredith) about 37 miles northeast of Amarillo, Texas. Originally, CRMWA was organized to operate Lake Meredith, which was built and financed by the U.S. Bureau of Reclamation as part of the Canadian River Project. Later, the RCWF was constructed to supplement the lake supply.

The water supply from CRMWA is conveyed via a 358-mile underground pipeline aqueduct system. Figure 4.3 depicts the current groundwater allocation of CRMWA supplies between the eleven member cities.

4.1.1 Lake Meredith

When construction began on Lake Meredith in 1962, initial estimates placed the firm yield of the Lake at 103,000 acre-feet per year (ac-ft/yr). Lake Meredith began to fill shortly after the Sanford Dam was completed in 1965. In 1968, CRMWA began delivering supply from Lake Meredith to member cities. Lubbock's initial allocation was 38,169 ac-ft/yr or 37 percent of the initial firm yield estimate. Later studies indicated that the firm yield of the lake was only 76,000 ac-ft/yr and Lubbock's allocation was reduced to 28,164 ac-ft/yr. As drought conditions continued over the last decade, the firm yield of the reservoir was further reduced to less than 50,000 ac-ft/yr. By 2011, insufficient inflows rendered the lake unusable until 2015 when the lake began to refill.

As a result of the declining water levels in the lake, the allocations to the member cities including Lubbock were proportionally reduced. Groundwater from the RCWF was used to make up the difference as much as possible. In 2011, during the worst one-year drought on record, Lake Meredith was used for summer peaking capacity only. After the summer of 2011, water could not be pumped from the lake until 2015, when inflows allowed water levels to begin recovering. Historic water levels in Lake Meredith are presented in Figure 4.4.

Figure 4.1. Current Water Supply Location Map

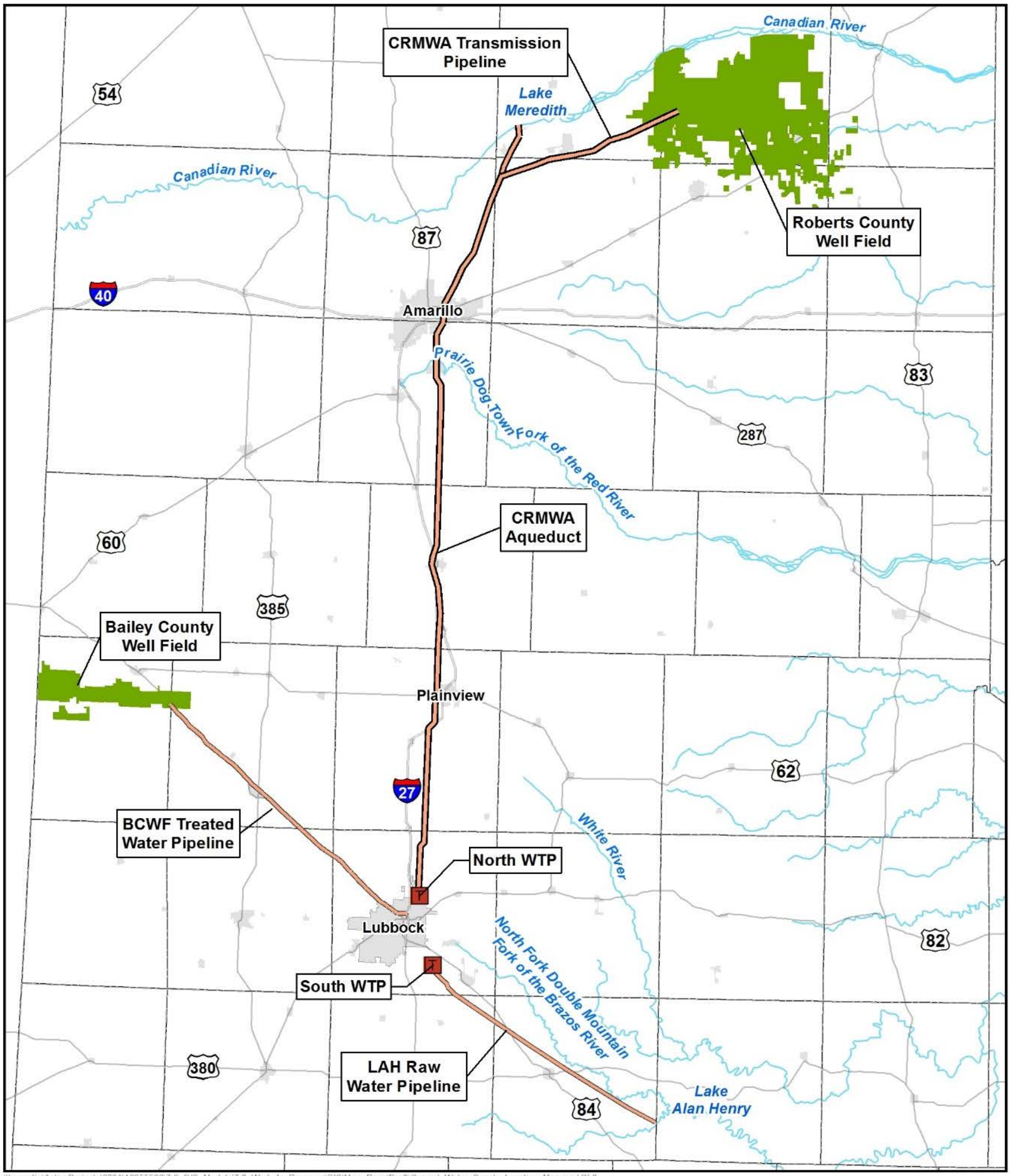


Figure 4.2. Water Supply Contributions for 1992, 2002, 2012, 2016 and 2017

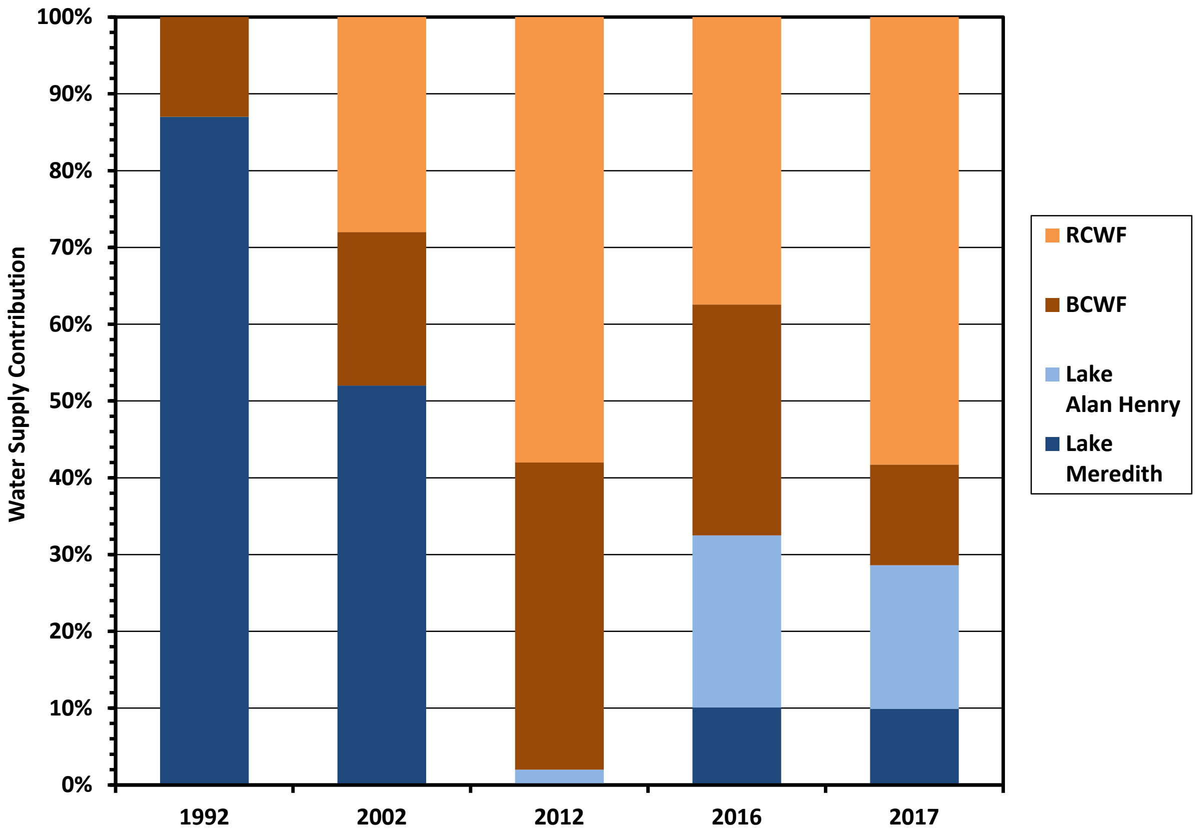


Figure 4.3. Current CRMWA Member City Groundwater Allocations

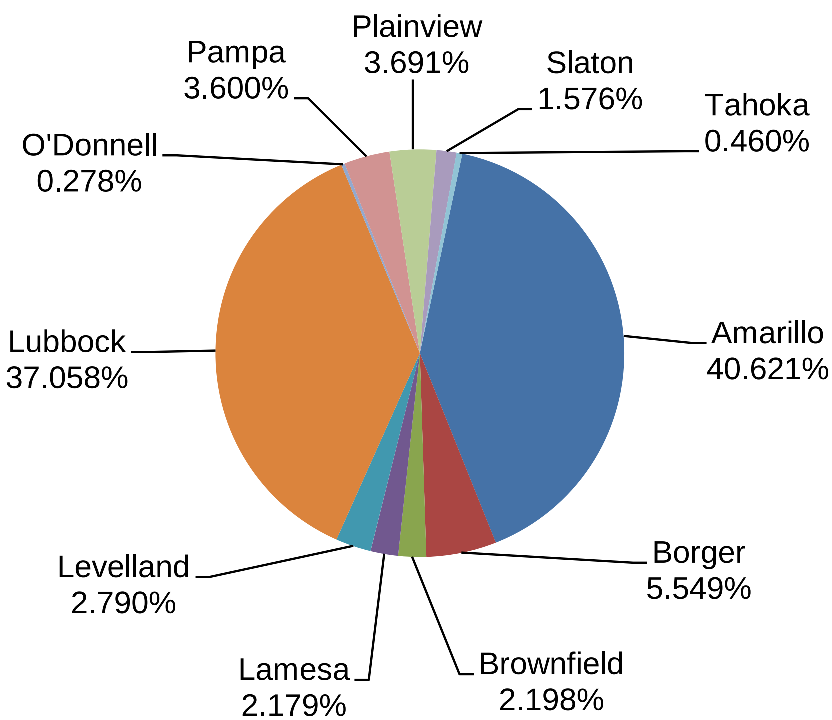
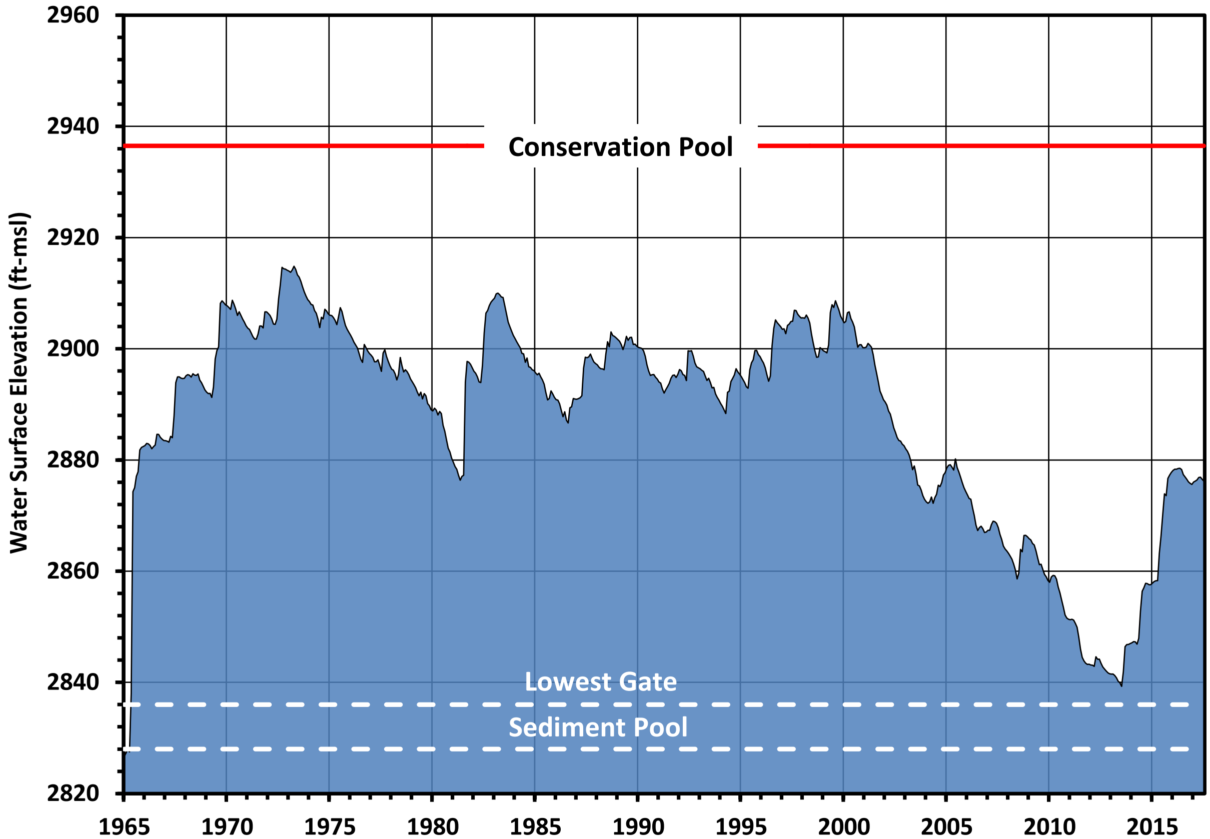


Figure 4.4. Historic Water Levels in Lake Meredith



In January 2009, the results of a Freese & Nichols, Inc. report[1] concerning Lake Meredith were presented to the Panhandle (Region A) Regional Water Planning Group. The conclusions of this study indicate that the decreased inflows to Lake Meredith is most likely attributed to changes in the groundwater to surface water interactions and land-use changes in the watershed. Declines in the Ogallala Aquifer and Dockum Formation water levels appear to have impacted spring flow into the lake. In addition, the increase in shrub (especially salt cedar) in the watershed also appears to contribute to reduced reservoir inflows. The report indicates that the decreased inflows to the lake do not appear to be meteorological in origin. Changes in precipitation amounts, precipitation intensity and evaporation were not considered to be contributing factors.

In 2015, CRMWA resumed deliveries from Lake Meredith to the City, delivering approximately 3,826 ac-ft to Lubbock in 2016. However, considering the findings of the 2009 study and the lack of substantial storage recovery during the recent wet period, the City does not consider Lake Meredith to be a long-term viable water supply source. As a result, the City estimates that approximately 7,400 ac-ft/yr of supplies will be available until 2031 from Lake Meredith.

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[1] Surface Water Study. Freese and Nichols. January 2009.

4.1.2 Roberts County (John C. Williams) Well Field

CRMWA began efforts to supplement supply from Lake Meredith with groundwater as early as the 1990s. In 1994, CRMWA purchased 42,864 acres of water rights in Roberts and Hutchinson counties and began construction of the RCWF (also called the John C. Williams Well Field). Phase 1 and Phase 2 of the RCWF were completed in 2002 and 2006, respectively, containing 29 wells permitted to supply 40,000 ac-ft/yr of groundwater from the Ogalla Aquifer. A 35-mile, 54-inch diameter transmission line was also constructed connnecting the RCWF to the main CRMWA Aqueduct that transports water to its member cities. CRMWA began blending the groundwater with Lake Meredith water in 2002. Due to the need to replace lost capacity created by Lake Meredith's decline, Phase 3 of the RCWF was constructed and placed into operation in 2011, expanding the total number of wells to 43.

On June 23, 2011, CRMWA signed a contract with Mesa Water to purchase 211,000 additional acres of water rights that are predominately contiguous to the RCWF. According to an internal memorandum[2] prepared by City staff to evaluate the purchase of the Mesa Water rights, the strategic value of this purchase included:

- expansion of the RCWF which is one of Lubbock's key water supplies;
- Mesa's water rights' accessibility to the existing RCWF infrastructure;
- Mesa's water rights' volume of water per surface acre that is at least three times greater than well fields on the South Plains; and
- the high quality of the groundwater in Roberts County.

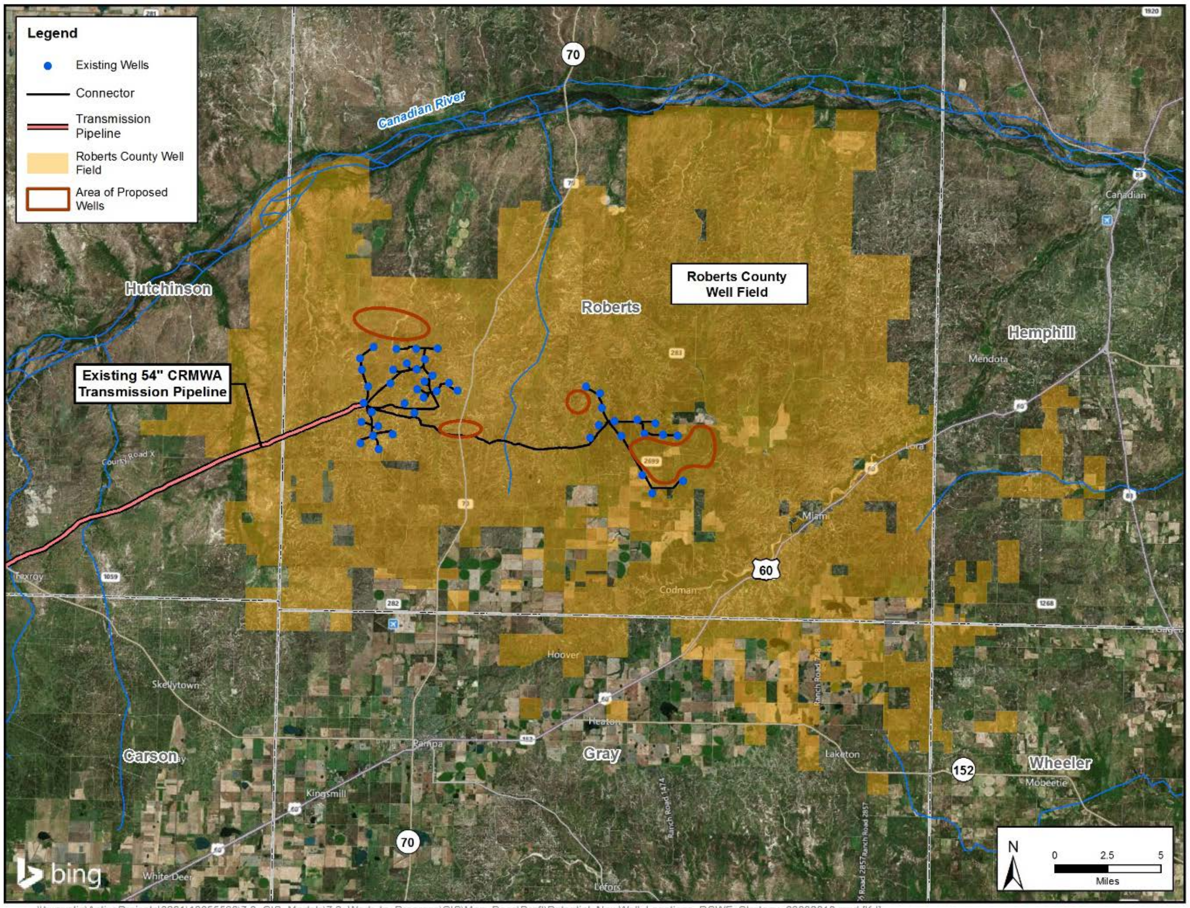
By 2011, CRMWA began supplying its members with 100 percent groundwater when Lake Meredith's water levels declined to a level which precluded releasing water from the lowest gate of the intake structure (Figure 4.4). The layout of the RCWF is depicted in Figure 4.5.

CRMWA's goal is to maintain the peak capacity of the RCWF at 93 million gallons per day (mgd) even though the 54-inch diameter transmission line can only supply approximately 65 mgd. At a 93 mgd peaking capacity, the RCWF can maintain a 70% load factor giving CRMWA the operational flexibility to rotate and rest wells. The current capacity of the RCWF is estimated to be 83.2 mgd. Without capacity maintenance, the well field capacity will continue to decrease over time as regional water levels decline in response to pumping.

In 2018, CRMWA anticipates delivering 25,570 ac-ft/yr of supply from the RCWF to Lubbock. The City anticipates that the 2018 level of supplies from the RCWF will remain constant until 2035 when performance will begin to decline from heavy utilization. Near the end of the century, the source will be exhausted if the well field is not expanded to maintain its capacity.

[2] Evaluation of Mesa Water Rights in Roberts County – Memo, City Staff, August 9, 2011.

Figure 4.5. Roberts County Well Field



\\tx-austin\ActiveProjects\3291\10055566\7.0_GIS_Models\7.2_Work_In_Progress\GIS\Map_Docs\Draft\Potential_NewWell_Locations_RCWF_Strategy_08082018.mxd [KJ]

4.2 Bailey County (Sandhills) Well Field

The BCWF (also called the Sandhills Well Field) is located approximately 60 miles northwest of the City of Lubbock in Bailey and Lamb counties. In 1954, the City purchased the initial 53,910 acres of water rights to create the well field. In 1957, the City's water rights were expanded to 75,041 acres.[3] Today, the current water right holdings for the BCWF are approximately 83,305 acres. Water from the BCWF is pumped from the Ogallala Aquifer from wells constructed mostly in the 1950s and 1960s.[4] The 175 active wells are distributed over approximately 50% of the water rights owned by the City in the well field. Figure 4.6 shows a layout of the BCWF with the associated well locations and collection system. Note that the number of irrigated fields (identifiable in Figure 4.6) surrounding the BCWF indicates extensive agricultural usage of groundwater adjacent to the well field.

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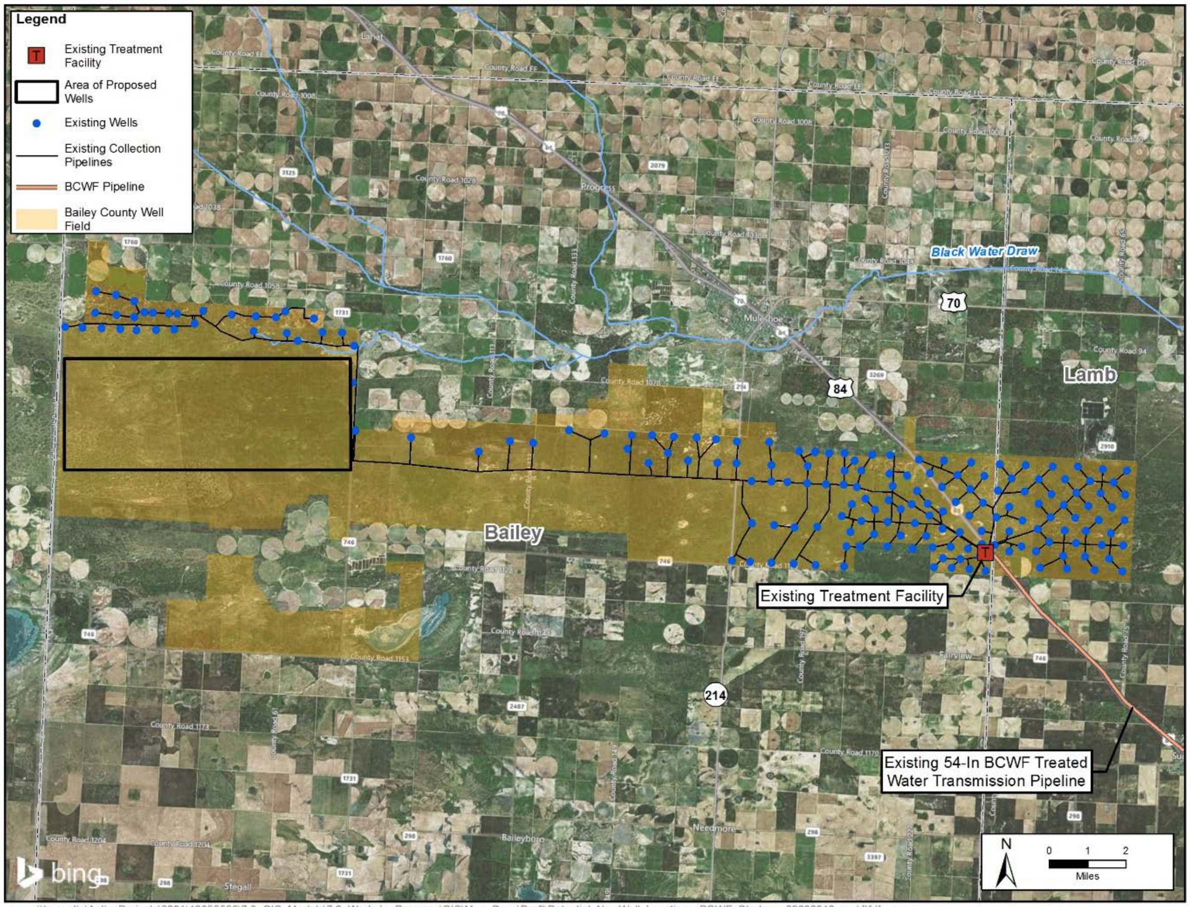
[3] City of Lubbock Water Advisory Commission; Orientation Manual. September 18, 2003.

[4] Comprehensive Ground Water Management Study for the City of Lubbock. Geraghty & Miller, Inc. April 1992: (Vol. 1) 36.

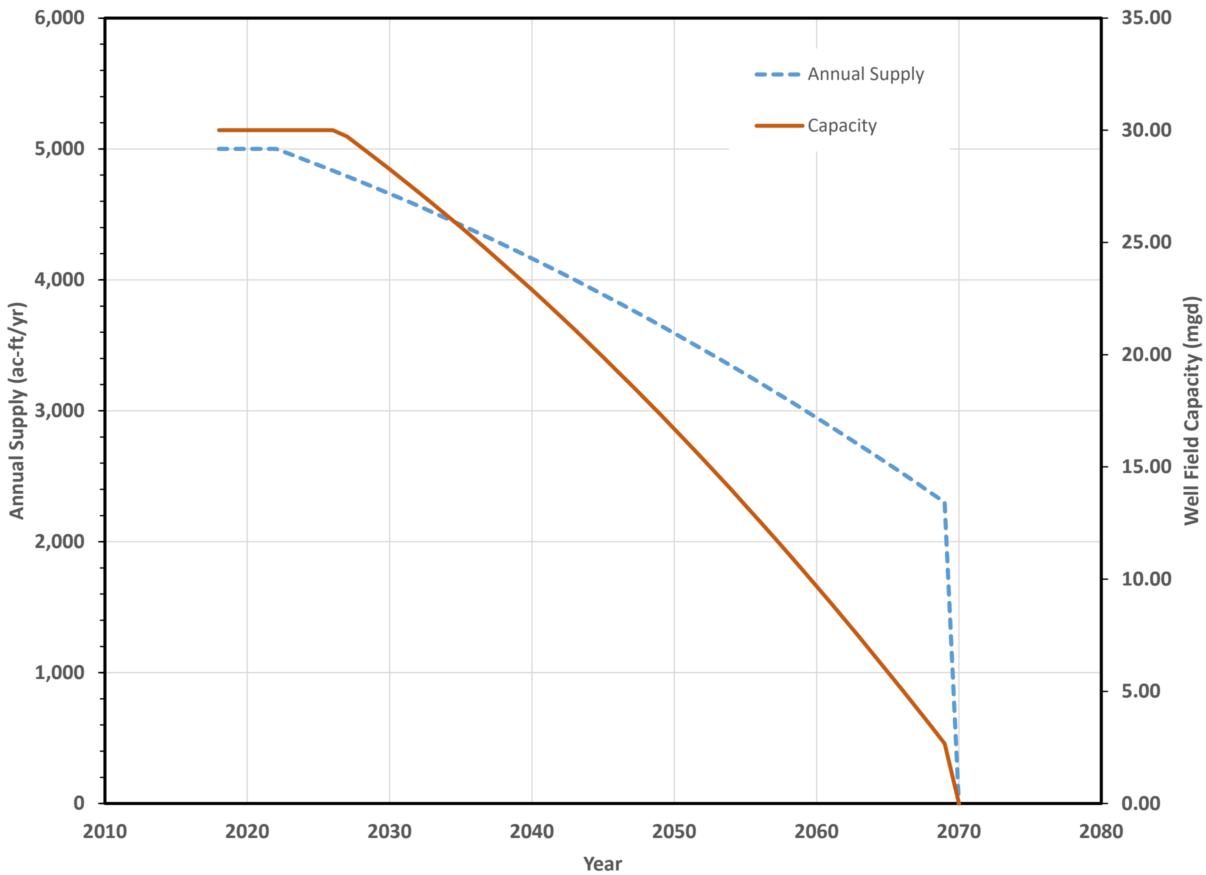
Figure 4.6. Bailey County Well Field



\\tx-austin\ActiveProjects\3291\10055566\7.0_GIS_Models\7.2_Work_In_Progress\GIS\Map_Docs\Draft\Potential_NewWell_Locations_BCWF_Strategy_08082018.mxd [KJ]

The City produced 6,000 ac-ft/yr of groundwater, on average, from 2000 to 2010 from the BCWF. However, with the loss of Lake Meredith as a water supply in 2011, the City was forced to pump 20,630 ac-ft from the BCWF in 2011 and 10,881 ac-ft in 2013. Pumping from the BCWF was less than 8,000 ac-ft/yr in 2014 and 2015, but increased to 11,407 ac-ft in 2016. As a result of this increased pumping, the well field's capacity has dropped below the 38 mgd capacity of the transmission line that transports water from the BCWF to the City. The well field capacity is expected to continue to decrease each year unless additional wells are installed. Figure 4.7 illustrates the projected decrease in the well field's supply and production capacity under an initial annual demand of 5,000 ac-ft/yr without construction of additional wells. As shown in the figure, under a target demand of 5,000 ac-ft/yr, well capacities will continue to decrease as water levels decline. When the production capacity decreases below 2 mgd, the transmission pipeline will not be able to operate effectively and supply from the BCWF will cease. Since the average well production capacity in the well field is 200-250 gallons per minute, a minimum of 28 wells would be required for every additional 10 mgd capacity needed.

Figure 4.7. Projected Supplies from Bailey County Well Field



The goal for this well field is to extend its useful life by limiting its usage to 5,000 ac-ft/yr. This includes a year-round base load supply of 2 mgd (2,240 ac-ft/yr) to maintain continuous operation of the transmission pipeline, with the remainder taken during the summer months to provide peaking supply. Limiting use of the BCWF to meet primarily peaking demands is recommended in a 2012 report completed by Daniel B. Stephens & Associates, Inc.[5]

4.3 Lake Alan Henry

Construction of the John T. Montford Dam was completed in October 1993, creating LAH. The most recent bathymetric survey completed by the Texas Water Development Board (TWDB) in 2017 estimates a storage capacity of 96,239 ac-ft. Results from this survey were released in draft form in the spring of 2018. This is somewhat larger than the previous estimate of 94,808 ac-ft, which was based on a 2005 TWDB survey. The difference is attributable to improved survey techniques in the later survey. The reservoir completely filled for the first time in 2004 and remained near capacity until 2011 when extreme drought conditions began. Over the course of the recent drought, lake level dropped almost 20 ft from the conservation pool level before significant rainfall and flooding refilled the reservoir to its capacity in the summer of 2015. Historic water levels are presented in Figure 4.7.

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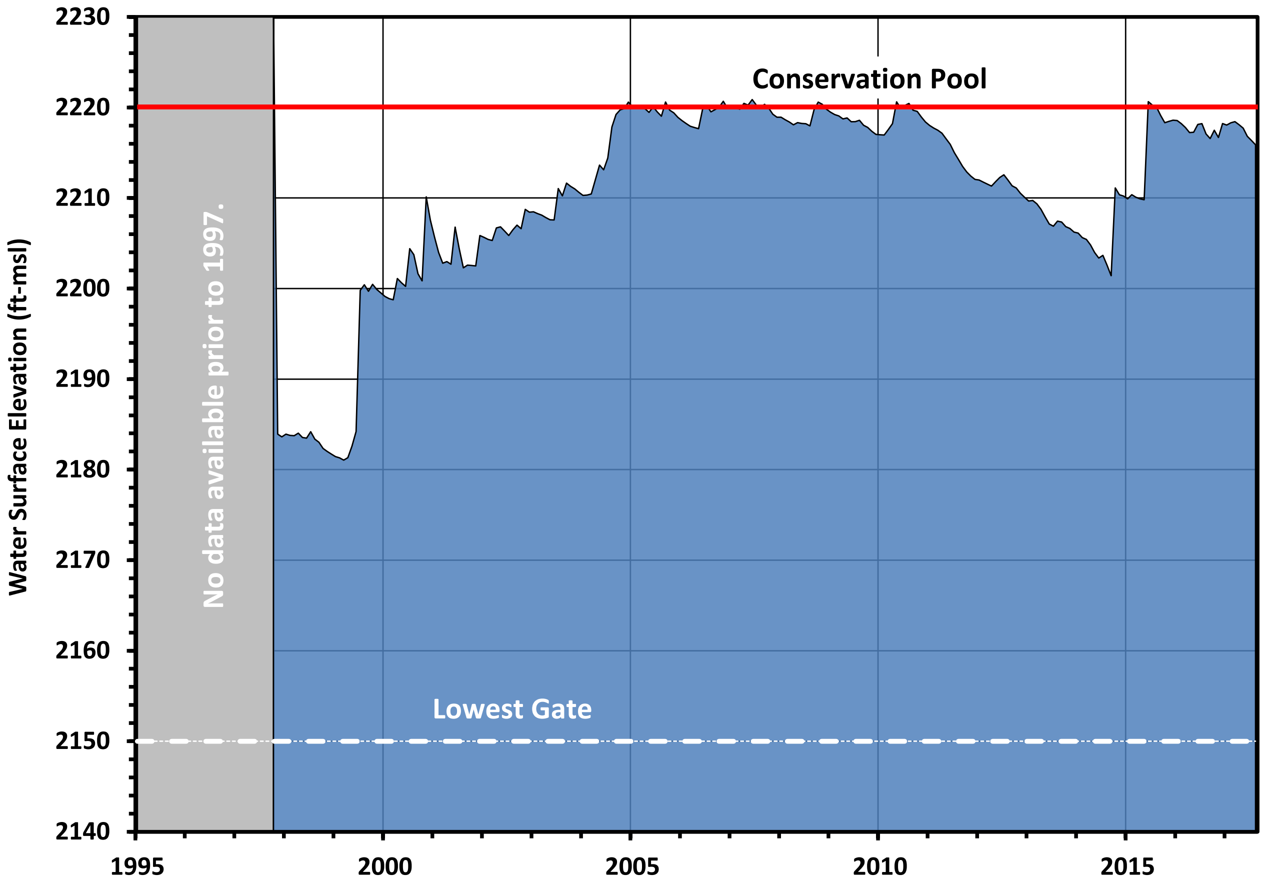
[5] Updated Bailey County Well Field Modeling, Daniel B. Stephens & Associates, Inc. October 2012: 6.

Figure 4.8. Lake Alan Henry Water Levels



During development of the 2018 Strategic Water Supply Plan, the yield of LAH was updated considering the recent and new critical drought of record occurring between 2011 and 2015. The new yield analysis estimates the 2-year safe yield to be 12,875 ac-ft/yr under current (2018) sediment conditions, and 11,375 ac-ft/yr under future (2118) conditions, based on the 2005 TWDB capacity survey.

In 2007, the City began the preliminary engineering for the water supply infrastructure that would deliver treated water from LAH to the City's distribution system. Infrastructure for LAH was designed to be completed in two phases. Phase 1 infrastructure includes two pump stations, 50-miles of raw water pipeline, a water treatment plant, and finished/treated water transmission pipelines connecting to the City's distribution system. Phase 1 was completed in September 2012 with a peak raw water transmission line capacity to the South Water Treatment Plant (SWTP) of 15 mgd and an annual delivery of 8,000 ac-ft. However, the peak supply rate into the distribution system is limited to 10 mgd, based on a limitation in the capacity of the system to integrate increased supplies. Phase 2 of the LAH infrastructure project (described in detail in Section 10.2) would expand the system to a peak capacity of 30 mgd and an annual delivery of 16,000 acft.

Considering the updated 2-year safe yield for current and future conditions is greater than the current delivery infrastructure, the City anticipates that 8,000 ac-ft/yr of supply will be available reliably from LAH throughout the planning horizon.

4.4 Existing Supplies Water Quality

Table 4.1 compares the water quality for each of Lubbock's current water supplies. Overall, Lubbock's sources of water are generally compatible with one another in terms of water quality. The groundwater quality in Roberts County is comparable to the City's groundwater resources in Bailey County and the City's surface water resource at LAH. Lake Meredith water quality has degraded significantly as the lake's volume of water has been depleted over the past decade. In general, the water in the Ogallala Aquifer underlying CRMWA's existing well field in Roberts County becomes saltier with depth. Therefore, total dissolved solids (TDS), chloride, and sodium are higher in the RCWF than the BCWF.

Water quality issues became a concern in Lake Meredith shortly after CRMWA began delivering water to its member cities. In 1969, CRMWA began preparing a plan to address the elevated levels of chlorides in the lake. In 1971, the source of the problem was identified when salt springs along the Canadian River were discovered near Logan, New Mexico. This problem was eventually addressed in 2001 when the Lake Meredith Salinity Control Project was placed into operation to mitigate the salt springs. In addition to salinity, CRMWA also made plans to address the general water quality of the lake. In 2002, water from the RCWF was blended with Lake Meredith at the aqueduct system, improving delivered water quality. In the early 2000s, Lake Meredith's water level began to decline, which led to further water quality issues. Figure 4.9 shows the increasing chloride concentration in the lake as water levels in the reservoir have declined over time. However, the recent inflows that have led to some recovery in water levels have significantly reduced the chloride levels in the lake.

Table 4.1. Water Quality of Lubbock Raw Water Supplies

Selected Water Quality Parameters	Lake Alan Henry[1]	Lake Meredith[2]	BCWF[3]	RCWF[4]
pH	8.0	8.5	7.4	7.7
Total Alkalinity (mg/L)[5]	170	224	157	200
Turbidity (NTU)[6]	1.72	6.1	0.1	0.5
Conductivity (uS/cm)[7]	1490	2835	536	1002
Total Dissolved Solids (mg/L)	777	1429	408	571
Fluoride (mg/L)	1.06	0.51	1.46	0.75
Chloride (mg/L)	291	586	17.5	148
Nitrate (mg/L)	0.114	<0.02	1.52	1.44
Sulfate (mg/L)	125	309	41.5	67.6
Potassium (mg/L)[8]	5.5	8.8	4.7	5.5
Sodium (mg/L)[8]	248	499	32.9	199
Calcium (mg/L)[8]	31.4	74.6	53.4	47.6
Magnesium (mg/L)[8]	11.9	41.5	17.9	25.5

1. Analytical results extracted from the City of Lubbock's 2017 water quality compliance monitoring.
2. Analytical results provided by Rod Goodwin, Canadian River Municipal Water Authority. Sample collected from intake tower May 2018.
3. Analytical results extracted from the City of Lubbock's 2017 water quality compliance monitoring.
4. Analytical results provided by Rod Goodwin, Canadian River Municipal Water Authority. Composite sample for all Phases collected May 2018.
5. mg/L = milligrams per liter
6. NTU = Nephelometric Turbidity Units
7. μS/cm = microSiemens per centimeter
8. Bailey County Well Field minerals results extracted from the City of Lubbock's water quality compliance monitoring.

Figure 4.9. Lake Meredith Chloride Concentration

4.5 Current Water Supply Capacity

In order to evaluate the amount of water that Lubbock can supply to its customers, the existing water system infrastructure capacity must be evaluated. Figure 4.10 shows Lubbock's current water sources and supply infrastructure with the corresponding capacity or firm supply from each. As the City adds new water supplies and increases the amount of water being delivered, improvements to the supply and distribution system will be necessary.

Current peak-day supply projections were developed for each of the City's water supply sources as described below. These peak-day supply projections represent the supply capabilities of the City's existing water sources with no expansion or maintenance over the 100-year planning period.

Lake Alan Henry – The current transmission line and pump stations from LAH were constructed to deliver 15 mgd to the SWTP. However, the SWTP capacity of 12.5 mgd sets the maximum peak-day capacity that can be delivered to the City's distribution system from LAH. Because of hydraulic limitations in the City's water distribution system, only 10 mgd can actually be pumped into the system until system improvements are implemented.

CRMWA Supplies – Water supplies from Lake Meredith are delivered through a 148 mile aqueduct system (CRMWA Aqueduct). Supplies from the RCWF are delivered through a 54-

inch transmission line that discharges into the CRMWA Aqueduct near Amarillo. The RCWF pipeline has a peak capacity of 65 mgd, of which Lubbock's share is 24 mgd. The capacity of the aqueduct after the RCWF supplies enter the system is 103 mgd, with Lubbock having a share of 38 mgd. The capacity of the system is reduced to 53 mgd between Amarillo's delivery point and the Lubbock Regulating Reservoir, with Lubbock holding a 42 mgd portion.

Bailey County Well Field – The 54-inch transmission line from the BCWF to Lubbock has a maximum capacity of 38 mgd. However, due to heavy utilization, the BCWF has a production capacity of only 30 mgd. The BCWF will continue to decline in capacity until the well field is exhausted in 2073.

The total terminal storage reservoir capacities associated with the North Water Treatment Plant (NWTP) and SWTP are not included in the water supply capacity estimates because they are reserved for emergency situations only. During an emergency situation, Lubbock has 615 million gallons of storage when the terminal storage reservoirs are full (see Figure 4.10). This would be an equivalent of almost 8 days of water supply at a peak demand of 78 mgd.

Lubbock's raw water supplies are treated at one of three treatment facilities before entering into the City's distribution system. These treatment facilities include the BCWF chlorination facility, the NWTP, and the SWTP. The NWTP has excess capacity to treat and deliver additional water into the distribution system. However, the SWTP does not have any additional capacity, although current plans are to re-rate and increase the rated capacity of the treatment plant based upon recent analyses. LAH Phase 1 can deliver up to 10 mgd of treated water to Pump Stations 8, 10, and 14. These pump stations are operating at maximum capacity; therefore, additional quantities of water delivered to the SWTP for treatment will need to be routed to a different pump station, such as PS 7. Figure 4.11 provides the locations of the SWTP, existing pump stations, and a proposed pump station and 4.5-mile, 30-inch connection from Pump Station 14 to Pump Station 16 (formerly Pump Station 7), also known as the Low Head C Transmission Line. The proposed connection is represented by the solid yellow line in the figure. Several of the water supply strategies in this Plan include the cost of the connection between Pump Station 14 and Pump Station 16 to allow for the additional water to be treated and transported from the SWTP into the distribution system.

Currently, treated water from the BCWF is transported to Lubbock and enters the distribution system at either Pump Station 9 or Pump Station 16 (formerly Pump Station 7).

Figure 4.10. Current Water Supply Capacity Schematic

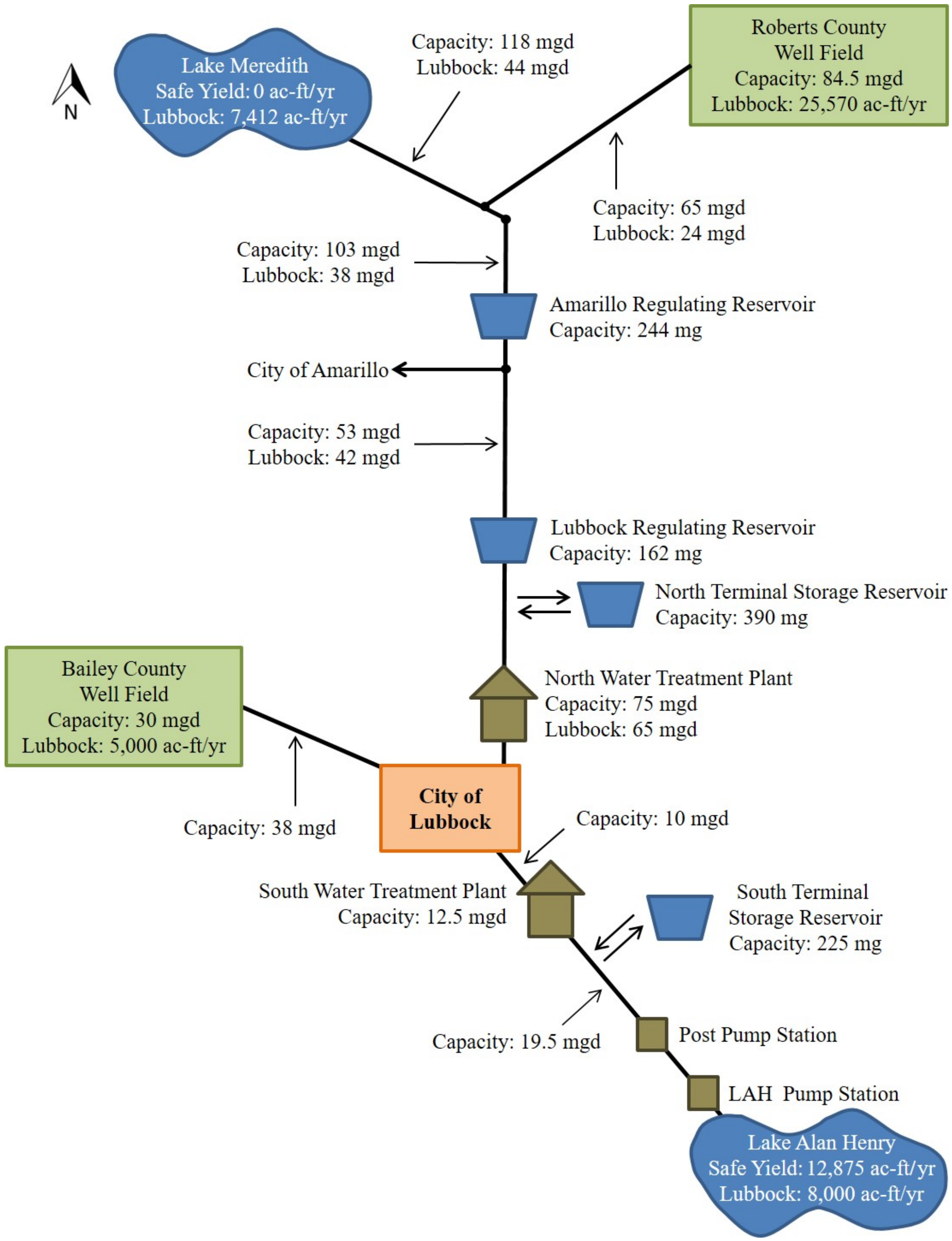
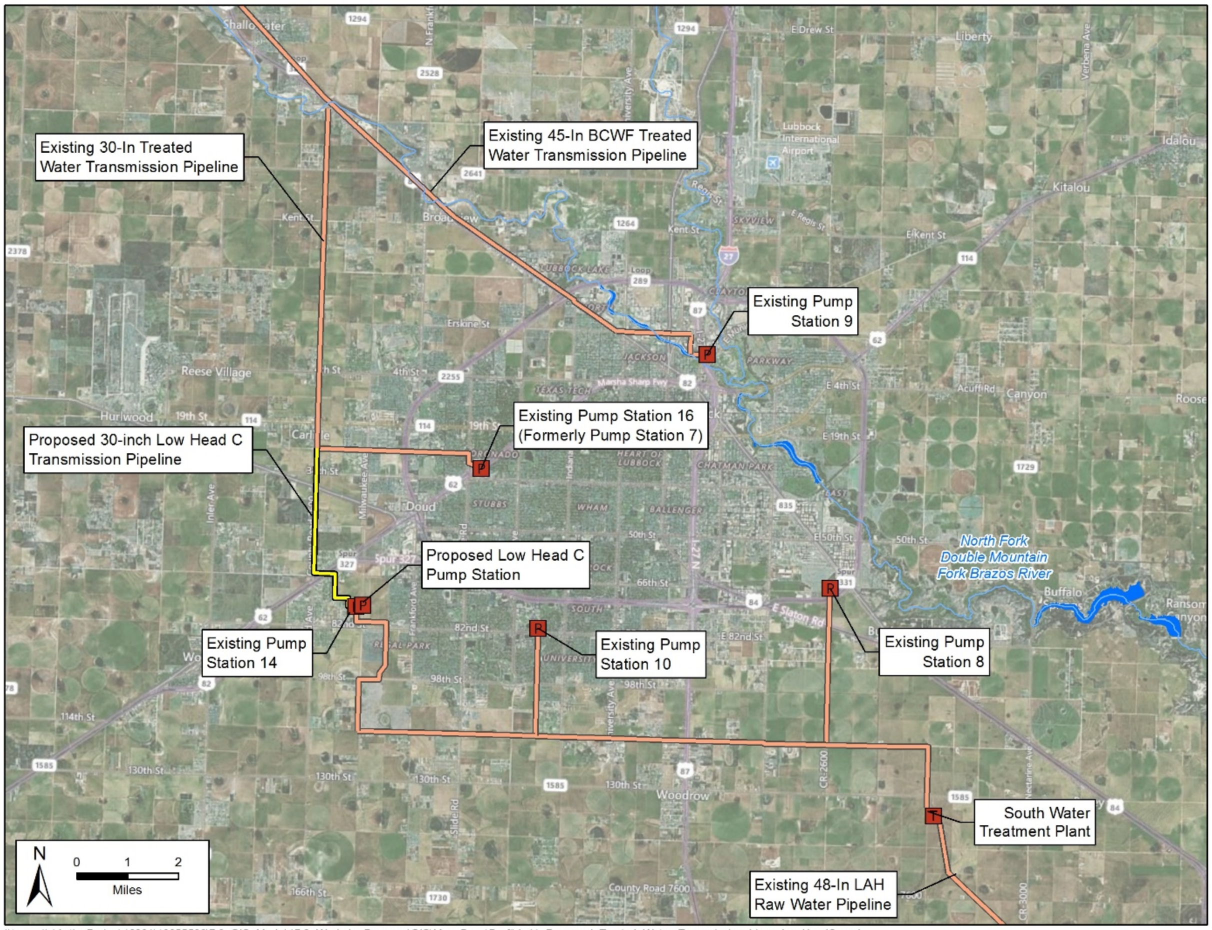


Figure 4.11. Proposed Low Head C Transmission Line



\\tx-austin\ActiveProjects\3291\10055566\7.0_GIS_Models\7.2_Work_In_Progress\GIS\Map_Docs\Draft\4_11_Proposed_Treated_Water_Transmission_Lines_LowHeadC.mxd

5 Water Needs

This section compares Lubbock's future water supply and capacity needs resulting from growth in population and water demands that were presented in Section 2 to the projected supplies from existing sources presented in Section 4. Future water supply and capacity needs (or shortages) are considered to be the difference between future demands and available supplies or capacities. Projected available supplies and capacities are based on a "do nothing" scenario where the City of Lubbock (City) does not maintain the current water supply capacities by adding additional wells or other infrastructure.

Water supply strategies must be evaluated, recommended, and implemented to meet the City's future water needs. Evaluations of several water supply strategies are documented in Sections 6-10. These strategies are grouped into four main categories: water conservation, reclaimed water, groundwater, aquifer storage and recovery (ASR), and surface water. A scoring and ranking of the alternatives is presented in Section 12. Five alternative water supply package of various strategies that can meet Lubbock's future water needs have been formulated and are presented in Section 13.

5.1 Water Supply Needs

Needs are presented for the three demand scenarios presented in Section 2 and visually illustrated in Figure 5.1. Table 5.1 provides a decadal summary of projected demands, current supplies, and expected surplus or need of annual supplies for Lubbock throughout the 100-year planning period. For the expected demand scenario, the City is expected to need additional supplies now, should a severe drought occur and demands not be mitigated by aggressive conservation measures. Assuming continued conservation demand levels, the City is not expected to have a water supply need until around 2030. As Lubbock's population and water demands grow and the performance of its current supplies declines over time, the expected water supply needs will increase. By the end of the 100-year planning period, Lubbock's water supply needs are expected to range between about 40,000 acre-feet per year (ac-ft/yr) to 60,500 ac-ft/yr, depending on the demand scenario.

Figure 5.1. Comparison of Annual Water Supply and Demands

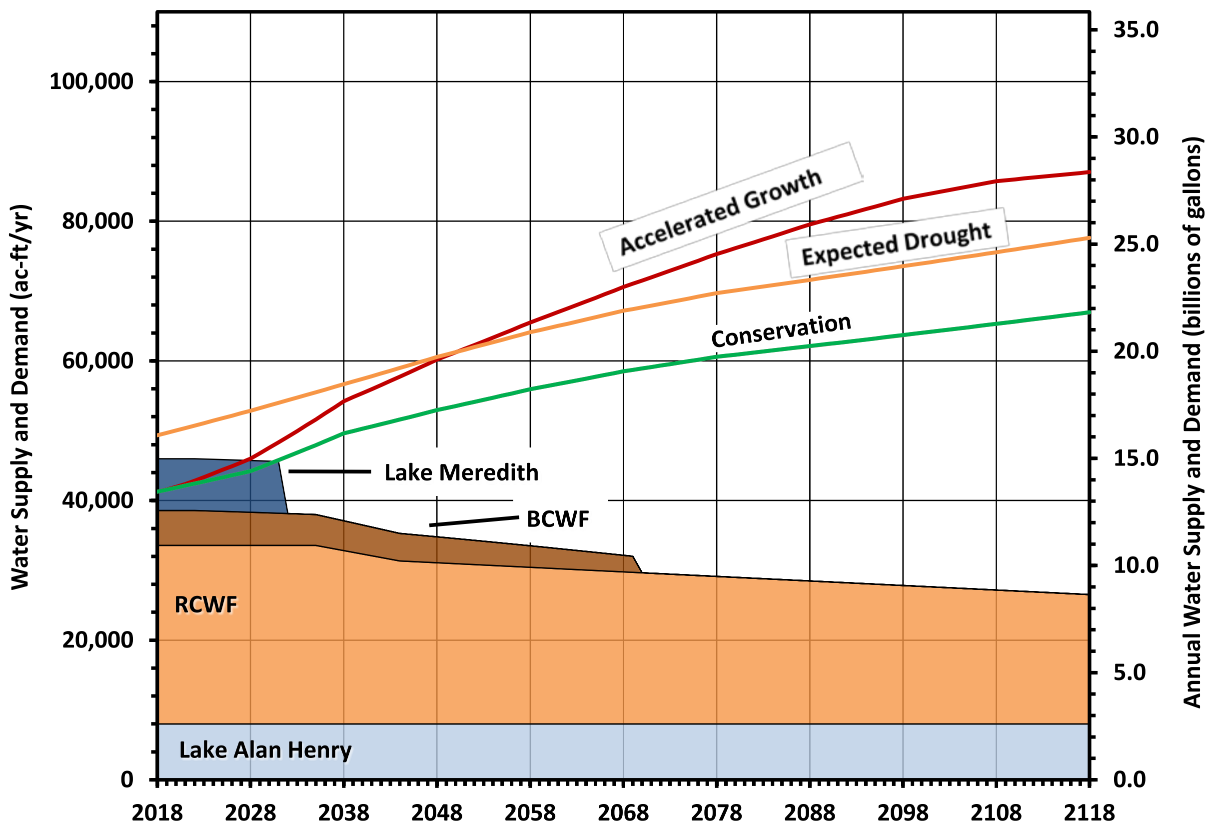


Table 5.1. Decadal Summary of Annual Demands, Supplies and Needs

Demands, Supplies and Needs	2018	2038	2058	2078	2098	2118
Projected Demands (ac-ft/yr)						
Conservation Demands	41,266	49,624	55,929	60,580	63,687	66,954
Expected Drought Demands	49,344	56,664	64,108	69,703	73,558	77,625
Accelerated Growth Demands	41,266	54,228	65,508	75,311	83,211	87,044
Current Supplies (ac-ft/yr)						
Lake Meredith	7,412	0	0	0	0	0
Bailey County Well Field	5,000	4,268	3,082	0	0	0
Roberts County Well Field	25,570	24,829	22,437	21,130	19,830	18,530
Lake Alan Henry	8,000	8,000	8,000	8,000	8,000	8,000
Total Current Supply	**45,982**	**37,097**	**33,519**	**29,130**	**27,830**	**26,530**
Surplus/(Need) (ac-ft/yr)						
Conservation Demands	4,716	(12,527)	(22,410)	(31,450)	(35,857)	(40,424)
Expected Demands	(3,362)	(19,567)	(30,588)	(40,573)	(45,728)	(51,095)
Accelerated Demands	4,716	(17,131)	(31,988)	(46,181)	(55,381)	(60,514)

5.2 Water System Capacity Needs

In addition to meeting the Annual Water Demands (AWDs), the supply system must be capable of supplying water at Peak Day Demand (PDD) rates. In 2018, Lubbock's water supply is expected to be capable of delivering a maximum peak day supply of 74 million gallons per day (mgd). The current water supply peak day projections for the next 100 years are summarized with respect to the three PDD scenarios in Figure 5.2 and Table 5.2. Development of the projected PDD scenarios is discussed in Section 2.

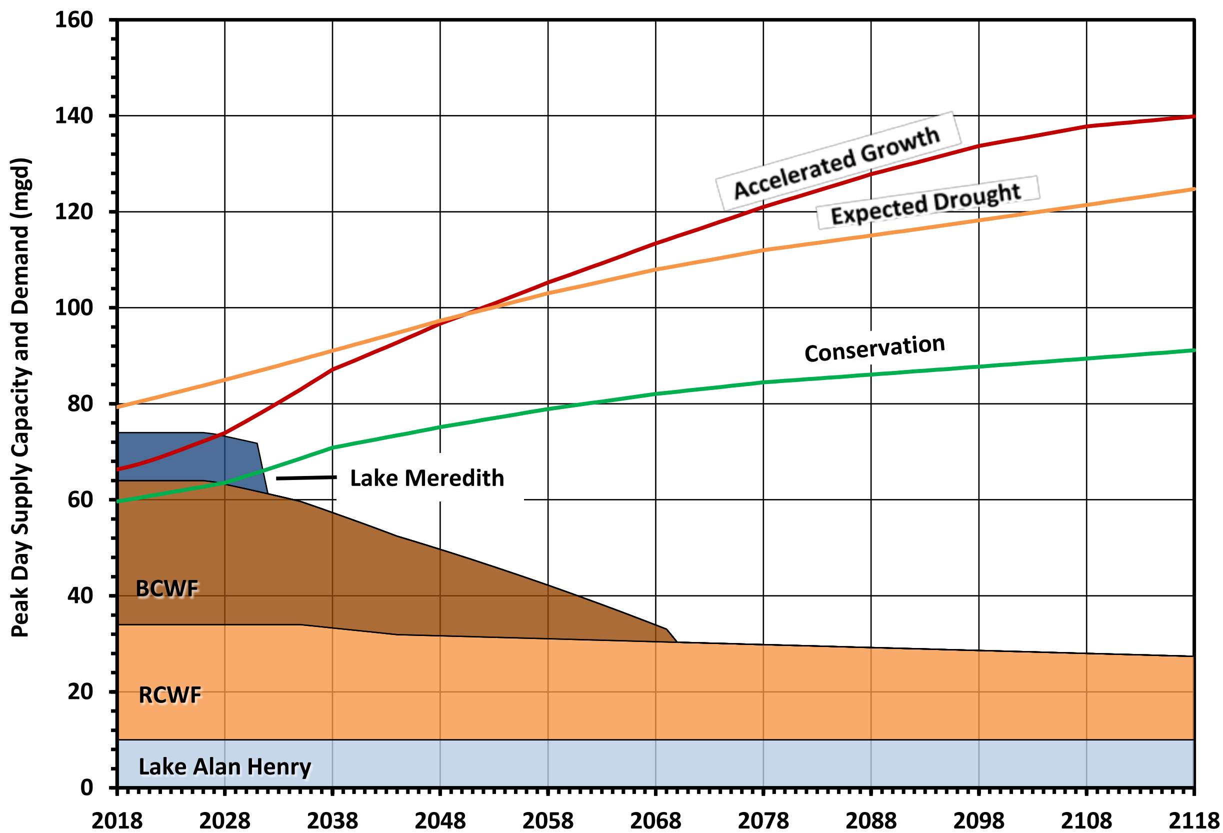
The current system lacks the capacity to meet PDDs under the expected demand scenario, which does not include any conservation efforts under the PDDs. Assuming that current conservation efforts will continue to reduce PDDs, the City will not need additional capacity to meet PDDs until about 2029 under the Accelerated Growth demand projection, and about 2033 under the Conservation demand projection. By the end of the 100-year planning period, the capacity of the system is expected to have a deficit in meeting PDDs ranging between 63.8 mgd and 112.5 mgd, depending on the demand scenario.

Table 5.2. Decadal Summary of Peak Day Demands, Supplies and Needs

Supplies, Demands, and Needs	2018	2038	2058	2078	2098	2118
Projected Demands (mgd)						
Conservation Demands	59.6	70.9	78.9	84.5	87.7	91.1
Expected Drought Demands	79.3	91.1	103.0	112.0	118.2	124.7
Accelerated Growth Demands	66.3	87.1	105.3	121.0	133.7	139.9
Current Supply Capacity (mgd)						
Lake Meredith (Lubbock's portion)[1]	10.0	0.0	0.0	0.0	0.0	0.0
Roberts County Well Field (Lubbock's portion)	24.0	23.30	21.06	19.83	18.61	17.39
Bailey County Well Field[2]	30.0	24.03	11.15	0.0	0.0	0.0
Lake Alan Henry[3]	10.0	10.0	10.0	10.0	10.0	10.0
Total Current Supply	74.0	57.33	42.21	29.83	28.61	27.39
Surplus/(Need) (mgd)						
Conservation Demands	14.4	(13.5)	(36.7)	(54.6)	(59.1)	(63.8)
Expected Demands	(5.3)	(33.7)	(60.8)	(82.2)	(89.6)	(97.4)
Accelerated Demands	7.69	(29.8)	(63.1)	(91.2)	(105.1)	(112.5)

1. Due to susceptibility to drought, the supplies from Lake Meredith are considered to be temporary and subject to interruption.
2. The current well field capacity of the Bailey County Well Field is 30 mgd, less than the 38 mgd capacity of the transmission line.
3. While the capacity of the South Water Treatment Plant is 12.5 mgd, hydraulic constraints within the water distribution system limit supplies from Lake Alan Henry to 10 mgd.

Figure 5.2. Comparison of Peak Day Capacity and Demands



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6 Water Conservation Strategies

Water conservation can be defined as a beneficial reduction in water loss, water use, or water waste.[1] A reduction in water use can be accomplished by implementing water conservation or water efficiency measures.

A *water conservation measure* is an action, behavioral change, device, technology, or improved design or process implemented to reduce water loss, waste, or use.

Water efficiency is application of a water conservation practice that results in more efficient water use and reduces water demand. The value and cost-effectiveness of a water efficiency measure should be evaluated in relation to its effects on the use and cost of other natural resources (e.g. energy or chemicals).

Water conservation is the "least expensive supply of water" that can be developed since it represents a water savings of existing water supplies. In addition, water conservation can effectively delay expensive water supply projects and reduce Peak Day Demand (PDD) impacts during the summer months. In this section, the City of Lubbock's (City's) current conservation efforts are discussed along with other potential future conservation strategies. Each water conservation strategy presented in this section is not ranked against other water supply strategies in this Plan because it is difficult to accurately quantify the full impact of conservation efforts. However, all of the strategies as a combined package are compared to the other water supply strategies as a point of reference.

In February 2013, the City adopted the 2013 Strategic Water Supply Plan (SWSP). As part of that plan, several water conservation options were included and evaluated. In November 2013, Alan Plummer Associates Inc., (APAI) completed a technical memorandum,[2] which further examined the effectiveness of those options. The City of Lubbock has since implemented some of the options identified in the APAI memorandum. The current water conservation actions implemented by the City are summarized in Section 6.4, 6.6 and 6.7. In 2016, the City engaged APAI to provide an updated memorandum that examined additional conservation strategies selected after a public involvement process.[3] These additional conservation strategies are summarized in Section 6.8.

6.1 Overall Water Conservation Trends

Lubbock's overall water conservation (combined indoor and outdoor) can be quantified by calculating the change in per capita potable water consumption (that is, gallons per capita per day [gpcd]) from year to year before and after implementation of water conservation measures.

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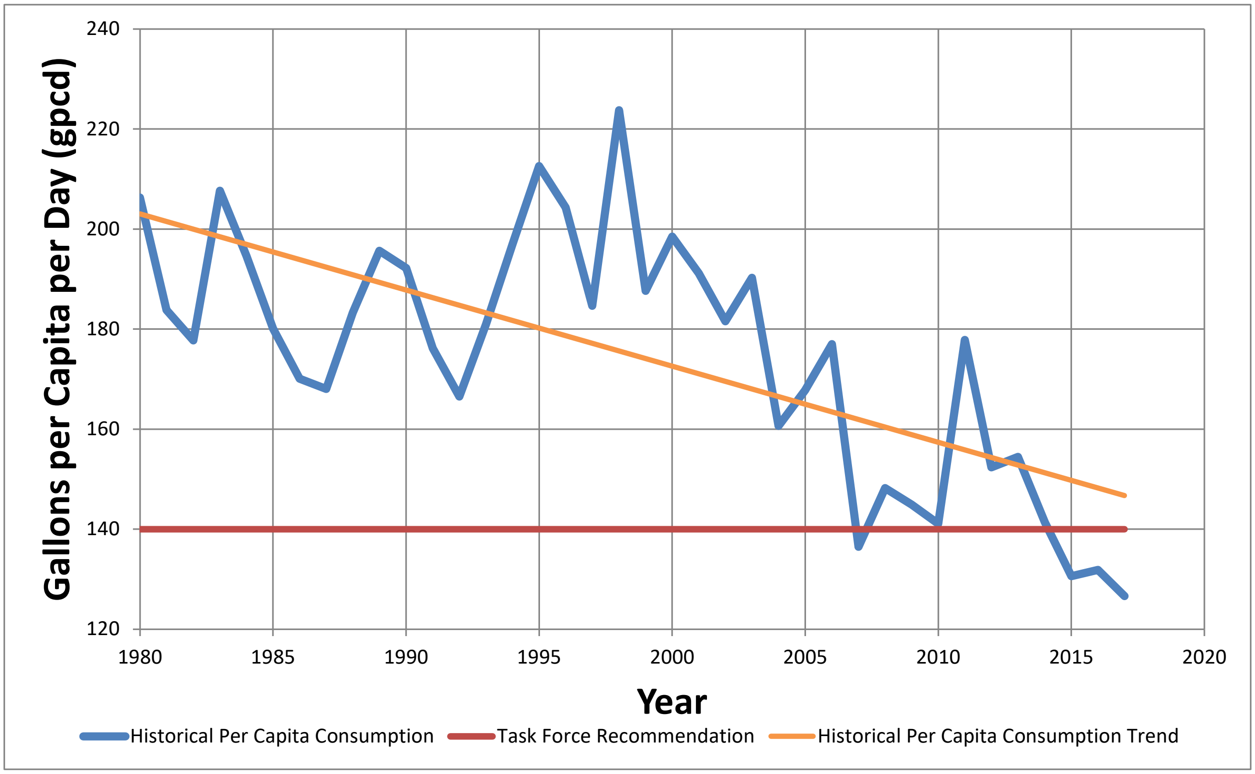
[1] Conservation also includes the preservation of water quality.

[2] Alan Plummer, Inc. City of Lubbock Water Conservation Planning and Strategy Evaluation – Technical Memorandum, November 22, 2013.

[3] Alan Plummer Inc., City of Lubbock Water Conservation Program Development – Technical Memorandum, August 31, 2016.

The City's per capita consumption has declined gradually over the past 36 years, with an approximate 34% reduction from 1980 to 2016 as depicted in Figure 6.1 (see Appendix A.1).

Figure 6.1. Lubbock's Historic Per Capita Water Consumption



The Texas Commission on Environmental Quality (TCEQ) rules[4] require water conservation plans to contain specific, quantifiable five- and ten-year goals. In accordance with TCEQ rules, the City's Water Use Management Plan adopted by City Council on December 18, 2014 set a per capita goal of 150 gpcd for year 2019 and a goal of 147 gpcd for year 2024. The State of Texas Water Conservation Task Force, developed by the 78th Texas Legislature to realize water conservation's full potential, has recommended that cities seek to achieve a per capita consumption of 140 gpcd.[5]

Based on a comparison of the Expected Consumption and the Conservation Consumption projections shown in Section 2.2, continued conservation, such as that outlined in Section 6.8, could reduce the per capita demand for the City by 21 gpcd by 2035 (see Figure 6.2). This translates into a reduction in water demand of 7,564 acre-feet (ac-ft) in 2035, or almost 14% when compared to the Expected Water Demand. By achieving this reduction, some water supply projects could be delayed as much as 20 years.

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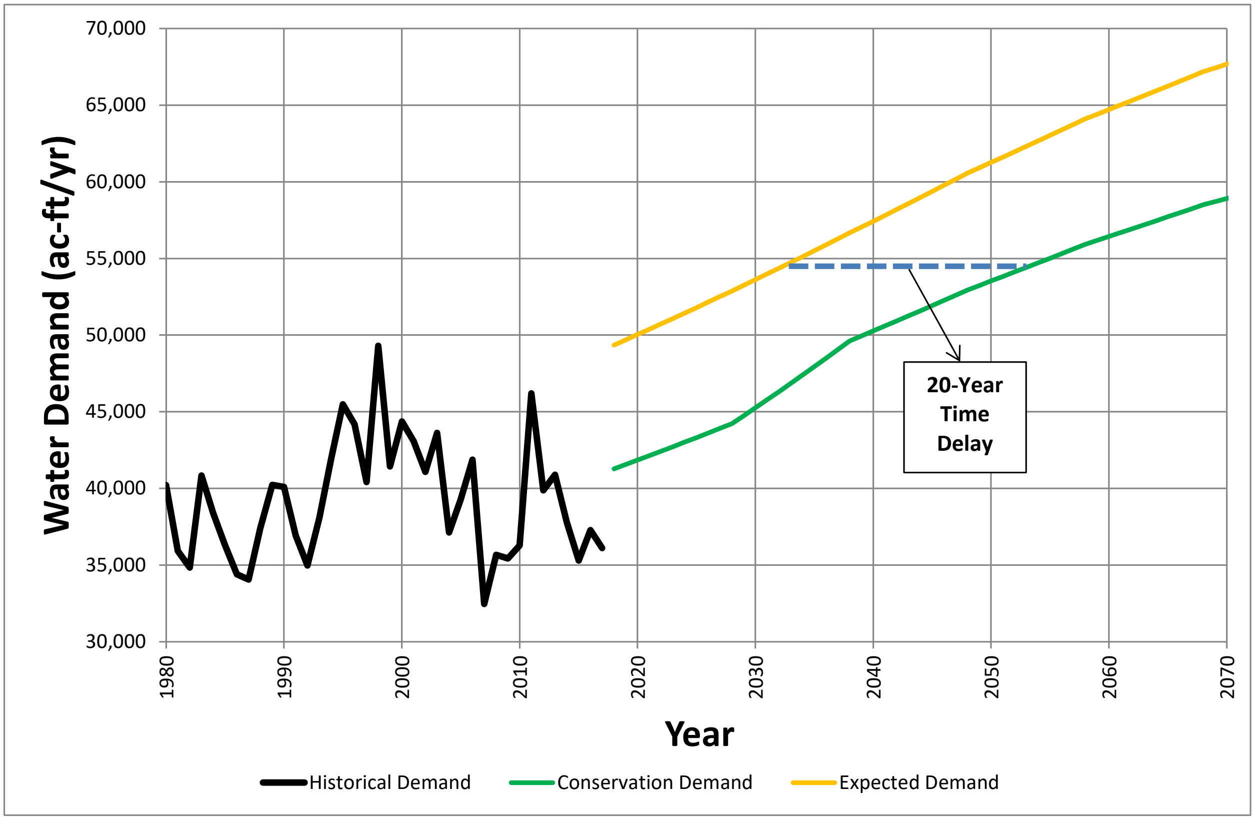
[4] Texas Administrative Code. Title 30; Part 1; Chapter 288; Subchapter A; Rule 288.2; section (a); subsection (1) (C).

[5] Texas Water Development Board Special Report: Report to the 79th Legislature. Water Conservation Implementation Task Force. Austin, TX. 2004: 31-33.

Figure 6.2. Time Delay in Expected Demand vs. Conservation Demand



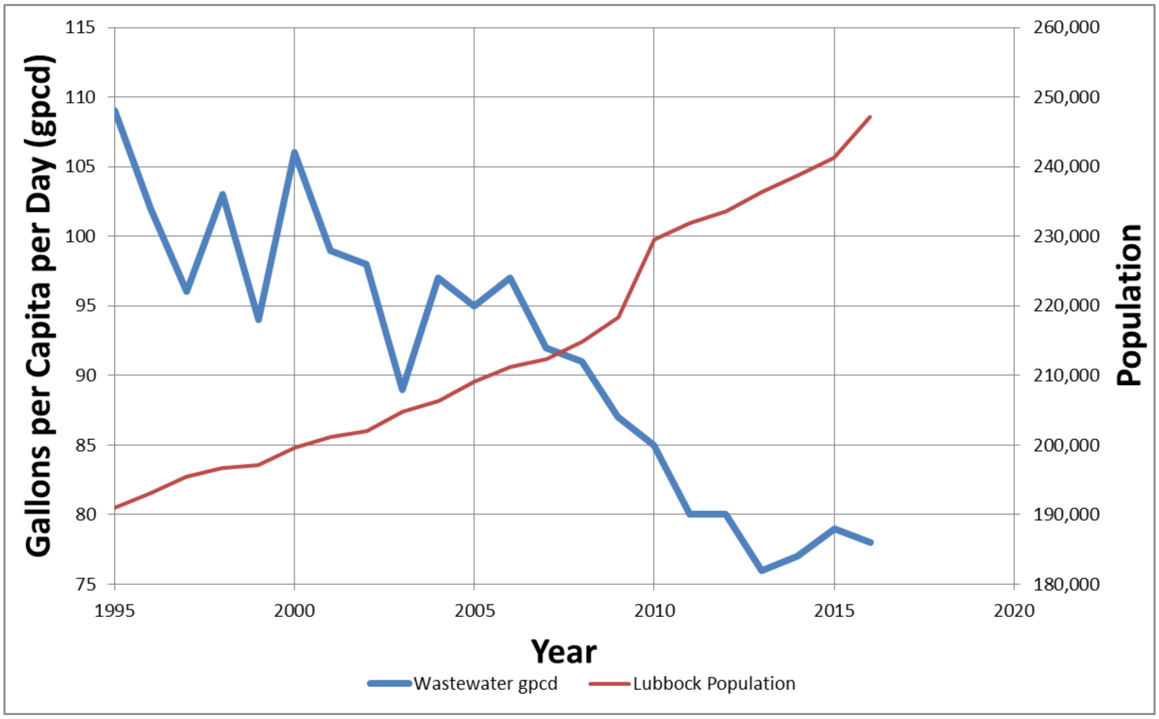
To continue to achieve its water conservation goals, the City must continue to facilitate and support cost effective measures that reduce residential and commercial water use year round. Much of the water conservation achieved thus far can be attributed to the implementation of a conservation rate structure, conservation education, and water conservation ordinances.

6.2 Indoor Water Conservation Trends

Wastewater usage trends provide insight into the amount of indoor water conservation that is occurring. Figure 6.3 reveals that the City has experienced a long history of indoor water conservation, presumably due to more efficient residential and commercial plumbing fixtures as well as reduced potable water usage in industrial processes and commercial ventures such as restaurants.

Figure 6.3 shows that the wastewater per capita use decreased by 28% from 1995 to 2016 while the population served has increased by 29% over the same time period.

Figure 6.3. Per Capita Wastewater Usage and Population



Much of the indoor water savings has been driven by State of Texas legislative actions. The State acknowledged the need for indoor water conservation in 1991 when the Texas Legislature passed the Water Saving Performance Standards (Senate Bill 587), placing stringent water-use standards on indoor plumbing equipment.[6] Toilets sold in Texas prior to January 1, 1992 used between 3.0 to 8.0 gallons per flush (gpf), whereas toilets installed after January 1, 1992 were required to use 1.6 gpf or less.[7] This legislation also set standards for urinals (1.0 gpf), faucets (2.2 gallons per minute [gpm]), and showerheads (2.5 gpm). The 2016 Llano Estacado (Region O) Plan estimated that the City of Lubbock could conserve up to 3,382 ac-ft (or a reduction of 8 gpcd) by 2017 simply with these new indoor plumbing standards.[8] Subsequently, the State passed House Bill 2667 which took effect in 2014 and raised the standards by requiring that toilets sold in Texas must be high-efficiency toilets (HET) that use 1.28 gpf or less.

These state initiatives support the findings from an American Water Works Association (AWWA) study from 1999 which showed that the main water using fixtures related to average household indoor water usage are toilets, washing machines, and showerheads (as shown in

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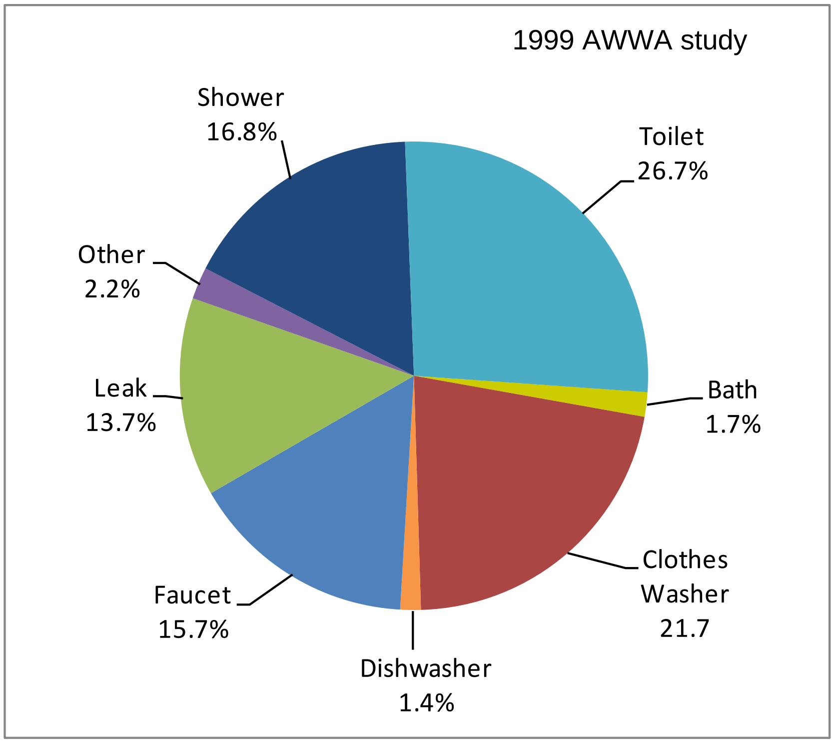
[6] State of Texas Health and Safety Code; Water Saving Performance Standards. Section 372.002.

[7] Waskom, R. and M. Neibauer. "Water Conservation In and Around the Home." Colorado State University; Consumer Series, Housing: Fact Sheet No. 9.952. 2010: 1.

[8] 2016 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. December 2015: 5-72.

Figure 6.4). The greatest potential for indoor water conservation savings exists by addressing water use associated with these fixtures.

Figure 6.4. Average Household Indoor Water Usage[9]



6.3 Current Conservation Rate Structure

Prior to 1991, the City used a decreasing water block rate structure. This meant that the cost of water per 1,000 gallons decreased as a customer used more. In 1991, the City changed the decreasing block rate to a uniform rate where the customer paid the same rate regardless of the volume used. In 2007, the City implemented an increasing block, or conservation, rate structure with a unique average winter consumption (AWC) calculated for each residential customer annually which determined the cost and rate ranges for each of the three blocks. The first conservation block rate structure began approximately 10 years ago. Water usage data during this period suggests that the conservation rate structure contributed to the decline in the City's per capita consumption.

In 2017, the City's rate consultant, NewGen Strategies, evaluated the effectiveness of the City's existing water rate structure. A modified block rate structure that continues to encourage conservation was recommended for City Council consideration and approval. The new structure eliminated the annual residential AWC calculation and established four block rates rather than three block rates for residential customers. The new rate structure was

[9] Mayer, P.W., W.B. DeOreo, E.M. Opitz, J.C. Kiefer, W.Y. Davis, B. Dziegielewski, and J.O. Nelson. Residential End Uses of Water. AWWA Research Foundation and American Water Works Association. 1999: ES 6.

implemented in December 2017. The current structure encourages customers to use their water more efficiently by charging higher rates for the higher volumes of water used. See Table 6.1 for Lubbock's current residential volume block rates. Additional details regarding Lubbock's current and historic water rates are located in Appendix C.1.

Table 6.1. Lubbock's Current Water Rate Structure

Monthly Rate per 1,000 Gallons	0 to 1,000 gallons	1,001 to 5,000 gallons	5,001 to 10,000 gallons	10,001 to 30,000 gallons	30,001 gallons and over
Single Family Residential	$18.00 base rate	$4.03	$6.97	$8.36	$8.57

Monthly Rate per 1,000 Gallons	Block 1 0 to AWC	Block 2 AWC to 150% of AWC	Block 3 150% of AWC and over
Multi-Family & Commercial	$4.76	$6.50	$7.79

The City of Lubbock's rate structure attempts to optimize three competing goals that all water systems must seek to balance. These goals are revenue stability, water conservation, and affordability.

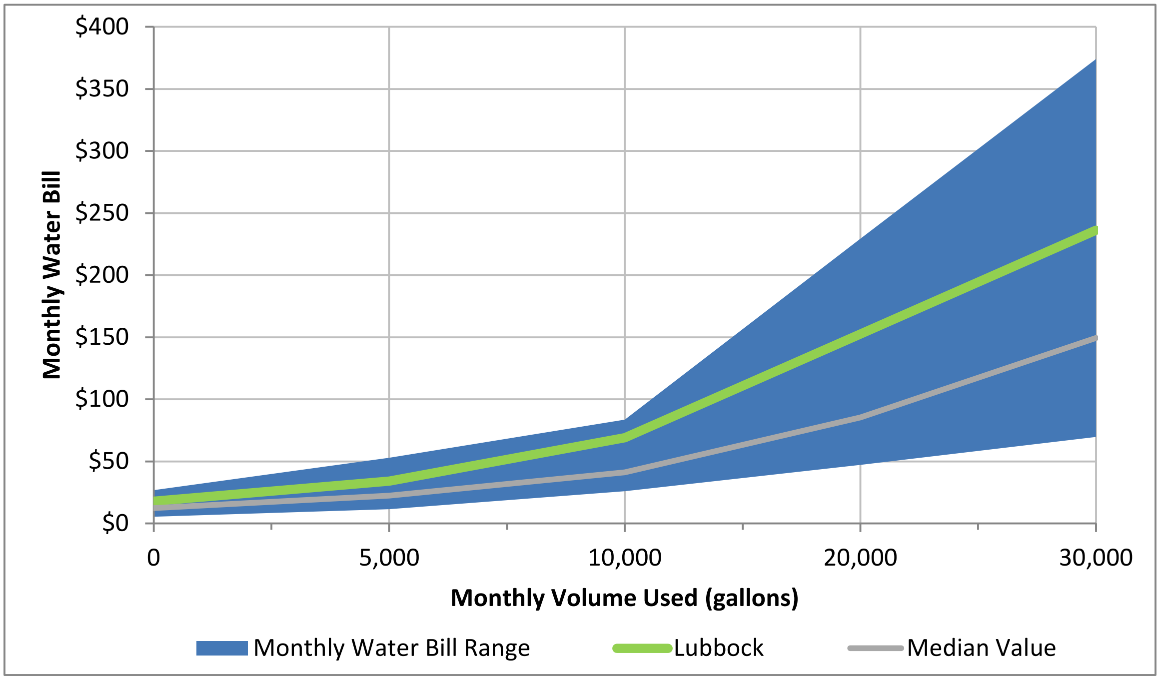
- **Revenue stability** is strengthened by covering a portion of the City's debt through the base rate.
- **Water conservation** is facilitated through an increasing volume block rate structure.
- **Affordability** is addressed by seeking to set base charges and Block 1 volume rates at reasonable levels.

Overall, Lubbock's water rates have encouraged customers to conserve and use water more efficiently. However, when certain drought triggers are met, Lubbock's Drought and Emergency Contingency Plan requires additional short-term conservation measures to be implemented.

Figure 6.5 compares the City's water rates to those of 16 other major Texas cities with populations over 150,000, as of May 2018 (see Appendix C.2). The monthly water bills used in this comparison include the base charge, volume charges, and water supply fees (if applicable). The following cities were used in the comparison:

Amarillo	Arlington	Austin	Brownsville
Corpus Christi	Dallas	El Paso	Fort Worth
Garland	Grand Prairie	Houston	Irving
Laredo	Pasadena	Plano	San Antonio

Figure 6.5. 2018 Residential Water Bill Comparison for Major Texas Cities



(Rates shown are for 5/8″ and/or 3/4″ meters as of May 2018.)

6.4 Water Use Management Plan

The City's Water Use Management Plan consists of a Water Conservation Plan and a Drought and Emergency Contingency Plan.

In July 1991, the City of Lubbock adopted its first Water Conservation and Drought Contingency Plans. The original water conservation goal was to reduce the overall water usage by 9.5 gpcd, which was five percent of the water demand. The first plan outlined eight principal water conservation methods: public education and information, plumbing codes, efficiency retrofit programs, universal metering and meter repair, water conservation landscaping, leak detection and repair, recycling and reuse, and non-declining block rate structure. The City subsequently updated the Water Use Management Plan in August 1999, June 2002, April 2004, July 2006, July 2010, March 2012, December 2014, and January 2017.

In 2006, the City moved into Stage 1 of its Drought and Emergency Contingency plan for the first time. During the severe drought in 2012, the City moved into Stage 2 in an effort to reduce water demand until Lake Alan Henry (LAH) was capable of delivering water to the City later that same year. At the same time, the City designated specific days that a customer could irrigate landscaping based on the last digit of their address. The City continued to be in at least Stage 1 of its drought restrictions without interruption from 2006 to 2016. Trends in per capita consumption and overall water usage during this period indicate that the drought restrictions were effective in reducing the City's PPD during the summer months as well as the overall annual water usage. The reduction in water demand has allowed the City to delay construction of major, costly water supply projects. As a result, in January 2017, the City Council adopted a new Water Use Management Plan that moved twice a week irrigation in Stage 1 to normal water conservation measures to be implemented regardless of drought condition. The City is currently implementing the following water conservation measures year round as detailed in the Code of Ordinances Articles 22.08.039(c)(4) through (c)(6):

> Landscape irrigation is allowed to occur twice each week and is based on the last digit of the property address with Sundays not allowing for landscape irrigation. For summer irrigation (April 1st through September 30th) the maximum irrigation rate is 1.5 inches per zone per week and is restricted to the hours of 6:00 p.m. to 10:00 a.m. For winter irrigation (October 1st through March 31st) the maximum irrigation rate is 1 inch per zone per month for dormant grasses (i.e. Bermuda) and 1 inch per zone per week for cool season grasses (i.e. Fescue). During the winter, irrigation can occur when temperatures are above 35^{o}F eliminating the time of day restrictions.
>
> The following schedule is the twice a week water schedule using the last digit of the property address:
>
> Monday and Thursday for addresses ending in 3, 4, 9, and 0
>
> Tuesday and Friday for addresses ending in 1, 5, and 6
>
> Wednesday and Saturday for addresses ending in 2, 7, and 8
>
> Irrigation should occur without water runoff. This may be accomplished by correctly cycling the sprinkler system and allowing time for the water to soak into the landscape between irrigation events.
>
> Hand watering for landscape irrigation purposes is allowed on a daily basis regardless of the time of year and regardless of the time of day.
>
> New plant material may be irrigated on a more frequent basis until the new plant material is established as defined in Section 22.03.133(a)(4) of this Code of Ordinances related to the operation of irrigation systems.

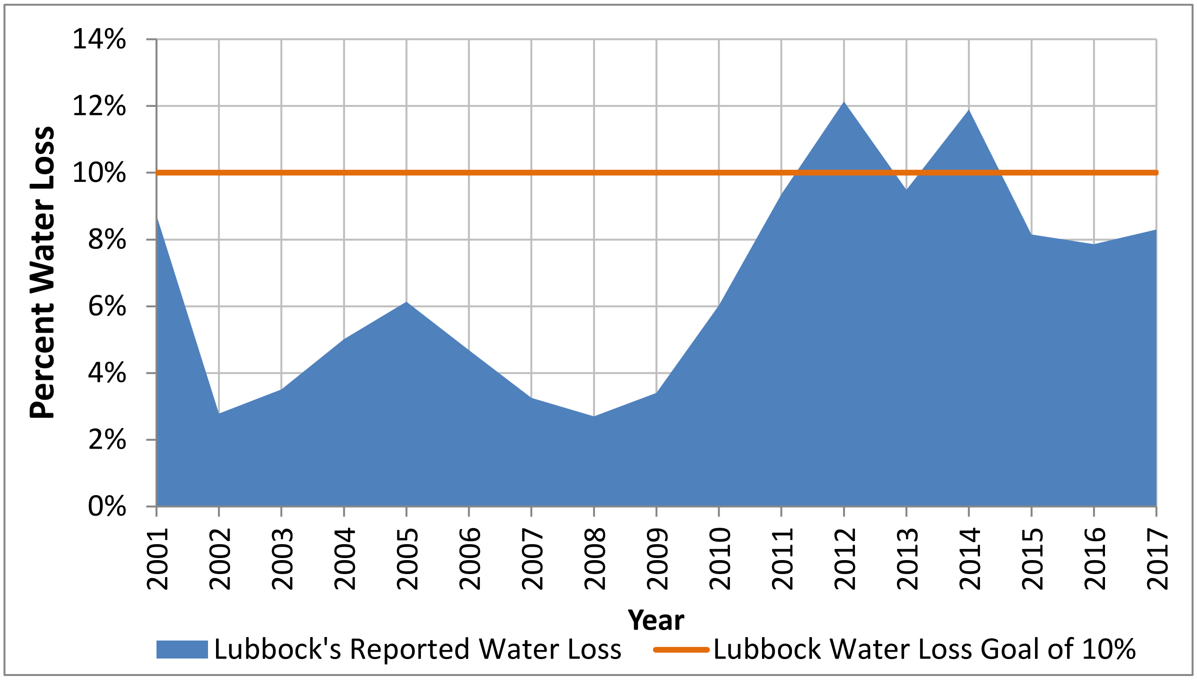
6.5 Unaccounted for Water

One important method of conserving water is to reduce the amount of unaccounted for water, often considered to be water lost from the system. The City's historic unaccounted for water as a percent of the total water used in the system is depicted in Figure 6.6. The Texas Water Development Board (TWDB) indicates that system water losses greater than 15% is excessive.

The AWWA Benchmarking Performance Indicators for Water and Wastewater - 2016 Edition changed its water loss performance measure from a percent of total water used to gallons lost per connection. Using the new benchmark method, the City's water loss for 2017 was 21.74 gallons of water lost per connection, or 8.05 gallons less than the mean AWWA benchmark of 29.79 gallons lost per connection for Region IV.[10]

[10] Benchmarking – Performance Indications for Water and Wastewater Utilities: 2016 Annual Survey Data and Analyses Report. American Water Works Association. 2016.

Figure 6.6. City of Lubbock Water Loss History



The City's goal as stated in the City's Water Conservation Plan is to keep water losses below 10% for its delivery system.[11] As depicted in Figure 6.6, the City has been successful in meeting this goal except for the years 2012 and 2013. In 2017, water losses were at 8.2%. The City seeks to continually improve this measure by implementing effective meter change out, construction meter control, and water main repair and replacement programs.

6.5.1 Water Main Replacement Program

This program manages the replacement of old water lines that are prone to leaks and breaks. In the past 10 years, the City has spent more than $20 million on the replacement of aging pipelines and valves, including the 34th Street and Downtown Waterline Replacement projects. The City routinely monitors the water system for leaks. The goal is to repair detected and/or reported leaks in a timely manner. In the past four years, the City has repaired 2,846 leaks.

6.5.2 Meter Change-out Program

The City uses a random sampling technique to test meter accuracy and to determine when meters need to be repaired or replaced. The City randomly samples approximately 400 water meters each year. Depending on the results of this sample, additional sampling may be done to target meters of a certain age or meters located within a certain geographic area of the City. Meters found to have an accuracy worse than +/- 4% are either repaired or replaced as appropriate.

[11] City of Lubbock Code of Ordinances; Water Use Management Plan. Article 22.08.034.

6.5.3 Fire Hydrant - Construction Meter Program

This program measures water used from fire hydrants by construction contractors and City departments to reduce unaccounted for water use. Contractors lease the fire hydrant meters and are billed at the Commercial Block 2 rate for water used. Any City department using water from a fire hydrant must also use a fire hydrant meter.

6.6 Water Education Team Effort

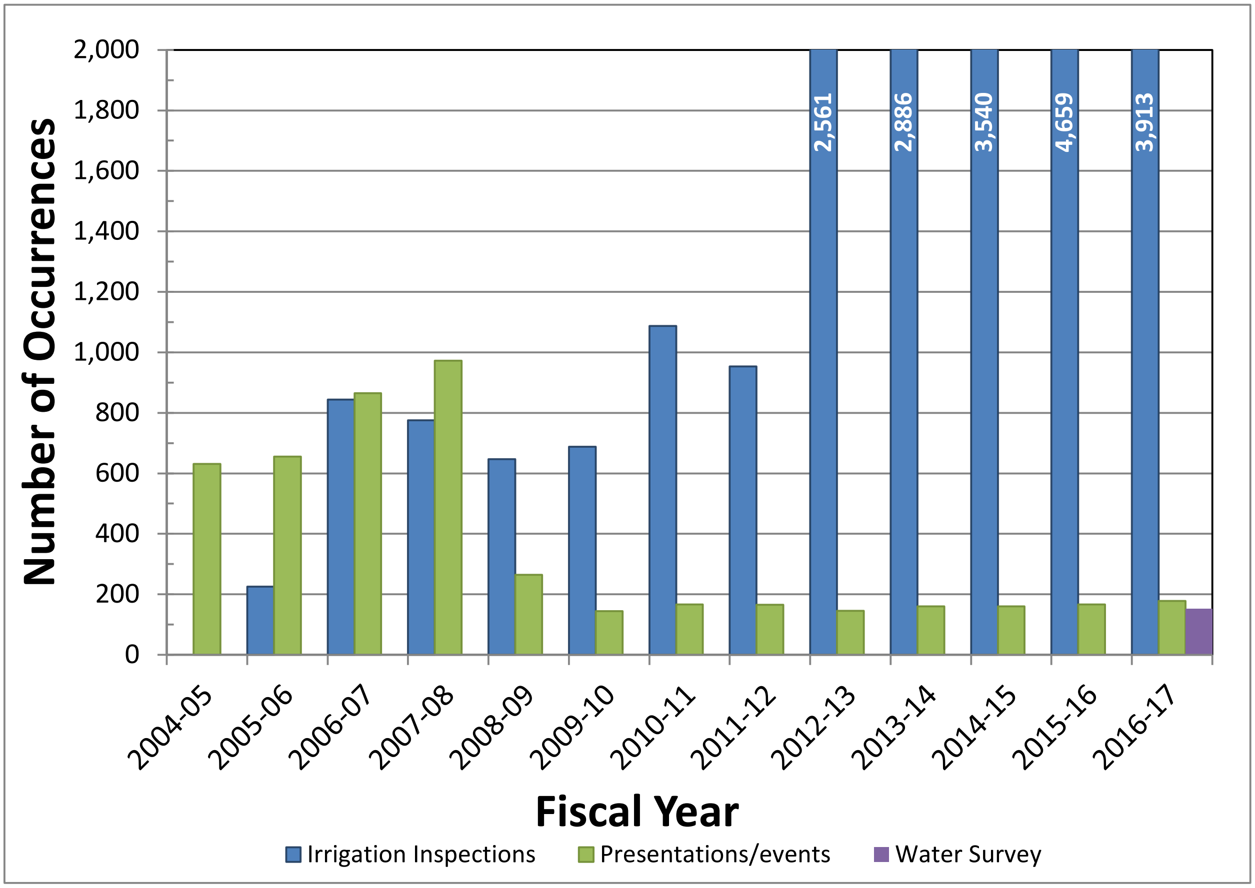
Educating the public and customers is a crucial component of the City of Lubbock's water conservation efforts. To make wise water-use decisions, customers must be equipped with accurate information and knowledge about how they can help. With this in mind, the City created the Water Education Team (WET) in 1996 to raise awareness and disseminate information about water conservation opportunities in the City. The WET focuses on reaching people through public school programs, community events, digital and social media outreach, water surveys and assessments, and irrigation consultations.

The mission statement of the WET is to "*Support sustainable development of the community through outreach and education. Seek to enhance our customer's trust in our Utilities' ability to provide sustainable water and wastewater services at an optimal value*."

Figure 6.7 shows the City's water conservation efforts over the last ten years through educational outreach programs, including public school lessons, residential home water surveys[12], and TCEQ mandated irrigation inspections.

[12] The residential home water survey program began in 2016.

Figure 6.7. Water Conservation Education Outreach



6.6.1 Public-School Programs

The WET, since creation in 1996, has coordinated and implemented educational programs that allow students (kindergarten through 12th grade) to explore the science of water and become familiar with water stewardship concepts. The program is free of charge and consists of nine interactive presentations (see Appendix C.3). Teachers can either request that the City's educator give the presentation or teachers can request lesson plans and materials be delivered to their classroom at http://mylubbock.us/k-12education.

6.6.2 Annual Home & Garden Show

The WET has participated in the annual West Texas Home Builder's Home and Garden Show since 2001. Each year 4,000-6,000 citizens attend. The WET is available at the event to provide information, answer questions, and support the community-wide water conservation effort through home and landscape design.

6.6.3 Digital & Social Media Outreach

Social media and website content have become a valuable resource to the WET since 2015. Currently WET manages four social sites: Facebook, Twitter, Nextdoor, and Instagram and a website with forty associated website pages. These sites have assisted the City in educating citizens about conservation practices, water quality, and water ordinances.

6.6.4 Residential Home Water Surveys

In 2016, the Water Resource Department began offering Residential Home Water Surveys at no charge for Lubbock residents who have an abnormally high water bill. Over the past two years, surveyors have assisted customers by checking for water fixture leaks and making recommendations about optimizing water conservation in homes. They also educate customers on how to read their water meters, check for leaks and other home conservation strategies. Some examples include installing high efficiency toilet parts, sink aerators, showerheads, and using toilet tank bladders.

6.6.5 Irrigation Consultations

The City's irrigation inspectors routinely conduct one-on-one consultation with customers regarding the proper use of their sprinkler systems. These consultations typically are identified while performing inspections on irrigation systems. The inspectors assist homeowners and businesses in optimizing their sprinkler system by determining proper "cycle and soak" run times. When requested, the City's irrigation inspectors assist in teaching customers how to operate controllers and settings.

6.7 Existing Water Conservation Ordinances

The City Council has adopted ordinances that encourage customers to conserve water. These ordinances include:

A *Water Rate Structure Ordinance* (Sec. 22.03.081 – 22.03.097) that defines the City's conservation block rate structure where higher rates apply to greater volumes of water consumed. See Section 6.3 for more details.

A *Water Conservation Plan* (Sec. 22.03.131 – 22.03.134) that restricts the use of outdoor irrigation throughout the year. This ordinance prohibits irrigation systems and devices from being used between 10:00 am and 6:00 pm as well as assigning days for watering landscape each week based on customers' addresses. These restrictions are permanent and year-round.

A *Drought and Emergency Contingency Plan* (Sec. 22.08.001 – 22.08.103) that mandates additional water conservation by providing an implementation plan for drought and emergency contingency measures.

The City's Water Use Management Plan includes both the Water Conservation Plan and Drought and Emergency Contingency Plan.

6.8 Additional Potential Water Conservation Strategies

In addition to the water conservation strategies outlined above, the City is also considering other water conservation opportunities as described in an APAI technical memorandum[13] prepared for the City that describes various conservation programs that could be implemented in the future. The summaries provided below are extracted from the technical memorandum.

[13] Alan Plummer Inc., City of Lubbock Water Conservation Program Development – Technical Memorandum, August 31, 2016.

6.8.1 Residential Water Conservation Checklist

The Residential Checklist is intended to accomplish the same goals as the Residential Indoor Water Efficiency Survey Program. The major difference is that the checklist allows the residential customer to conduct their own indoor water efficiency survey by utilizing an online checklist.

Based on analysis of 2012 residential water consumption data, average residential indoor water use accounts for approximately 61.5 gpcd or 64,242 gallons per account per year.

The average administrative cost per home was estimated at $10.

The anticipated water savings were estimated at 9,000 gallons per home per year. The water savings associated with program recommendations and findings are based on an average 10-year equipment life.

Over the 10-year program, assuming that 2,500 homes participate in the program, the projected water savings are 225 million gallons (mg) at a cost to the City of $25,000 ($10 per home) and a unit cost of $0.11 per thousand gallons.

At a projected savings rate of 22.5 mg per year, the Residential Checklist would be expected to reduce per capita consumption by 0.25 gpcd.

6.8.2 Residential Indoor Water Efficiency Surveys

The intent of this program would be twofold. The first intent is to assist residential water customers in lowering their indoor water consumption by conducting a free residential indoor water efficiency survey. The second intent would be to assist the Water Utilities staff and Water Board of Appeals in cases where residential customers are contesting a high bill. Under the proposed system, a residential customer contesting a high bill would be required to undergo a residential water efficiency survey as part of the appeals process.

This program would be administered in-house and conducted by City staff. The average audit cost per home was estimated to be $192.50, including administrative costs.

The anticipated water savings are estimated at 9,000 gallons per home per year. Assuming that 1,000 homes participate in the program, over 10 years the projected water savings are 90 mg at a cost to the City of $192,500 and a unit cost of $2.14 per thousand gallons.

At a projected savings of 9.0 mg per year, the Residential Indoor Water Efficiency Survey Program would be expected to reduce per capita consumptions by 0.10 gpcd.

6.8.3 Residential Irrigation Checkup

Based on analysis of 2012 residential water consumption data, average residential outdoor water use accounts for approximately 22.5 gpcd or 23,570 gallons per account per year.

The first intent of this program would be to assist residential water customers in lowering their outdoor water consumption by conducting a free residential irrigation checkup. The second intent of the program would be to assist the Lubbock Water Board of Appeals in cases where residential customers are contesting a high bill. Under the proposed program, a residential customer contesting a high bill where an automatic irrigation system is in operation would be required to undergo a residential irrigation audit checkup.

The average irrigation checkup cost per home was estimated at $192.50, including administrative costs. The anticipated water savings are estimated at 7,800 gallons per home per year.

During the 10 year program, assuming that 500 homes participate in the program, the projected water savings are 3.9 mg per year (39,000,000 gallons total) at a cost to the City of $96,250 and a unit cost of $2.47 per thousand gallons saved.

At a projected savings of 3,900,000 gallons per year, the Residential Irrigation Checkup Program would be expected to reduce per capita consumption by 0.04 gpcd.

6.8.4 Industrial, Commercial and Institutional Customers Water Efficiency Surveys

This program would offer free comprehensive water efficiency surveys for Lubbock industrial, commercial and institutional (ICI) customers. The approximately 5,200 ICI customers in the City use an average of about 390,000 gallons per year.

The anticipated average identified water savings are estimated at 25% of average annual consumption, or 97,500 gallons per building per year for 10 years (975,000 gallons total). The average audit is expected to cost $1,200 per building.

Assuming a rate of 110 building audits per year, the projected water savings are 329 ac-ft over the 10 year program at a cost to the City of $132,000 and a unit cost of $1.23 per thousand gallons. At a projected savings of 10,725,000 gallons per year, the ICI Water Efficiency Survey Program would be expected to reduce per capita consumption by 0.12 gpcd.

6.8.5 Car Wash Certification Program

The goal of this program would be to facilitate long-term water efficiency gains through a cooperative program between the City and area car washes. This voluntary program would provide recommended best management practices that are intended to insure both water efficiency and customer satisfaction.

It is estimated that there are approximately 30 active car washes within the City. Those 30 car washes use approximately 55 mg of water per year or an average of 5,022 gallons per car wash per day. The anticipated average identified water savings are estimated at 10% of average annual consumption, or an average of 500 gallons per participating car wash per day. The average administrative cost per facility was estimated to be $200.

Assuming a participation rate of 50%, or 15 car washes, the projected water savings are 2,737,500 gallons per year during the 5 year program (13,687,500 gallons total), at a total cost to the City of $3,000 and a unit cost of $1.10 per thousand gallons. At a projected savings of 2,737,500 gallons per year, the Car Wash Certification Program is expected to reduce per capita consumption by 0.03 gpcd.

6.8.6 Restaurant Certification Program

The goal of this program would be to facilitate long-term water efficiency gains through a cooperative program between the City and restaurants. This voluntary program would provide recommended best management practices that are intended to insure both water efficiency and customer satisfaction.

It is estimated that there are approximately 270 active restaurants within the City. Those 270 restaurants use approximately 248 mg of water per year or an average of 2,516 gallons per restaurant per day. The anticipated average identified water savings are estimated at 15% of average annual consumption, or an average of 377 gallons per participating restaurant per day. The average administrative cost per facility was estimated to be $100.

Assuming a participation rate of 50%, or 135 restaurants, the projected water savings are 18,576,665 gallons per year at a total cost to the City of $13,500 and a unit cost of $0.73 per thousand gallons. At a projected savings of 18,576,665 gallons per year, the Restaurant Certification Program is expected to reduce per capita consumption by 0.21 gpcd.

6.8.7 Low Income Leak Repair Program

Under this program, only homeowners that meet specific qualification requirements would be eligible for assistance. Qualification of homeowners would be accomplished by the City, County, or other non-profit agency that already qualifies citizens for other types of assistance programs. Upon receiving the referral, the Lubbock Water Department would schedule a contracted plumber to assess the situation and make the necessary repairs. The average repair cost per home was estimated to be $500, and the average administrative cost per home was estimated at $50.

The anticipated water savings were estimated at 57,800 gallons per home per year and are based on an average leak rate of 0.11 gpm.

Assuming that 50 percent of qualified homes participate in the program, or 483 homes, the projected water savings are 27,917,400 gallons per year. After 10 years, 279,174,000 gallons would have been saved at a cost to the City of $265,650 and a unit cost of $0.95 per thousand gallons. At a projected savings of 28,023,186 gallons per year, the Low Income Leak Repair Program would be expected to reduce per capita consumption by 0.32 gpcd.

6.8.8 Commercial Non-Profit Retrofit Program

This program would be intended to provide authorized domestic plumbing retrofits to qualifying non-profit facilities, including both residential and commercial customers.

Assuming that 1,000 residential units are retrofitted each year during the 10-year program, the projected water savings are 31,217,000 gallons per year (312,170,000 gallons total) at a cost to the City of $339,000 and a unit cost of $1.09 per thousand gallons saved. At the projected water savings volume, the residential component of the Non-Profit Retrofit Program would be expected to reduce per capita consumption by 0.35 gpcd.

Assuming that 1,000 commercial toilet and faucet combinations are retrofitted each year during the 10 year program, the projected water savings are 39,625,000 gallons per year (396,250,000 gallons total) at a cost to the City of $279,000 and a unit cost of $0.70 per thousand gallons saved. At the projected water savings volume, the commercial component of the Non-Profit Retrofit Program would be expected to reduce per capita consumption by 0.45 gpcd.

6.8.9 Summary of Conservation Strategies

Table 6.2 provides a summary of the conservation strategies discussed in this section. The table compares the expected number of participants, estimated annual cost, unit cost per 1,000 gallons, gpcd reduction potential, and total potential water savings.

It was estimated that the total cost to implement all of these strategies would be approximately $1.346 million. These strategies could reduce per capita water use by 1.87 gpcd. This translates to approximately 1.464 billion gallons saved during the program or 4,545 ac-ft.

Table 6.2. Summary of Conservation Strategies

Program	Participants per Year (Estimated)	Total Estimated Cost	Cost per 1,000 Gallons	GPCD Reduction Potential	Total Potential Water Savings in Gallons
Residential Water Conservation Checklist	2,500 homes	$25,000	$0.11	0.25	225,000,000
Residential Indoor Water Efficiency Survey	1,000 homes	$192,500	$2.14	0.10	90,000,000
Residential Irrigation Checkup	500 homes	$96,250	$2.47	0.04	39,000,000
ICI Water Efficiency Surveys	110 buildings	$132,000	$1.23	0.12	107,725,000
Car Wash Certification Program	15 facilities	$3,000	$0.22	0.03	13,687,500
Restaurant Certification Program	135 facilities	$13,500	$0.73	0.21	18,576,665
Low Income Leak Repair Program	483 homes	$265,650	$0.95	0.32	279,174,000
Commercial Non-Profit Retrofit Program (Residential Unit)	1,000 units	$339,000	$1.09	0.35	312,700,000
Commercial Non-Profit Retrofit Program (Commercial Unit)	1,000 units	$279,000	$0.70	0.45	396,250,000
TOTAL		$1,345,900		1.87	1,463,536,500

Note: gpcd = gallons per capita per day; ICI = industrial, commercial and institutional (customers).

7 Reclaimed Water Strategies

The use of reclaimed water (treated wastewater or effluent) is considered an important water supply strategy in the 2017 State Water Plan.[1] The State Water Plan predicts that by 2070, reclaimed water will represent over 14% of the water produced by all water strategies in Texas. Since Lubbock must import its potable water from such long distances, reusing water makes economical and practical sense. Using reclaimed water can reduce dependency on new water supplies. Various types of reclaimed water uses are discussed in the following section. The Jim Bertram Lake 7 strategy, which uses reclaimed supplies, is evaluated in the Section 10 on Surface Water Strategies.

7.1 Types of Reclaimed Water Uses

Reclaimed water can be used for a variety of beneficial uses depending on the level of wastewater treatment. This includes both non-potable and potable uses, and can include both indirect and direct methods of delivery.

Indirect reuse is the process of discharging treated effluent into the bed and banks of a river or stream, allowing it to flow downstream to a point where it is diverted and used for a beneficial purpose. The discharged water co-mingles with existing streamflows and can be used as-is for some purposes (gravel pit operations, irrigation, etc.), or the captured water can be pumped back into the raw water supply for treatment to potable standards. Water that is discharged into a river basin for conveyance downstream requires a permit from the Texas Commission on Environmental Quality (TCEQ) before it can be re-diverted. Several of the City of Lubbock's (City's) potential water supply strategies utilize this process.

Direct reuse is the process of utilizing the reclaimed water directly from the wastewater treatment plant, with no intervening discharge into a river or stream. The water can be used for non-potable or potable uses, depending on how much additional treatment is provided after the reclaimed water leaves the wastewater treatment facility.

7.1.1 Non-Potable Reuse

Non-potable reuse is the process of conveying treated wastewater effluent to an end-user for beneficial uses such as irrigation, manufacturing, oil/gas operations, mining, or power generation. The reclaimed water can be conveyed either directly or indirectly. The effluent may need to go through additional treatment by the end user depending on the final use of the water. Reclaimed water used in this way can reduce demand on the City's potable water supply, which is more expensive due to the costs to transport, treat, and deliver potable water to customers.

[1] Water for Texas: 2017 State Water Plan. Texas Water Development Board. May 2016.

30 Texas Administrative Code (TAC) Chapter 210.32 identifies the following two types of non-potable reclaimed water uses, when the water is conveyed directly to the end user (direct reuse).

- Type I Reclaimed Water is defined as using reclaimed water where contact between humans and the water is likely. Examples of this type of use include landscape irrigation, public golf course irrigation, fire protection, and toilet or urinal flushing.
- Type II Reclaimed Water is defined as using reclaimed water where contact between humans and the water is unlikely. Examples of this type of use include dust control, cooling tower applications, irrigation of food crops where the reclaimed water is not expected to come in direct contact with the edible part of the crop, and maintenance of impoundments or natural water bodies where direct human contact is not likely.

In order for the City to reuse Type I and II reclaimed water directly, it must maintain an authorization from the TCEQ pursuant to 30 TAC Chapter 210 (commonly referred to as a "210 Authorization"). The City is considering the possibility of amending the existing 210 Authorization to expand the potential non-potable reuses of its treated wastewater.

The City has not deployed a widespread reclaimed water distribution system since most potential users have opted to use more economical local groundwater supplies. Currently the City's non-potable reuse customers include two private cotton farming operations and the Xcel Energy (Southwestern Public Service) Jones Power Plant.

- *Private Cotton Farming Operations* – In March 2016, the City entered into new contracts with two cotton farmers to supply them Type II reclaimed water under the current 210 Authorization from the TCEQ. The City is not obligated to provide a specific amount of water to the farmers. The contracts expire in 2021.
- *Xcel Energy – Jones Power Plant* – In May 1968, the City entered into a contract with Southwestern Public Service (now Xcel Energy) to supply up to 7.7 million gallons per day (mgd) of reclaimed water to the Jones Power Plant located a few miles southeast of the City's water reclamation plant. The contract was amended in 1992 to send a total of 7.0 mgd. Then, in July 2009, the City amended the contract again to supply up to 9.0 mgd to the Jones Power Plant until 2045.[2] Jones Power Plant typically uses less than 5.0 mgd throughout the year.

7.1.2 Potable Reuse

Potable reuse typically is done directly, wherein the treated wastewater is transmitted through a pipeline back to the raw water supply used for potable purposes. The wastewater will go through additional advanced treatment barriers before being injected back into the raw water supply. A direct potable reuse system could also be developed where the reclaimed water is not injected back into the raw water supply, but is treated to potable quality through consecutive treatment barriers and introduced directly into the potable water system. This type of system would require substantial safeguards to minimize the risk of contaminated water supply being introduced into the potable water system.

[2] Third Amendment to Contract between the City of Lubbock and Southwestern Public Service for the sale and purchase of treated sewage effluent. July 28, 2009: Resolution 2009-R0271.

The primary concerns associated with the use of reclaimed water to supplement the potable water supply include regulatory limitations and public perception. Particular challenges to public acceptance of reuse projects include: perceptions of health risks, the source of recycled water, the issue of choice and options, trust and knowledge, and the cost of recycled water. A successful project will need to address these public acceptance issues. Direct potable reuse strategies are evaluated in Sections 7.5, 7.6, and 7.9.

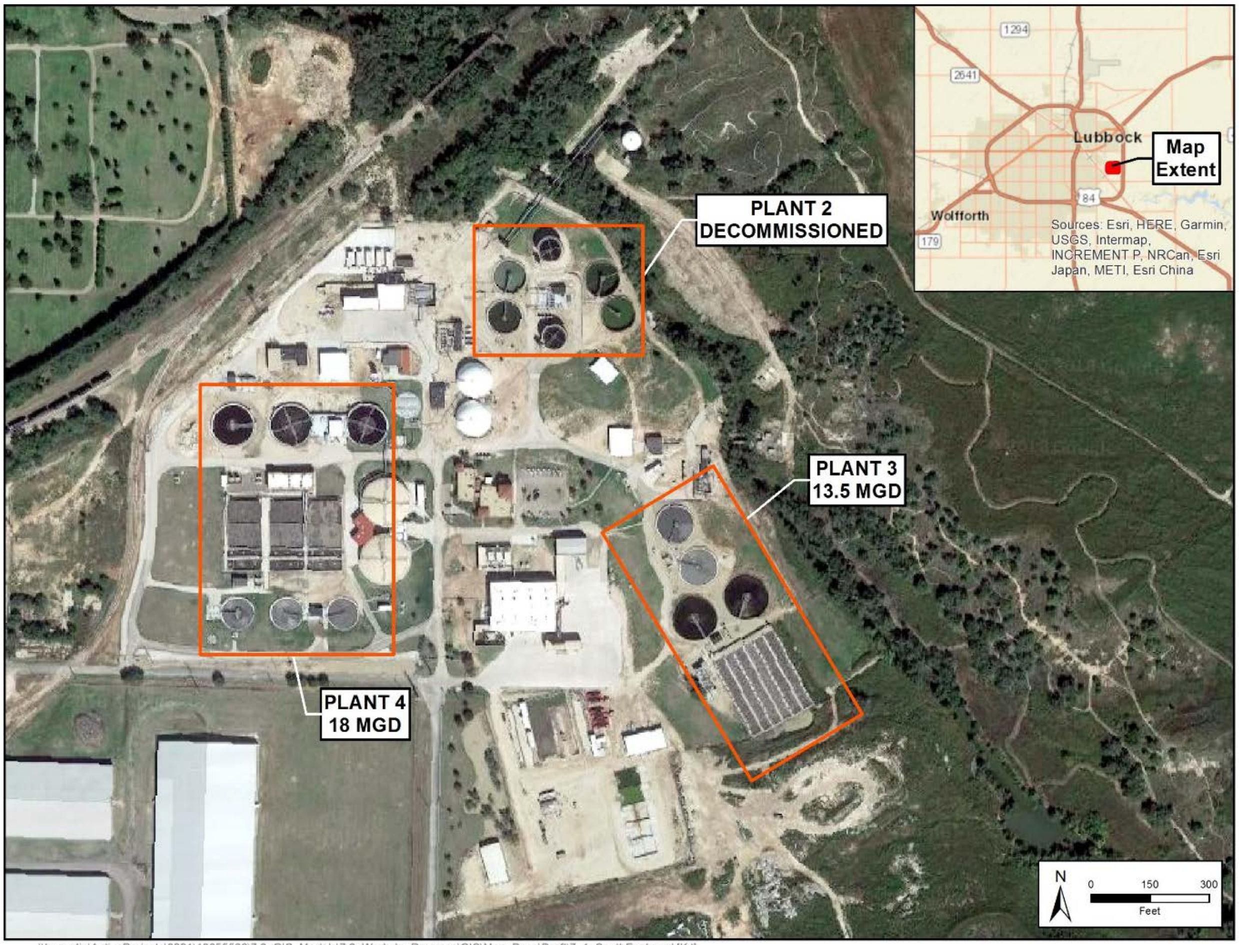
7.2 Existing Reclaimed Water Infrastructure

Two wastewater treatment facilities are owned and operated by the City: that Southeast Water Reclamation Plant (SEWRP) and the Northwest Water Reclamation Plant (NWWRP).

Southeast Water Reclamation Plant

Over the past decade, specific improvements have been undertaken by the City to improve the quality of effluent produced at the SEWRP so it can be discharged into the North Fork of the Double Mountain Fork of the Brazos River (North Fork). The SEWRP currently consists of two operating treatment facilities, Plants 3 and 4. Plant 1 was taken out of service and demolished. Plant 2 is also out of service and plans are being developed to decommission and potentially repurpose Plant 2 structures. Plants 3 and 4 are connected at the headworks of the SEWRP, but function independently until the plants discharge into two effluent pumping stations (EPS) (EPS-1 and EPS-2). Plant 4 modifications completed in 2012 include a conversion of the conventional activated sludge process with aeration basins to biological nutrient removal (BNR) utilizing an Integrated Fixed-film Activated Sludge (IFAS) process. Effluent from the two plants are filtered through new cloth media units and disinfected with an ultraviolet (UV) disinfection system prior to discharge or disposal.

Figure 7.1. Southeast Water Reclamation Plant



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Digester and sludge handling improvements were completed in 2018, which has further improved the quality of the effluent. In order for all of the City's effluent to meet stream discharge requirements, Plant 3 will need to be upgraded in a manner similar to Plant 4. The design of Plant 3 improvements is estimated to be completed by 2021. By increasing the quality of the effluent, the City achieves greater flexibility in how it can beneficially reuse its reclaimed water. Evaluation of new reclaimed water strategies that take effluent from the SEWRP assume the Plant 3 BNR upgrade has been completed. The Plant 3 13.5 mgd BNR upgrade is estimated at $24.8 M in January 2017 prices, based on the Texas Water Development Board (TWDB) costing model. The existing SEWRP layout is depicted in Figure 7.1.

Two of the SEWRP's permitted outfalls allow discharges into the North Fork. Outfall 001 is located at the intersection of Farm-to-Market Road (FM) 400 and the North Fork. Outfall 007 is located next to the SEWRP at the North Fork.

Northwest Water Reclamation Plant

The NWWRP began operations in early 2018. This new wastewater plant will accommodate growth in the northwest portion of the City. It will initially discharge up to 3 mgd at its permitted outfall (NWWRP Outfall 001) into Jim Bertram Lake No. 1. The NWWRP is projected to treat and discharge up to 6 mgd by 2022. Treated effluent discharged into Jim Bertram Lake No. 1 in Yellow House Draw flows into the North Fork. Treated water from the NWWRP will be high quality and ideal for reuse applications. The layout of the NWWRP (during construction) is shown in Figure 7.2.

Figure 7.2. Northwest Water Reclamation Plant (NWWRP) During Construction

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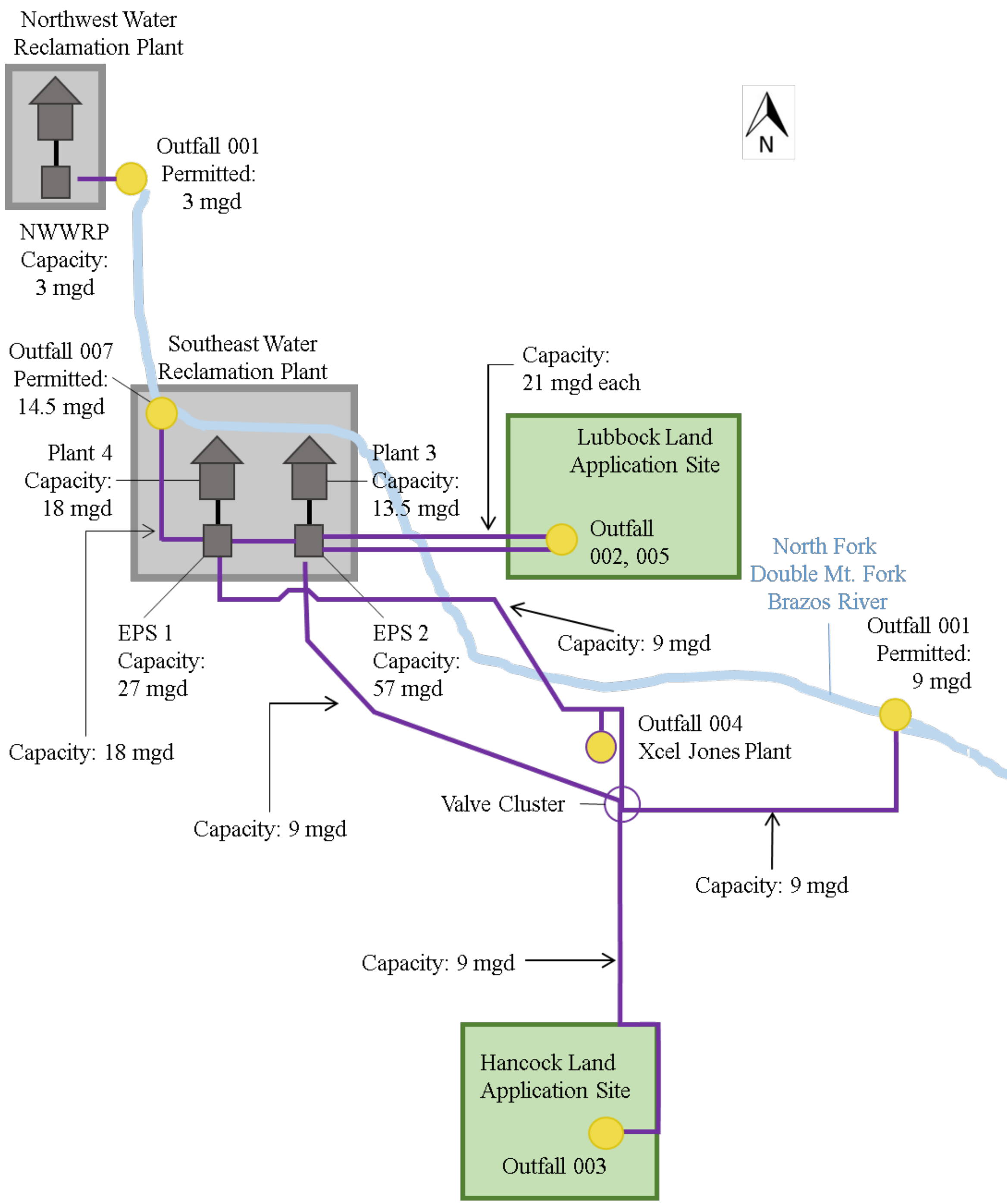
The current location of the effluent pipeline with its associated capacity is important in the evaluation of potential reuse strategies. Some reuse strategies may require modifications to the treatment and discharge facilities. Figure 7.3 shows a schematic of the existing reclaimed water effluent pipeline configuration. The permitted outfalls are labeled on the map.

Figure 7.3. Wastewater Effluent Pipeline System Schematic



7.3 Available Reclaimed Water

Reclaimed water volume projections are necessary to determine when associated water supply strategies will become viable options. Volume projections are developed by multiplying estimated population by the estimated per capita wastewater effluent usage each year.

7.3.1 Population

Population projections were calculated using the City's population and growth rates discussed in Section 2.1. However, the populations of the four communities that receive potable water from the City were not included in these projections since they operate their own wastewater collection and treatment systems. The Expected Growth scenario is used (as described in Section 2.1) to develop the reclaimed water projections.

7.3.2 Per Capita Wastewater Usage

The City has experienced an average decrease of 1.2% per year in its per capita wastewater usage since 1995. Due to conservation and reuse, most large cities in Texas are continuing to experience decreasing per capita wastewater flows. Therefore, Lubbock's future per capita wastewater usage was determined by using the previous five-year average per capita usage of 78 gallons per capita per day (gpcd) as a baseline and reducing the gpcd for 100 years until it reaches 65 gpcd. The City's wastewater flows have dropped as low as 65 gpcd during some months of the year. This projection is used in determining the reclaimed water demand projections.

7.3.3 Gross Reclaimed Water Availability

Lubbock's annual Reclaimed Water Availability (RWA) projections consist of a scenario which was developed using the Expected Growth scenario and the per capita wastewater usage described in the preceding paragraphs.

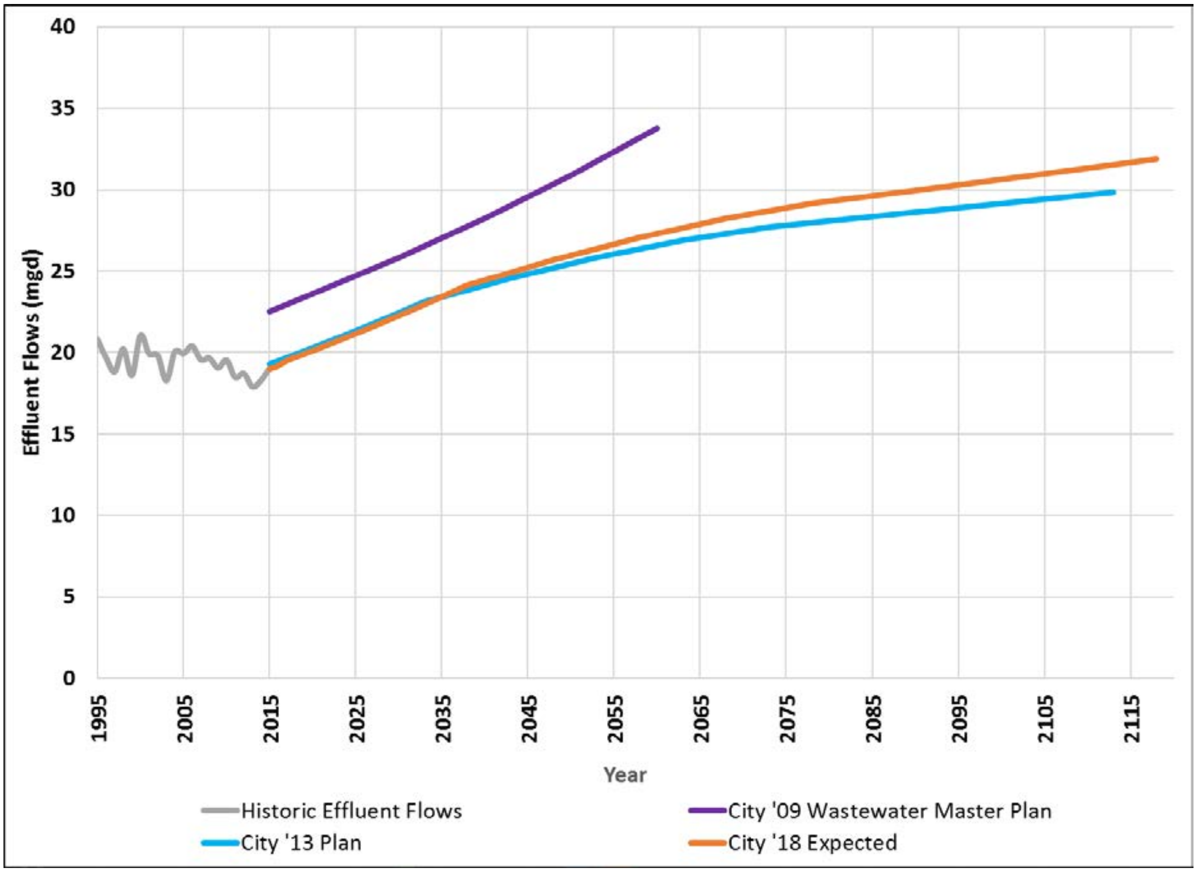
Expected RWA (Expected Growth x Per Capita Wastewater Usage) – This scenario is the most likely projection since it includes probable population growth projections.

A comparison of this Plan's RWA projections to the City's 2009 Wastewater Master Plan[3] and the 2013 Plan[4] is depicted in Figure 7.4 (see Appendix D.1).

[3] Wastewater Master Plan. City of Lubbock, Texas. Jacobs Engineering, Inc. 2009.

[4] City of Lubbock, "Strategic Water Supply Plan". February 2013.

Figure 7.4. Reclaimed Water Availability Projections



Note that the City's 2009 Wastewater Master Plan projects wastewater demands to 2060 while the 2013 Plan ends in 2113. The Expected RWA scenario projects that the following total volume of reclaimed water will be available for reuse in the designated years:

- 19.70 mgd (22,071 acre-feet per year [ac-ft/yr]) by the year 2018
- 24.15 mgd (27,057 ac-ft/yr) by the year 2038
- 28.24 mgd (31,639 ac-ft/yr) by the year 2068
- 31.88 mgd (35,717 ac-ft/yr) by the year 2118

7.3.4 Net Reclaimed Water Availability

Commitments to electric generation and land application uses must be subtracted from the total RWA in order to determine how much reclaimed water will be available for potable water supply strategies. Therefore, the following assumptions have been made.

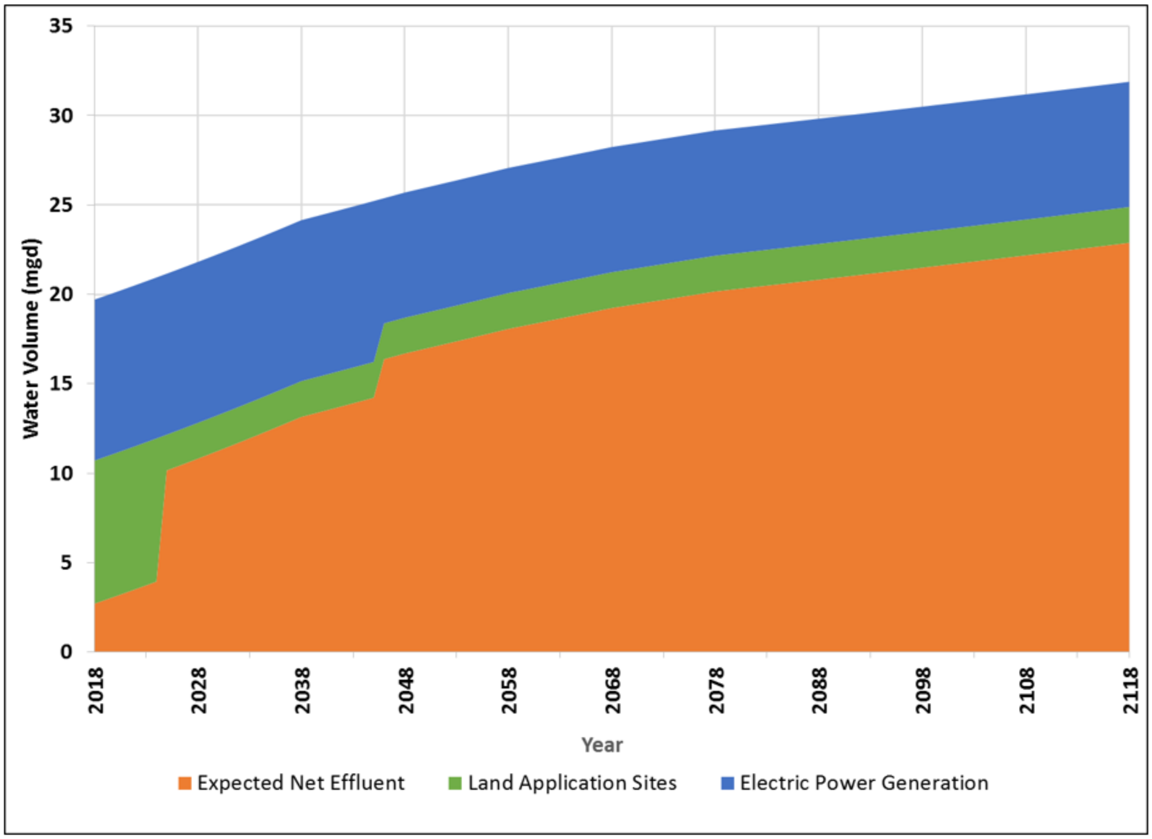
Electric Power Generation – Currently the reclaimed water for power generation is set to 9 mgd as per contract. The City is not anticipating any additional power generation plants being built in the future that will require access to the reclaimed water. It is anticipated Lubbock Power and Light will continue to purchase power and is not considering building a power generation plant at this time.

It is anticipated that in 2045 (Xcel's Jones Power Plant contract expiration), the Xcel contract will be renegotiated to match more closely the actual reclaimed water that is needed for electric power generation. Therefore, the total electric power commitment drops by 2 mgd to 7 mgd in 2045.

Land Application Operations – It is anticipated that it will take a minimum of 4 mgd of effluent to keep the Lubbock Land Application Site (LLAS) and 4 mgd of effluent to keep the Hancock Land Application Site (HLAS) operational. Projections assume that by 2024, the LLAS will be reduced in its size and the HLAS site will be decommissioned. Therefore, the combined reclaimed water commitment to the land application sites will drop from 8 mgd in 2018 to 2 mgd in 2025.

Figure 7.5 depicts the projected net reclaimed water that will be available for water supply projects. In addition, it depicts the water reserved for electric power generation and land application operations. Appendix D.2 includes a table of available net reclaimed water projections.

Figure 7.5. Net Reclaimed Water Availability



In the following sections, nine water supply strategies are presented that rely upon the net reclaimed water available during a given year. Both direct and indirect reuse strategies are discussed. Without the availability of reclaimed water, these strategies are not viable options. Each of the strategies utilizes the same reclaimed water source. As a result, if one of the strategies is implemented, it may necessitate the elimination or downsizing of other strategies that use the same reclaimed water source.

7.4 North Fork Diversion at County Road 7300 Strategy

The North Fork Diversion at County Road (CR) 7300 Strategy is considered an indirect reuse strategy. The City of Lubbock is permitted to discharge 9 mgd of treated effluent at SEWRP Outfall 001 located at the intersection of FM 400 and the North Fork (see Figure 7.2). With this strategy, the City will construct a diversion facility 2.7 river miles downstream from SEWRP Outfall 001 to recapture the discharged effluent. After diversion, the water (reclaimed effluent commingled with actual flows) will be pumped through the transmission line to the South Water Treatment Plant (SWTP). Costs for these facilities have been evaluated separately in a 2015 memorandum[5] which were reviewed but not utilized for the costing of this strategy in order to maintain a consistent costing approach within the strategies evaluated in this plan. A 9 mgd expansion of the SWTP and the new Low Head C transmission pipeline and pump station will be necessary to make this strategy viable. A recent evaluation indicates that the relatively short distance (2.7 miles) between the discharge and the intake may not provide sufficient natural attenuation and blending of supply for enhanced water quality. Therefore, additional advanced treatment facilities have been added to address water quality concerns. Alternatively, Section 7.6 presents a (Direct Potable Reuse (DPR) strategy taking reclaimed water directly to an advanced treatment facility near the SWTP.

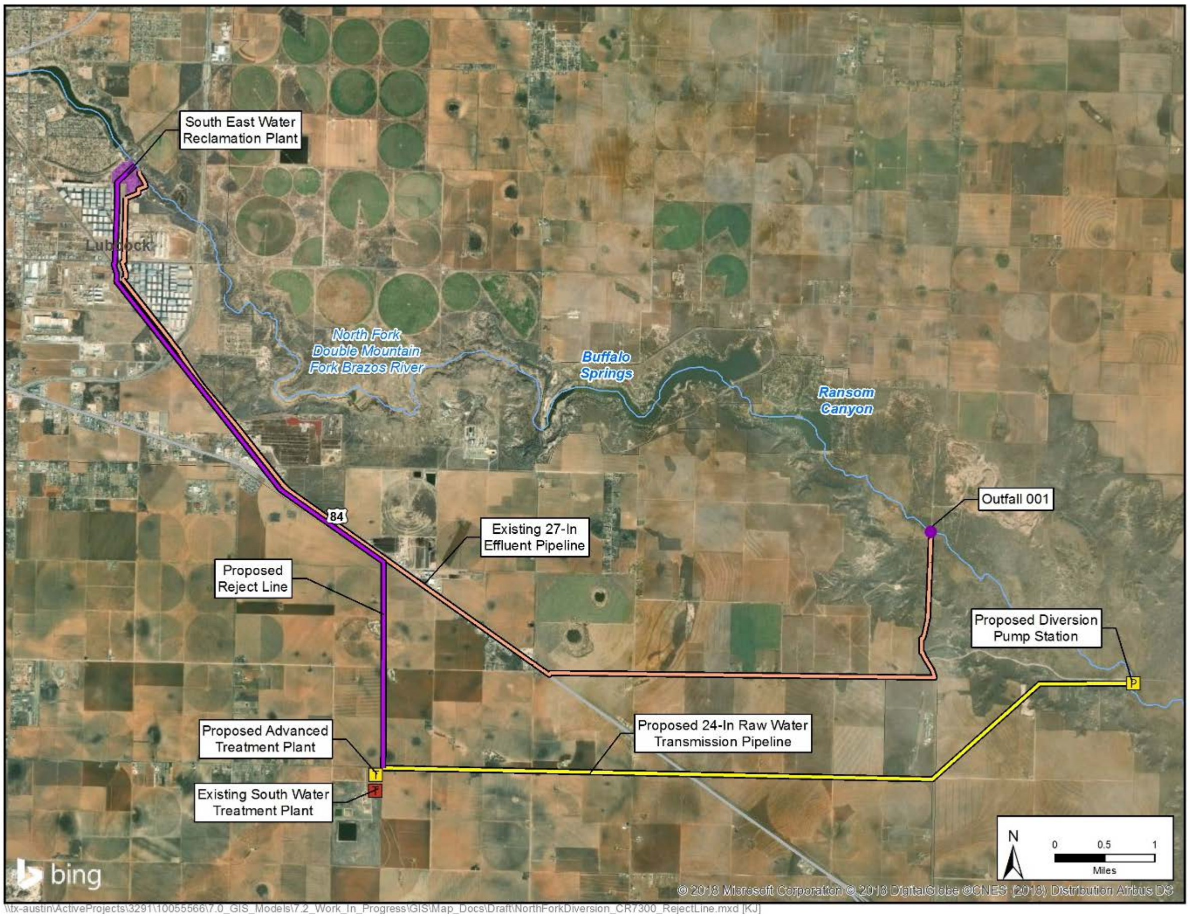
The major design features of this strategy include:

- Design flows associated with the intake, pump station, and transmission pipeline estimated at 5% downtime;
- A new intake structure and a 1,136 horsepower (hp) pump station at the CR 7300 crossing to divert the City's water from the North Fork;
- An 8-mile, 24-in transmission pipeline to deliver the water to the SWTP;
- A 9.5 mgd advanced treatment plant (ATP) constructed at the Lubbock SWTP;
- Reverse osmosis (RO) concentrate will be discharged through a 8-in, 7.5 mile transmission line to the North Fork Double Mountain Fork of the Brazos River
- A 4.5-mile, 30-in Low Head C Transmission pipeline to allow flow from the SWTP to reach Pump Station (PS) 16 or Bailey County groundwater to flow to PS 14 (see Figure 4.10);
- A 15 mgd Low Head C Pump Station to transfer water from the SWTP to PS 16; and
- An expansion of the SWTP capacity and the associated high service pump station by 9 mgd.

Figure 7.6 depicts the relative locations of the required CR 7300 infrastructure.

[5] CR 7300 Conceptual Design and Opinion of Probable Construction Cost. HDR. November 2015.

Figure 7.6 North Fork Diversion at County Road 7300



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7.4.1 Quantity of Available Water

This strategy is designed to treat and deliver an average of 9 mgd (10,089 ac-ft/yr) to the ATP; however, the efficiency of the RO is assumed 80 percent resulting in 0.72 mgd of reject and 8.28 mgd of treated reclaimed water to the SWTP each year. Carriage losses within the 2.7 miles of stream bed of the North Fork are considered negligible.

7.4.2 Strategy Costs

Costs associated with this strategy are presented in Table 7.1. Assumptions and conditions associated with these costs include:

- Existing infrastructure will be used for transmission of treated water from the SWTP into the City's water distribution system;
- Energy costs associated with the Low Head C Pump Station are not included with the transmission pipeline costs;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kilowatt-hour (kwh);
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

These costs do not include the costs necessary for advanced treatment required for a DPR project, which should be added to the costs shown below.

As shown, the total project cost is estimated to be $182,012,000. Annual debt service is $15,231,000; and, annual operational cost, including power, is $5,220,000. This results in a total annual cost of $20,451,000. The unit cost for 8.3 mgd or 9,274 ac-ft/yr supply of water is estimated to be $2,205 per ac-ft, or $6.77 per 1,000 gallons.

Table 7.1. North Fork Diversion at County Road 7300 Costs (January 2017 Prices)

Item	Estimated Costs for Facilities
Channel Dam and Intake Pump Station (9.5 mgd)	$11,496,000
Transmission Pipeline (24 in dia., 8 miles)	$5,170,000
RO Concentrate Pipeline (8 in dia., 7.5 miles)	$1,373,000
Low Head C Pipeline and Pump Station	$21,393,000
SWTP Expansion (9 mgd)	$18,776,000
Advanced Treatment Plant (9.5 mgd)	$67,807,000
TOTAL COST OF FACILITIES	**$126,015,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$43,309,000
Environmental & Archaeology Studies and Mitigation	$511,000
Land Acquisition and Surveying (107 acres)	$269,000
Interest During Construction (4% for 2 years with a 1% ROI)	$11,908,000
TOTAL COST OF PROJECT	**$182,012,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$15,231,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$159,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$587,000
Water Treatment Plant	$3,419,000
Pumping Energy Costs (11,725,477 kW-hr @ 0.09 $/kW-hr)	$1,055,000
TOTAL ANNUAL COST	**$20,451,000**
Available Project Yield (ac-ft/yr)	9,274
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1	$2,205
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$6.77

7.4.3 Implementation Issues

Environmental Issues

The primary environmental issue related to this strategy includes the construction of the diversion facilities. Therefore, there will be a potential impact on animal habitats, which must be mitigated. Studies will be necessary to determine the actual impact to cultural resources, wetlands, and threatened and endangered species. However, the construction of the diversion facilities should have a low to moderate impact relative to most of these concerns.

Permitting Issues

The City started discharging at Outfall 001 in May 2003 pursuant to Texas Pollutant Discharge Elimination System (TPDES) Permit No. 10353-002. Outfall 001 is permitted to discharge a maximum of 9.0 mgd (10,089 ac-ft/yr). In April 2004, the City filed an amendment to Water Use Permit 3985 with the TCEQ. The amendment's approval was delayed due to a contested case hearing regarding ownership of developed water return flows. The TCEQ ruled on the case and issued the City the Water Use Permit in December 2012. This permit authorizes the diversion of up to 10,089 ac-ft annually (minus 0.47% carriage losses) at the CR 7300 facility. Additional permitting will be required to construct the proposed diversion facility.

Other Issues

Property will need to be acquired at the proposed diversion location. In addition, pipeline utility easements will be necessary to construct a raw water transmission line to the SWTP.

7.5 Direct Potable Reuse to NWTP from SEWRP Strategy

This strategy includes conveying 9 mgd of reclaimed water from the SEWRP to an ATP for advanced treatment with multiple barriers before transporting and discharging into the raw water headworks at the North Water Treatment Plant (NWTP). The project purifies reclaimed water from the SEWRP through advanced treatment (RO, UV disinfection and advanced oxidation process [AOP]) to create a water supply that will be of higher quality than the City's other raw water sources. The treated reclaimed water will be blended with other raw water from Canadian River Municipal Water Authority (CRMWA) at the NWTP and undergo conventional treatment for distribution to customers. Human health risks for direct potable reuse are equal or less than those of other water supply sources when full advanced treatment is used (RO, UV disinfection and AOP). These processes are effective at removing identified emerging constituents of concern (ECCs) and other contaminants, including pathogens, from treated wastewater.

In the 2017 Direct Potable Reuse Feasibility Study[6] two alternatives were evaluated that provided DPR supplies to the NWTP. Option 6A delivered purified water from the SEWRP while Option 7B delivered purified water from the NWWRP. These alternatives varied based on the treatment scheme.

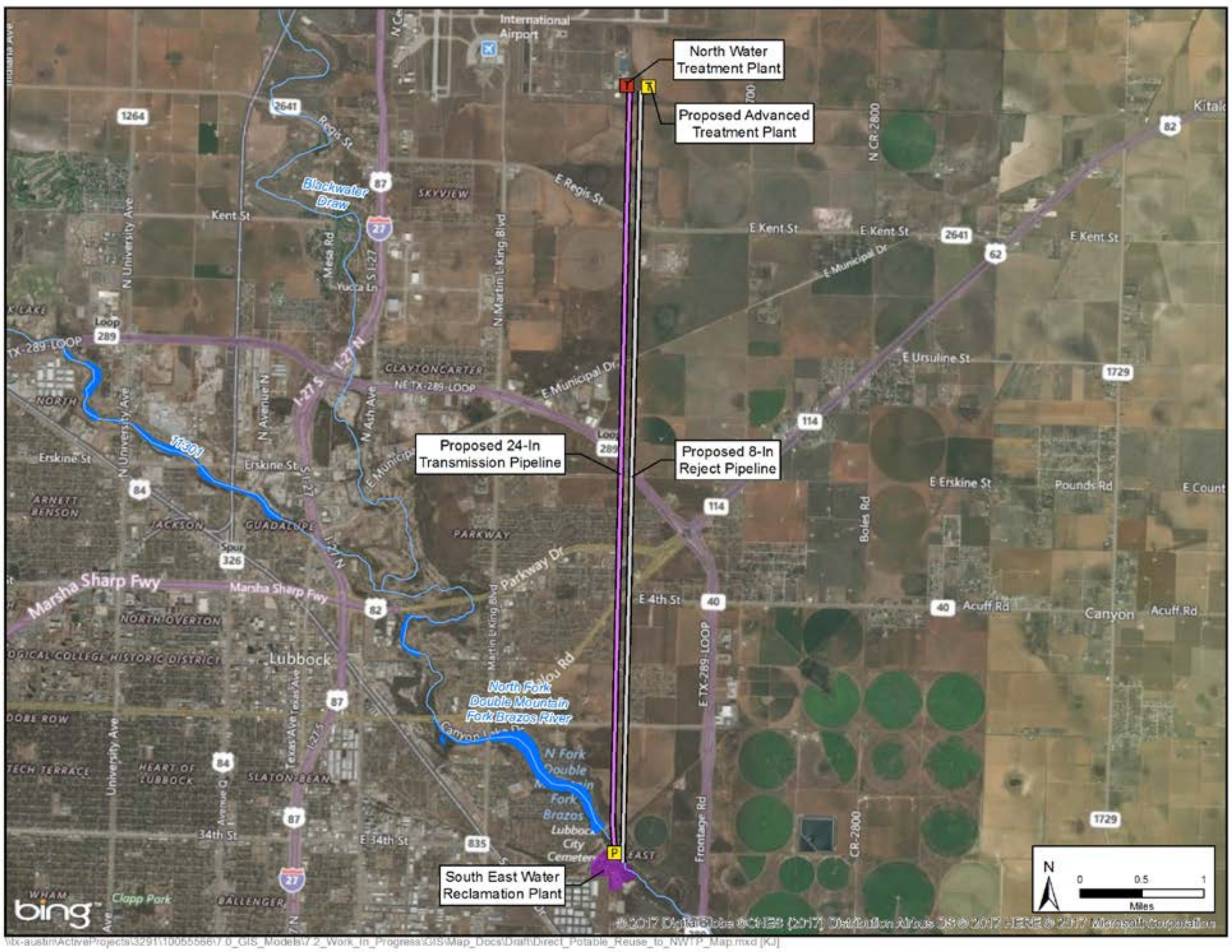
[6] City of Lubbock, "Potable Water Reuse Implementation Feasibility Study". March 2017

The major design features of this strategy include:

- The NWTP has an existing capacity adequate to treat and distribute the additional 9 mgd of reclaimed water. Therefore, an expansion of the NWTP is not necessary;
- A 9.5 mgd ATP at the Lubbock NWTP;
- A new 785 hp pump station at the SEWRP to deliver the treated reclaimed water to the ATP via a new 24-in, 6-mile transmission pipeline; and
- RO concentrate will be discharged through a 8-in, 6-mile transmission line to the North Fork Double Mountain Fork of the Brazos River

Figure 7.7 depicts the relative locations of the infrastructure needed for the Direct Potable Reuse to NWTP strategy.

Figure 7.7. Direct Potable Reuse to NWTP



7.5.1 Quantity of Available Water

This strategy is designed to treat and deliver an average of 9 mgd (10,089 ac-ft/yr) to the ATP; however, the efficiency of the RO is assumed to be 80 percent resulting in 0.72 mgd of reject and 8.28 mgd of treated reclaimed water to the NWTP each year.

7.5.2 Strategy Costs

Costs associated with this strategy are presented in Table 7.2. Assumptions and conditions associated with these costs include:

- Facilities are sized with a 1.0 Peaking Factor (PF);
- Concentrate reject from the RO plant will be stream discharged;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period;
- The project will be financed for 20 years at a 5.5% annual interest rate; and
- The project is assumed to have a 2-year construction period.

As shown, the total cost is estimated to be $117,104,000. Annual debt service is $9,799,000; and annual operational cost, including power, is $2,561,000. This results in a total annual cost of $12,360,000. The unit cost for 9,274 ac-ft/yr of supply at the NWTP is estimated to be $1,333 per ac-ft, or $4.09 per 1,000 gallons. This cost does not include the distribution of the potable water from the NWTP to potential customers.

7.5.3 Implementation Issues

Environmental Issues

Since the advanced treatment facilities are being constructed on property owned by Lubbock that is currently being used for similar purposes, environmental issues should be minimal. The transmission line corridor that will convey the reclaimed and concentrate water should be selected to avoid potentially sensitive areas.

Table 7.2. Direct Potable Reuse to NWTP from SEWRP Costs (January 2017 Prices)

Item	Estimated Costs for Facilities
Pump Station at SEWRP (9.5 mgd)	$3,740,000
Transmission Pipeline (24 in dia., 6 miles)	$8,306,000
Transmission Pipeline (8 in dia., 6 miles)	$1,320,000
Advanced Treatment Plant (9.5 mgd)	$67,807,000
TOTAL COST OF FACILITIES	**$81,173,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$27,929,000
Environmental & Archaeology Studies and Mitigation	$195,000
Land Acquisition and Surveying (91 acres)	$145,000
Interest During Construction (4% for 2 years with a 1% ROI)	$7,662,000
TOTAL COST OF PROJECT	**$117,104,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$9,799,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$96,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$94,000
Water Treatment Plant	$1,542,000
Pumping Energy Costs (8,646,512 kW-hr @ 0.09 $/kW-hr)	$829,000
TOTAL ANNUAL COST	**$12,360,000**
Available Project Yield (ac-ft/yr)	9,274
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1.0	$1,333
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1.0	$4.09

Permitting Issues

The drinking water produced for the project will meet or exceed all state and federal drinking water standards. The TCEQ is currently developing potable reuse guidance requirements to be applied to proposed projects and to be used as the basis for reviewing permit applications. TCEQ will require a pilot study prior to regulatory approval and for determining design values for the treatment technologies. Treatment requirements for any reclaimed water as a drinking water source may consider the pretreatment program, influent wastewater quality, vulnerability assessment of the collection system, results of effluent quality sampling/monitoring data, and wastewater treatment process.

Disposal of residuals from the project would meet all state and federal requirements for discharge of waste. A TPDES permit will be required to discharge RO concentrate. The water quality for RO concentrate discharged into the North Fork of the Double Mountain Fork (NFDMF) of the Brazos River will meet or exceed the stream standards for that segment.[7]

Stream crossings would be subject to Section 404 of the Clean Water Act. Due to the minimal and temporary impacts associated with the pipeline installation, it is likely that most of the proposed project would be authorized by Nationwide Permit 12.

Monitoring is likely to include Cryptosporidium (or a surrogate organism), other regulated contaminants, and may include contaminants on the U.S. Environmental Protection Agency (USEPA) Candidate Contaminate List (CCL), including ECCs and pharmaceuticals and personal care products (PPCPs).

Other Issues

Due to the nature of the project, a public outreach plan will be essential for successful implementation of the proposed reuse project.

Advanced treatment design considerations should include:

- multiple process barriers;
- redundancy and backup power sources;
- alternate storage or discharge locations to divert reclaimed water from the potable distribution system during an acute episode; and
- real-time monitoring and regular sampling to ensure process performance and avoid any acute episode of pathogens in the reclaimed water.

7.6 Direct Potable Reuse to SWTP from SEWRP Strategy

This strategy includes conveying 9 mgd of reclaimed water from the SEWRP to an ATP for advanced treatment with multiple barriers before transporting and discharging into the raw water supply headworks at the SWTP. The project purifies reclaimed water from the SEWRP through advanced treatment using RO, UV disinfection and AOP to create a water supply that will be of higher quality than the City's other raw water sources. The treated reclaimed water will be blended with other raw water supplies at the SWTP and treated again prior to being introduced into the distribution system. Human health risks for direct potable reuse are equal or less than those of other water supply sources when full advanced treatment is used (RO, UV disinfection and AOP). These processes are effective for removing identified ECCs and other contaminants, including pathogens, from treated wastewater.

The major design features of this strategy include:

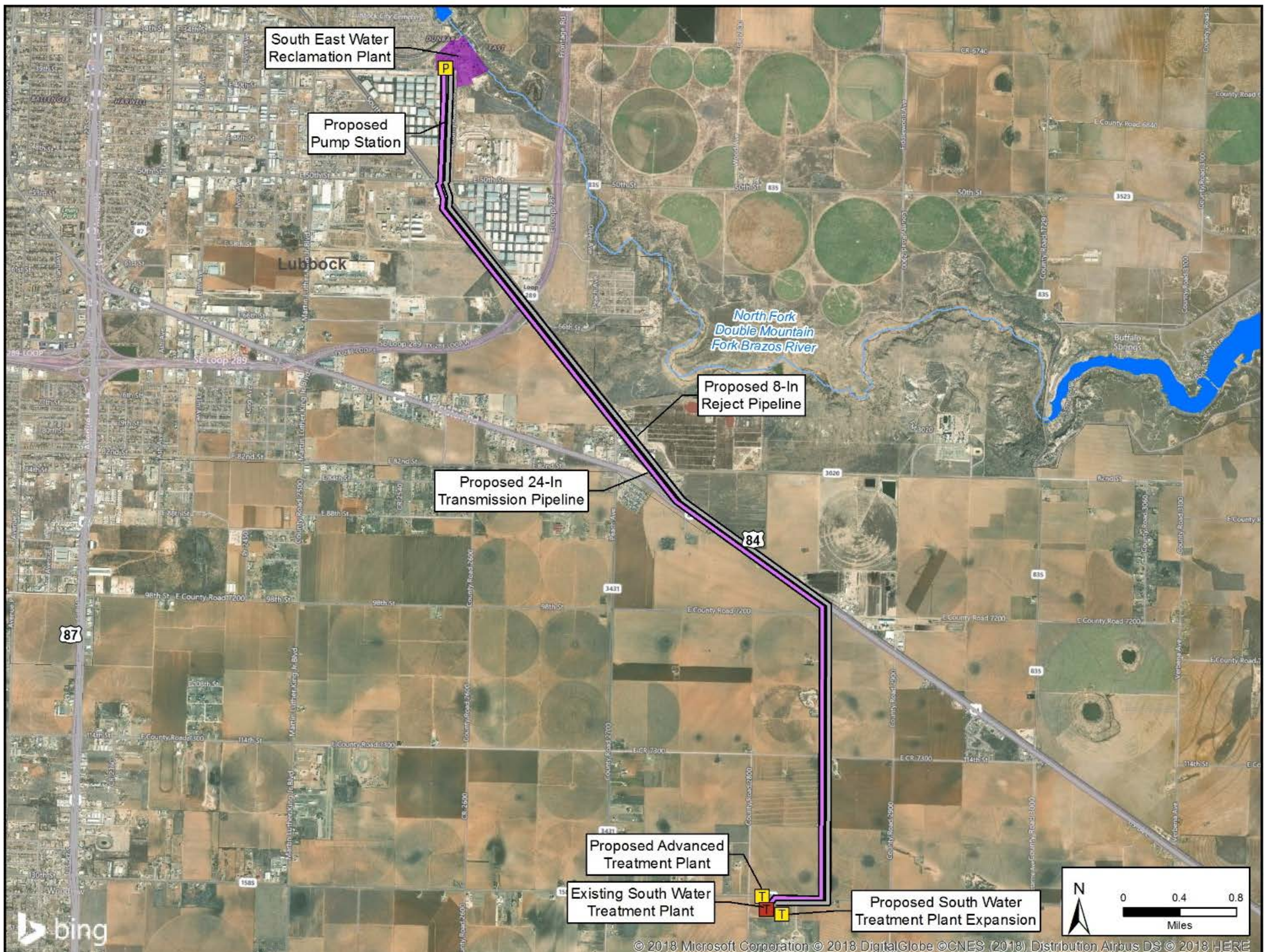
- Property for the SEWRP expansion and SWTP expansion is owned by the City;
- A 9.5 mgd ATP constructed at the Lubbock SWTP;
- A 0.45 mg ground storage tank and 500 hp pump station will be constructed at the SEWRP;

[7] City of Lubbock, "Potable Water Reuse Implementation Feasibility Study". March 2017. 7-9.

- A 7.5 mile, 24-inch diameter transmission pipeline to the SWTP.
- RO concentrate will be discharged through a 8-in, 7.5 mile transmission line to the North Fork Double Mountain Fork of the Brazos River
- A 8.3 mgd expansion of the SWTP's treatment facilities;
- A 4.5-mile, 30-in Low Head C Transmission pipeline to allow flow from the SWTP to reach PS#16 or Bailey County groundwater to flow to PS 14 (see Figure 4.10); and
- A 15 mgd Low Head C Pump Station to transfer water from the SWTP to PS 16.

Figure 7.8 depicts the relative locations of the infrastructure needed for the Direct Potable Reuse to SWTP strategy.

Figure 7.8. Direct Potable Reuse to SWTP



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7.6.1 Quantity of Available Water

This strategy is designed to treat and deliver an average of 9 mgd (10,089 ac-ft/yr) to the ATP; however, the efficiency of the RO is assumed 80 percent resulting in 0.72 mgd of reject and 8.28 mgd of treated reclaimed water to the SWTP each year.

7.6.2 Strategy Costs

Costs associated with this strategy are presented in Table 7.3. Assumptions and conditions associated with these costs include:

- Concentrate reject from the ATP will be stream discharged;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

As shown, the total cost is estimated to be $168,380,000. Annual debt service is $14,090,000; and, annual operational cost, including power, is $4,525,000. This results in a total annual cost of $18,615,000. The unit cost for a 9,274 ac-ft/yr uniform supply is estimated to be $2,007 per ac-ft, or $6.16 per 1,000 gallons.

7.6.3 Implementation Issues

Environmental Issues

Since the RO treatment facilities are being constructed on property owned by Lubbock that is currently being used for similar purposes, environmental issues should be minimal. The transmission line corridor that will convey the raw water to the SWTP should be designed to avoid any potentially sensitive areas.

Permitting Issues

The drinking water produced for the project will meet or exceed all state and federal drinking water standards. The TCEQ is currently developing potable reuse guidance requirements to be applied to proposed projects and to be used as the basis for reviewing permit applications. TCEQ will require a pilot study prior to regulatory approval and for determining design values for the treatment technologies. Treatment requirements for any reclaimed water as a drinking water source may consider the pretreatment program, influent wastewater quality, vulnerability assessment of the collection system, results of effluent quality sampling/monitoring data, and wastewater treatment process.

Disposal of residuals from the project would meet all state and federal requirements for discharge of waste. A TPDES permit will be required to discharge RO concentrate. The water quality for RO concentrate discharged into the NFDMF of the Brazos River will meet or exceed the stream standards for that segment[8].

Stream crossings, if any, would be subject to Section 404 of the Clean Water Act. Due to the minimal and temporary impacts associated with the pipeline installation, it is likely that most of the proposed project would be authorized by Nationwide Permit 12.

[8] City of Lubbock, “Potable Water Reuse Implementation Feasibility Study”. March 2017. 7-9.

Monitoring is likely to include Cryptosporidium (or a surrogate organism), other regulated contaminants, and may include contaminants on the USEPA CCL, including ECCs and PPCPs.

Table 7.3. Direct Potable Reuse to SWTP Costs (January 2017 Prices)

Item	Estimated Costs for Facilities
8.7 mgd Pump Station and Storage Tank	$3,750,000
Transmission Pipeline (24 in dia., 7.5 miles)	$5,063,000
RO Concentrate Pipeline (8 in dia., 7.5 miles)	$1,141,000
Low Head C Transmission Line	$9,393,000
Low Head C Transmission Pump Station	$12,000,000
SWTP Expansion (8.3 mgd)	$17,600,000
Advanced Treatment Plant (9.5 mgd)	$67,807,000
TOTAL COST OF FACILITIES	**$116,754,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$40,084,000
Environmental & Archaeology Studies and Mitigation	$401,000
Land Acquisition and Surveying (84 acres)	$125,000
Interest During Construction (4% for 2 years with a 1% ROI)	$11,016,000
TOTAL COST OF PROJECT	**$168,380,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$14,090,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$160,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$384,000
Water Treatment Plant	$3,302,000
Pumping Energy Costs (7318440 kW-hr @ 0.09 $/kW-hr)	$679,000
TOTAL ANNUAL COST	**$18,615,000**
Available Project Yield (ac-ft/yr)	9,274
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1.0	$2,007
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1.0	$6.16

Other Issues

Due to the nature of the project, a public outreach plan will be essential for successful implementation of the proposed reuse project.

Advanced treatment design considerations should include:

- multiple process barriers;
- redundancy and backup power sources;
- alternate storage or discharge locations to divert reclaimed water from the potable distribution system during an acute episode; and
- real-time monitoring and regular sampling to ensure process performance and avoid any acute episode of pathogens in the reclaimed water.

7.7 South Fork Discharge Strategy

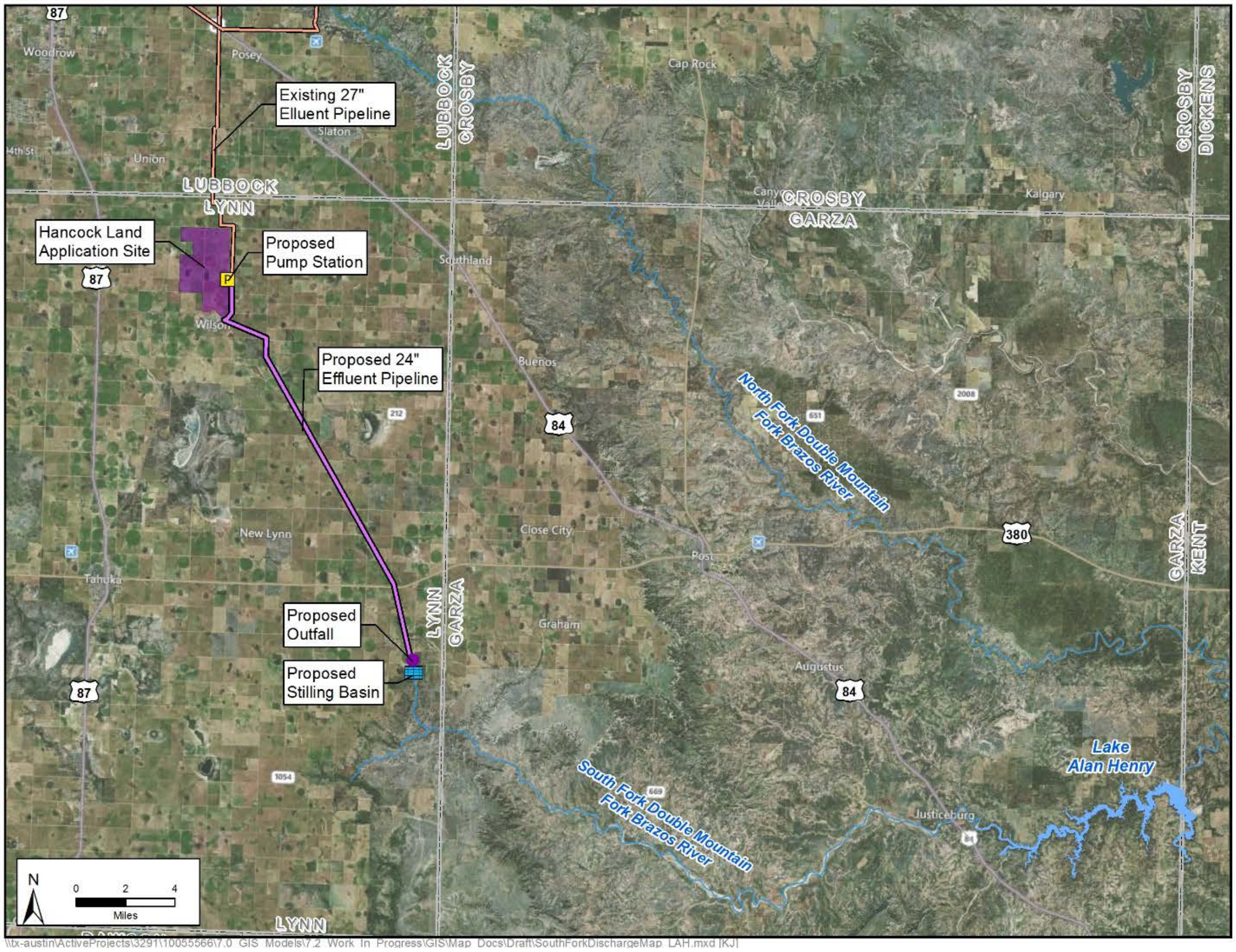
Another potential indirect reuse strategy includes the discharge of treated effluent into the South Fork of the Double Mountain Fork of the Brazos River (South Fork) to increase the firm yield of LAH. The City operates an existing pipeline that transports reclaimed water from the SEWRP to the HLAS located north of the community of Wilson, Texas. This strategy extends the existing reclaimed water pipeline from the HLAS to a tributary on the South Fork enabling the City to discharge up to 9 mgd of reclaimed water into the South Fork. The discharged water will flow downstream and be stored in LAH. The additional water will be pumped to the SWTP via the LAH raw water pipeline.

The major design features of this strategy include:

- A new 9 mgd pump station at the HLAS;
- An 18-mile, 24-in transmission pipeline to discharge reclaimed water into the South Fork tributary;
- A stilling basin located at the discharge point of the 24-in transmission pipeline;
- Expansion of the Lake Alan Henry Pump Station (LAHPS) and Post Pump Station (PPS);
- The construction of the Southland Pump Station (SLPS);
- A 7.3 mgd expansion of the SWTP and associated high service pump station;
- A 4.5-mile, 30-in Low Head C Transmission pipeline to allow flow from the SWTP to reach PS 16 or Bailey County groundwater to flow to PS 14 (see Figure 4.10); and
- A 15 mgd Low Head C Pump Station to transfer water from the SWTP to PS 16..

Figure 7.9 depicts the relative locations of the South Fork Discharge infrastructure needed.

Figure 7.9. South Fork Discharge



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7.7.1 Quantity of Available Water

The City will discharge up to 9 mgd of reclaimed water into the South Fork tributary. The water will flow 36 river miles to LAH where the water will be stored until it is pumped back to the SWTP. Carriage losses from the discharge point to LAH are estimated to be 19% or 1.7 mgd. Therefore, this strategy is estimated to provide an additional peak day of 7.3 mgd or an average of 8,183 ac-ft/yr of water supply.

7.7.2 Strategy Costs

Costs associated with this strategy are presented in Table 7.4 and are provided with and without the inclusion of the LAH pipeline expansion. Assumptions and conditions associated with these costs include:

- Expansion costs for the LAH and PPSs;
- Construction of the SLPS;
- Energy costs to transmit water through the LAHPS and pipeline are included;
- Existing infrastructure will be used for transmission of treated water from the SWTP into the City's water distribution system;

- Energy costs associated with the Low Head C Pump Station were not included in transmission pipeline costs;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

As shown, the total project cost not including the LAH pipeline expansion is estimated to be $74,554,000. Annual debt service is $6,242,000; and, annual operational cost, including power, is $3,389,000. This results in a total annual cost of $9,631,000. The unit cost for 7.3 mgd or 8,183 ac-ft/yr of supply is estimated to be $1,177 per ac-ft, or $3.61 per 1,000 gallons. If the LAH pipeline expansion is included, the unit cost of the project is increased to $1,536 per ac-ft or $4.71 per 1,000 gal.

7.7.3 Implementation Issues

Environmental Issues

This strategy should have minimal impact on the environment since the return flows will be discharged into an existing river basin. The discharge parameters dictated by the TCEQ in the TPDES discharge permit that will be required should ensure that the treated effluent does not impair this segment of the South Fork. Mitigation for the impact to wildlife habitats has already been accomplished for LAH.

Permitting Issues

The City's existing discharge permit (TPDES Permit WQ0010353002) will need to be amended to include an additional outfall on the South Fork. If the existing HLAS pipeline is used, the amendment must include a request to discharge up to 10,089 ac-ft annually into the South Fork. The current permit only authorizes the discharge of treated effluent at FM 400 and the North Fork (Outfall 001) and at the SEWRP (Outfall 007). A water rights permit (bed and banks permit) will be required pursuant to the Texas Water Code Section 11.042 to authorize the conveyance and diversion of the City's reclaimed water. In addition, authorization to construct the discharge facility will be required.

Table 7.4. South Fork Discharge Costs (January 2017 Prices)

Item	Costs	Cost Including LAH Pipeline Expansion
Pump Station (9 mgd)	$2,840,000	$2,840,000
Transmission Pipeline (24 in dia., 18 miles)	$11,577,000	$11,577,000
Low Head C Transmission Pipeline	$9,393,000	$9,393,000
Low Head C Pump Station	12,000,000	12,000,000
LAH Pipeline Expansion		
LAH Pump Station Expansion (additional 15 mgd)		$6,150,000
Post Pump Station Expansion (additional 15 mgd)		$4,865,000
Southland Pump Station (30 mgd)		$9,147,000
SWTP Expansion (7.3 mgd)	$15,921,000	$15,921,000
TOTAL COST OF FACILITIES	**$51,731,000**	**$71,893,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$17,070,000	$24,127,000
Environmental & Archaeology Studies and Mitigation	$566,000	$566,000
Land Acquisition and Surveying (130 acres)	$306,000	$306,000
Interest During Construction (4% for 2 years with a 1% ROI)	$4,881,000	$6,785,000
TOTAL COST OF PROJECT	**$74,554,000**	**$103,677,000**
ANNUAL COST		
Debt Service (5.5 percent, 20 years)	$6,242,000	$8,679,000
Operation and Maintenance		
Pipeline, Wells, and Storage Tanks (1% of Facilities)	$210,000	$210,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$371,000	$875,000
Water Treatment Plant	$1,592,000	$1,592,000
Pumping Energy Costs (20,011,259 kW-hr @ 0.09 $/kW-hr)	$1,216,000	$1,216,000
TOTAL ANNUAL COST	**$9,631,000**	**$12,572,000**
Available Project Yield (ac-ft/yr)	8,183	8,183
Annual Cost of Water ($ per ac-ft)	$1,177	$1,536
Annual Cost of Water ($ per 1,000 gallons)	$3.61	$4.71

Other

Pipeline utility easements will be necessary to extend the existing reclaimed water pipeline to the South Fork. Easements will also be required for the construction of the stilling basin.

7.8 North Fork Diversion to Lake Alan Henry Pump Station Strategy

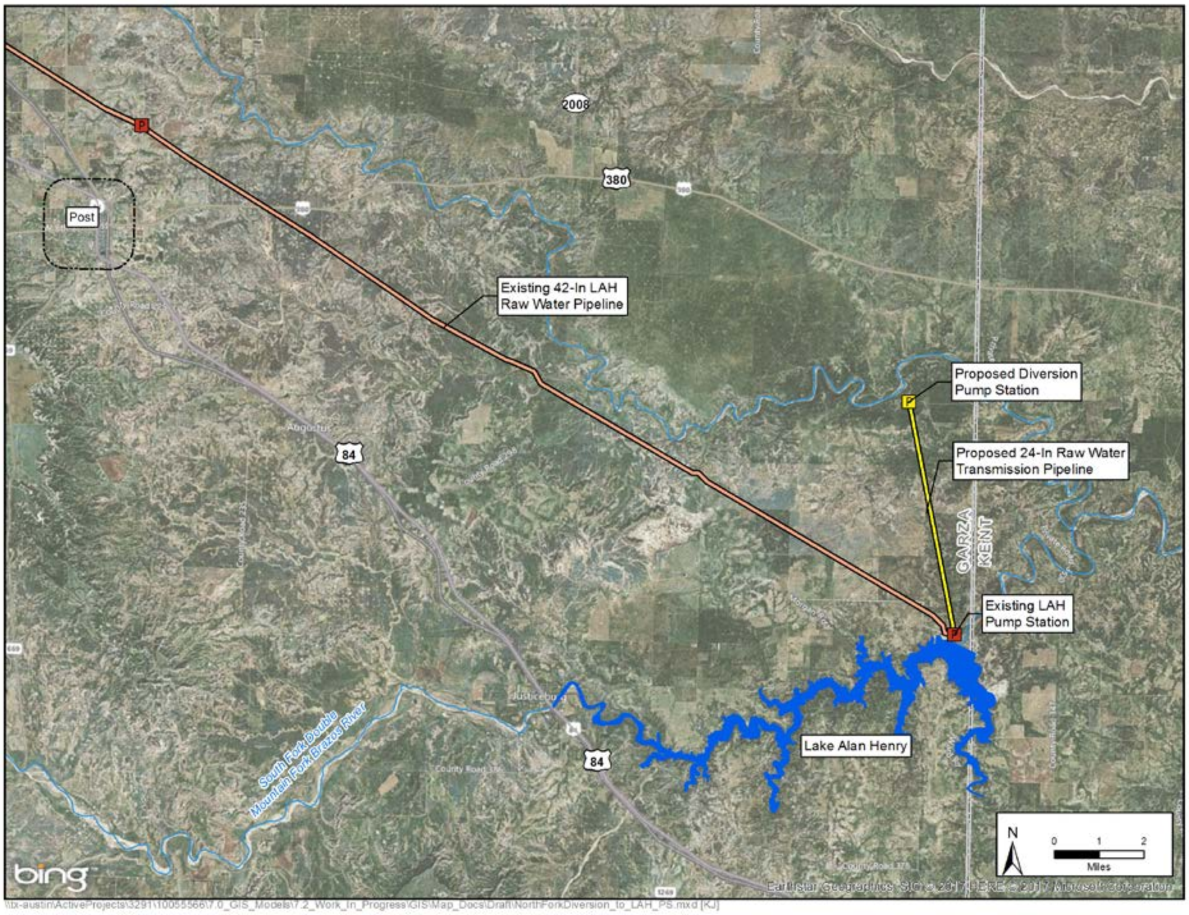
The North Fork Diversion to Lake Alan Henry Pump Station (NFD-LAHPS) is another potential indirect reuse strategy. Under this strategy, the City would discharge up to 9 mgd as permitted from Outfall 001. The water will travel approximately 67 miles downstream on the North Fork to the diversion site. Accounting for carriage losses, about 6.7 mgd of the discharged reclaimed water is estimated to be available for diversion. The water will then be pumped from the diversion site to the LAHPS. From the LAHPS, the water will be transported to the SWTP near Lubbock via the existing LAH raw water pipeline. The LAH pipeline's capacity was designed to transport up to 36 mgd of raw water.

The major design features of this strategy include:

- Design flows associated with the intake structure adjusted for carriage losses;
- Design associated with the intake, diversion pump station, and transmission pipeline excludes downtime allocation;
- A new intake structure and a 460 hp pump station constructed at the diversion location.
- The intake structure and diversion pump station include a small coffer dam to allow for the diversion of the reclaimed water at low flows;
- A 5-mile, 24-in transmission pipeline to deliver the diverted water to the LAHPS;
- Expansion of the LAHPS and PPS;
- The construction of the SLPS;
- A 6.7 mgd expansion of the SWTP and associated expansion of the high service pump station at the SWTP;
- A 4.5-mile, 30-in Low Head C Transmission pipeline to allow flow from the SWTP to reach PS 16 or Bailey County groundwater to flow to PS 14 (see Figure 4.11); and
- A 15 mgd Low Head C Pump Station to transfer water from the SWTP to PS 16.

Figure 7.10 depicts the relative locations of the NFD-LAHPS infrastructure needed. This strategy could be combined with the North Fork Scalping Operation strategy (diverting storm water flows) described in Section 10.5 because both strategies could utilize the same diversion dam and lake, and pipeline easement.

Figure 7.10. North Fork Diversion to Lake Alan Henry Pump Station



7.8.1 Quantity of Available Water

The strategy is estimated to provide a constant 6.7 mgd or 7,510 ac-ft/yr of reclaimed water for treatment at the SWTP. This quantity is calculated based on 9 mgd of treated effluent being discharged by the City at Outfall 001, reduced by approximately 26% due to carriage losses between the discharge and diversion points on the North Fork.

7.8.2 Strategy Costs

Costs associated with this strategy are presented in Table 7.5. Assumptions and conditions associated with these costs include:

- Expansion costs for the LAHPS, PPS, and SLPS are included in costs;
- Energy costs to transmit water through the LAHPS and pipeline are included;
- Existing infrastructure will be used for transmission of treated water from the SWTP into the City's water distribution system;
- Energy costs associated with the Low Head C Pump Station were not included in transmission pipeline costs;

- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

As shown, the total project cost not including the LAH pipeline expansion is estimated to be $67,285,000. Annual debt service is $5,630,000; and, annual operational cost, including power, is $3,413,000. This results in a total annual cost of $9,043,000. The unit cost for 6.71 mgd or 7,510 ac-ft/yr supply is estimated to be $1,204 per ac-ft, or $3.69 per 1,000 gallons. If the LAH pipeline expansion is included, the unit cost of the project is increased to $1,596 per ac-ft or $4.90 per 1,000 gal.

7.8.3 Implementation Issues

Environmental Issues

The primary environmental issue related to this strategy is the change in land use from ranchland to a low-head diversion lake, resulting in potential impacts to animal habitats, which must be mitigated. Studies will be necessary to determine the actual impact to cultural resources, wetlands, and threatened and endangered species. However, the construction of the diversion lake should have a low to moderate impact associated with most of these concerns. The sharpnose shiner and smalleye shiner exist within this part of the Brazos River Basin and are listed on the Federal threatened and endangered species list. The location of the diversion lake and intake pump station is in the critical habitat area of the shiners, which will make permitting of those structures difficult. Other threatened species that potentially live in the region surrounding the North Fork include the Texas horned lizard and black-footed ferret.

Permitting Issues

The City started discharging at Outfall 001 in May 2003 under its existing discharge permit TPDES Permit 10353-002. Outfall 001 is permitted to discharge a maximum of 9.0 mgd (10,089 ac-ft/yr). In order to implement this strategy, the City would need to submit an application to the TCEQ for a new water use permit which includes a bed and banks authorization allowing for the transportation and diversion of up to 10,089 ac-ft annually (minus carriage losses) of the City's return flows at the diversion location. Additional permitting will be required to construct the proposed diversion facility.

Table 7.5. North Fork Diversion to the Lake Alan Henry Pump Station Costs (January 2017 Prices)

Item	Costs	Cost Including LAH Pipeline Expansion
Intake Pump Stations and Channel Dam (7.1 mgd)	$7,094,000	$7,094,000
Transmission Pipeline (24 in dia., 5 miles)	$3,262,000	$3,262,000
LAH Transmission Pump Station Expansions		
LAH Pump Station Expansion (additional 15 mgd)		$6,150,000
Post Pump Station Expansion (additional 15 mgd)		$4,865,000
Southland Pump Station (30 mgd)		$9,147,000
Low Head C Transmission Pipeline	$9,393,000	$9,393,000
Low Head C Pump Station	12,000,000	12,000,000
SWTP Expansion (6.7 mgd)	$14,913,000	$14,913,000
TOTAL COST OF FACILITIES	**$46,662,000**	**$66,824,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$15,699,000	$22,756,000
Environmental & Archaeology Studies and Mitigation	$356,000	$356,000
Land Acquisition and Surveying (79 acres)	$166,000	$166,000
Interest During Construction (4% for 2 years with a 1% ROI)	$4,402,000	$6,307,000
TOTAL COST OF PROJECT	**$67,285,000**	**$96,409,000**
ANNUAL COST		
Debt Service (5.5 percent, 20 years)	$5,630,000	$8,068,000
Operation and Maintenance		
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$127,000	$127,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$477,000	$981,000
Water Treatment Plant	$1,491,000	$1,491,000
Pumping Energy Costs (11,841,882 kW-hr @ 0.09 $/kW-hr)	$1,318,000	$1,318,000
TOTAL ANNUAL COST	**$9,043,000**	**$11,985,000**
Available Project Yield (ac-ft/yr)	7,510	7,510
Annual Cost of Water ($ per ac-ft)	$1,204	$1,596
Annual Cost of Water ($ per 1,000 gallons)	$3.69	$4.90

Other Issues

Property will need to be acquired at the proposed diversion location to accommodate the pumping facilities. In addition, pipeline utility easements will be necessary to construct a raw water transmission line to the LAHPS.

7.9 Other Strategies

A number of strategies that were evaluated in the 2017 Lubbock DPR study have been included below. These include treatment and delivery of reclaimed supplies from the:

- NWWRP to the NWTP in Option 7B.
- NWWRP to PS 9 in Option 8.

The Lake 7 to NWTP in Option 4 utilizes reclaimed water; however, the description of this strategy is included in the Surface Water Strategies in Section 10.3.

7.9.1 DPR Option 7B from NWWRP to NWTP

This strategy includes conveying 6 mgd of reclaimed water from the NWWRP to an ATP for advanced treatment with multiple barriers before transporting and discharging into the raw water headworks at the NWTP. The project purifies reclaimed water from the NWWRP through advanced treatment (RO, UV disinfection and AOP) to create a water supply that will be of higher quality than the City's other raw water sources. The treated reclaimed water will be blended with other raw water from CRMWA at the NWTP and undergo conventional treatment for distribution to customers. Human health risks for direct potable reuse are equal or less than those of other water supply sources when full advanced treatment is used (RO, RO, UV disinfection and AOP). These processes are effective at removing identified ECCs and other contaminants, including pathogens, from treated wastewater.

In the 2017 Direct Potable Reuse Feasibility Study[9] two alternatives were evaluated that provided DPR supplies to the NWTP. Option 6A delivered purified water from the SEWRP while Option 7B delivered purified water from the NWWRP. These alternatives varied based on the treatment scheme

The major design features of this strategy include:

- The NWTP has an existing capacity adequate to treat and distribute the additional 6 mgd of reclaimed water. Therefore, an expansion of the NWTP is not necessary;
- A 6 mgd ATP at the Lubbock NWTP;
- A new 312 hp pump station at the NWWRP to deliver the treated reclaimed water to the ATP via a new 24-in, 8.8-mile transmission pipeline; and
- RO concentrate will be discharged through a 10-in, 6-mile transmission line to the North Fork Double Mountain Fork of the Brazos River.

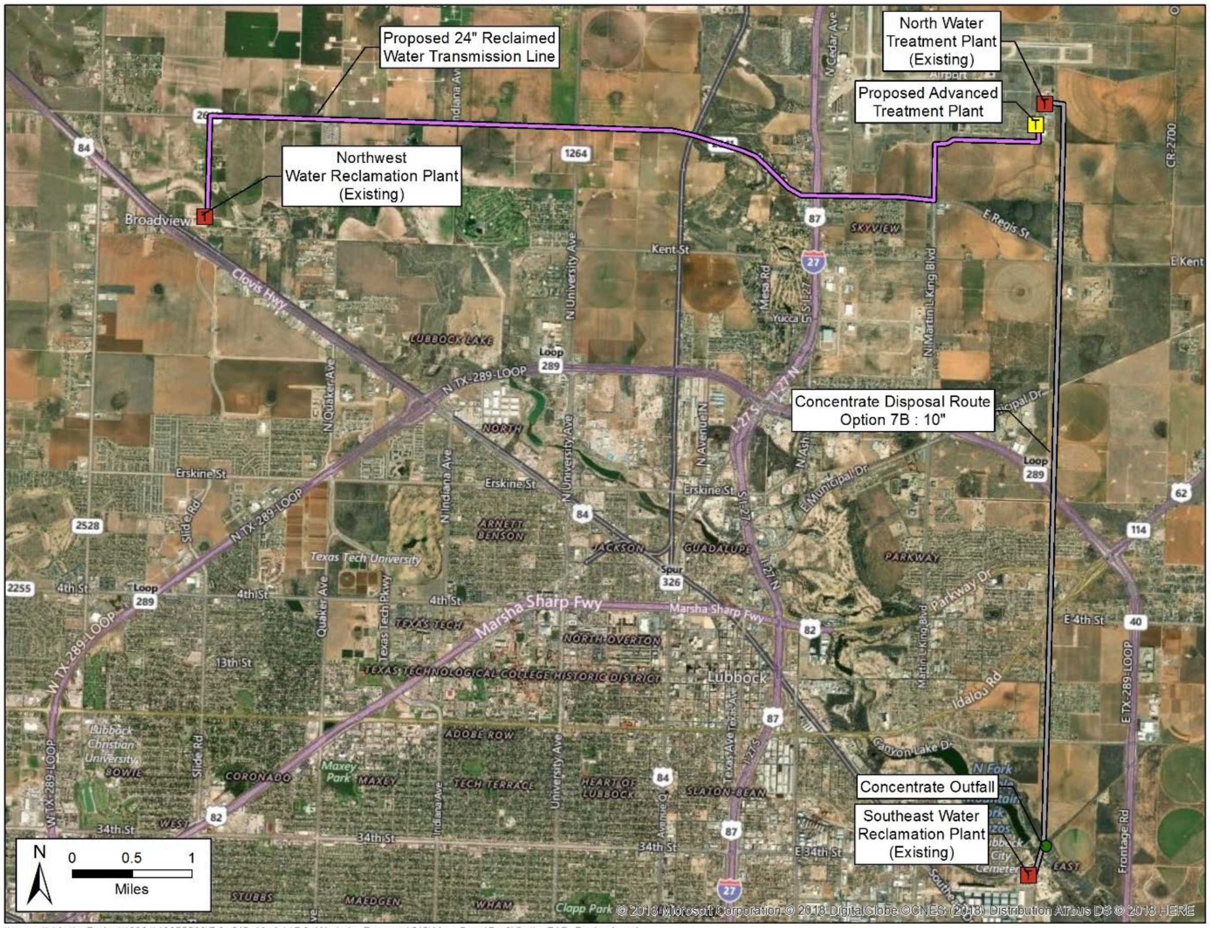
Figure 7.11 depicts the relative locations of the infrastructure needed for the Direct Potable Reuse from NWWRP to NWTP strategy.

[9] City of Lubbock, "Potable Water Reuse Implementation Feasibility Study". March 2017

Quantity of Available Water

This strategy is designed to treat and deliver an average of 6 mgd (6,720 ac-ft/yr) to the ATP; however, the efficiency of the RO is assumed 80 percent resulting in 1.2 mgd of reject and 4.8 mgd of treated reclaimed water to the NWTP each year.

Figure 7.11. DPR Option 7B from NWWRP to NWTP



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Strategy Costs

Costs associated with this strategy are presented in Table 7.6. Assumptions and conditions associated with these costs include:

- Facilities are sized with a 1.2 PF;
- Concentrate reject from the RO plant will be stream discharged;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period;
- The project will be financed for 20 years at a 5.5% annual interest rate; and

- The project is assumed to have a 2-year construction period.

As shown, the total cost is estimated to be $74,886,000. Annual debt service is $6,266,000; and, annual operational cost, including power, is $2,039,000. This results in a total annual cost of $8,305,000. The unit cost for 5,376 ac-ft/yr of supply at NWTP is estimated to be $1,545 per ac-ft, or $4.74 per 1,000 gallons. This cost does not include the distribution of the potable water from the NWTP to potential customers.

Implementation Issues

Environmental Issues

Since the advanced treatment facilities are being constructed on property owned by Lubbock that is currently being used for similar purposes, environmental issues should be minimal. The transmission line corridor that will convey the reclaimed water should be selected to avoid potentially sensitive areas.

Permitting Issues

The drinking water produced for the project will meet or exceed all state and federal drinking water standards. The TCEQ is currently developing potable reuse guidance requirements to be applied to proposed projects and to be used as the basis for reviewing permit applications. TCEQ will require a pilot study prior to regulatory approval and for determining design values for the treatment technologies. Treatment requirements for any reclaimed water as a drinking water source may consider the pretreatment program, influent wastewater quality, vulnerability assessment of the collection system, results of effluent quality sampling/monitoring data, and wastewater treatment process.

Disposal of residuals from the project would meet all state and federal requirements for discharge of waste. A TPDES permit will be required to discharge RO concentrate. The water quality for RO concentrate discharged into the NFDMF of the Brazos River will meet or exceed the stream standards for that segment[10].

[10] City of Lubbock, “Potable Water Reuse Implementation Feasibility Study”. March 2017. 7-9.

Table 7.6. Cost Estimate Summary for DPR Option 7B from NWWRP to NWTP (January 2017 Prices)

Item	Estimated Costs for Facilities
Pump Stations (7.2 mgd)	$2,653,000
Transmission Pipeline (24 in dia., 15 miles)	$9,326,000
Water Treatment Plant (6 mgd)	$41,443,000
TOTAL COST OF FACILITIES	**$53,422,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$18,232,000
Environmental & Archaeology Studies and Mitigation	$412,000
Land Acquisition and Surveying (105 acres)	$287,000
Interest During Construction (4% for 1 years with a 1% ROI)	$2,533,000
TOTAL COST OF PROJECT	**$74,886,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$6,266,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$93,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$66,000
Water Treatment Plant	$1,300,000
Pumping Energy Costs (6,444,568 kW-hr @ 0.09 $/kW-hr)	$580,000
TOTAL ANNUAL COST	**$8,305,000**
Available Project Yield (ac-ft/yr)	5,376
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1.2	$1,545
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1.2	$4.74

Stream crossings, if any, would be subject to Section 404 of the Clean Water Act. Due to the minimal and temporary impacts associated with the pipeline installation, it is likely that most of the proposed project would be authorized by Nationwide Permit 12.

Monitoring is likely to include Cryptosporidium (or a surrogate organism), other regulated contaminants, and may include contaminants on the USEPA CCL, including ECCs and PPCPs.

Other Issues

Due to the nature of the project, a public outreach plan will be essential for successful implementation of the proposed reuse project.

Advanced treatment design considerations should include:

- multiple process barriers;
- redundancy and backup power sources;
- alternate storage or discharge locations to divert reclaimed water from the potable distribution system during an acute episode; and
- real time monitoring and regular sampling to ensure process performance and avoid any acute episode of pathogens in the reclaimed water.

7.9.2 DPR Option 8 from NWWRP to PS9

This strategy includes treating 6 mgd of reclaimed water from the NWWRP at an adjacent ATP for advanced treatment with multiple barriers before transporting and discharging into the potable water line from the Bailey County Well Field near PS 9. The project purifies reclaimed water from the NWWRP through advanced treatment (RO, ultrafiltration, granular activated carbon [GAC] contactor and UV disinfection and AOP). This advanced treatment process is more robust than the other DPR options since it is not blended and retreated through other water treatment plants but introduced directly into the distribution system after advanced treatment.

The major design features of this strategy include:

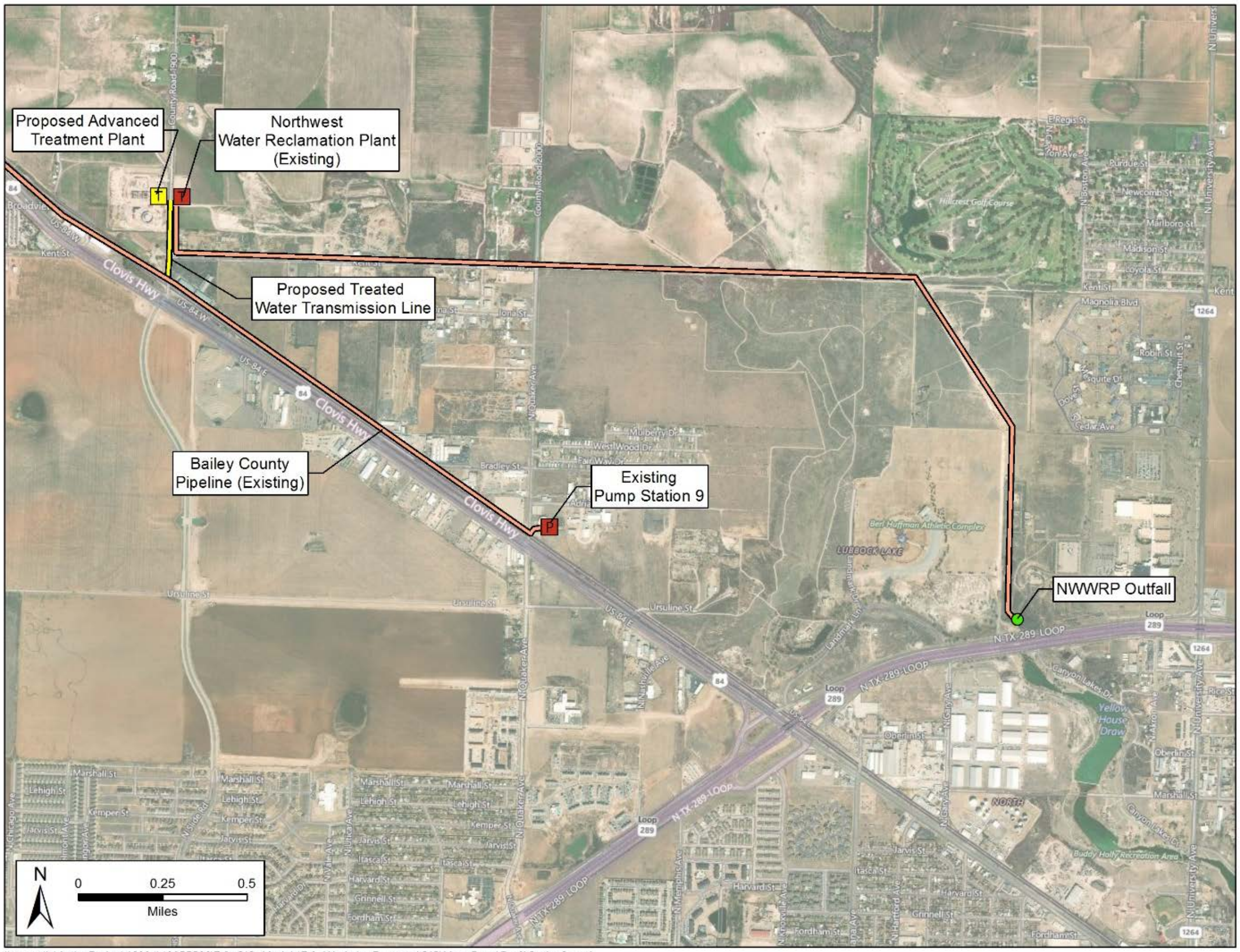
- A 6 mgd ATP at the Lubbock NWWRP;
- A new 126 hp pump station at the NWWRP to deliver the treated reclaimed water to the ATP via a new 18-in, ½ mile transmission pipeline; and
- 1.2 mgd of RO concentrate will be discharged through the existing NWWRP effluent pipeline and discharged at the NWWRP outfall.

Figure 7.12 depicts the relative locations of the infrastructure needed for the Direct Potable Reuse from the NWWRP to PS9.

Quantity of Available Water

This strategy is designed to treat and deliver an average of 6 mgd (6,720 ac-ft/yr) to the ATP; however, the efficiency of the RO is assumed 80 percent resulting in 1.2 mgd of reject and 4.8 mgd of treated reclaimed water to PS9 each year.

Figure 7.12. DPR Option 8 from NWWRP to PS9



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Strategy Costs

As shown, the total cost is estimated to be $81,728,000. Annual debt service is $6,839,000; and, annual operational cost, including power, is $2,267,000. This results in a total annual cost of $9,106,000. The unit cost for 5,376 ac-ft/yr of supply at PS9 is estimated to be $1,694 per ac-ft, or $5.20 per 1,000 gallons. This cost does not include the distribution of the potable water from the PS9 to potential customers.

Table 7.7. Cost Estimate Summary for DPR Option 8 from NWWRP to PS9 (January 2017 Prices)

Item	Estimated Costs for Facilities
Intake Pump Stations (5.8 mgd)	$1,492,000
Transmission Pipeline (18 in dia., 1 miles)	$284,000
Water Treatment Plant (6 mgd)	$56,674,000
TOTAL COST OF FACILITIES	**$58,450,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$20,443,000
Environmental & Archaeology Studies and Mitigation	$37,000
Land Acquisition and Surveying (11 acres)	$34,000
Interest During Construction (4% for 1 years with a 1% ROI)	$2,764,000
TOTAL COST OF PROJECT	**$81,728,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$6,839,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$3,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$37,000
Water Treatment Plant	$1,638,000
Pumping Energy Costs (6,544,334 kW-hr @ 0.09 $/kW-hr)	$589,000
TOTAL ANNUAL COST	**$9,106,000**
Available Project Yield (ac-ft/yr)	5,376
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1.2	$1,694
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1.2	$5.20

Implementation Issues

Environmental Issues

Since the advanced treatment facilities are being constructed on property owned by Lubbock that is currently being used for similar purposes, environmental issues should be minimal. The transmission line corridor that will convey the reclaimed water should be selected to avoid potentially sensitive areas.

Permitting Issues

The drinking water produced for the project will meet or exceed all state and federal drinking water standards. The TCEQ is currently developing potable reuse guidance requirements to be applied to proposed projects and to be used as the basis for reviewing permit applications. TCEQ will require a pilot study prior to regulatory approval and for determining design values for the treatment technologies. Treatment requirements for any reclaimed water as a drinking water source may consider the pretreatment program, influent wastewater quality, vulnerability assessment of the collection system, results of effluent quality sampling/monitoring data, and wastewater treatment process.

Disposal of residuals from the project would meet all state and federal requirements for discharge of waste. A TPDES permit will be required to discharge RO concentrate. The water quality for RO concentrate discharged into the NFDMF of the Brazos River will meet or exceed the stream standards for that segment.[11]

Stream crossings, if any, would be subject to Section 404 of the Clean Water Act. Due to the minimal and temporary impacts associated with the pipeline installation, it is likely that most of the proposed project would be authorized by Nationwide Permit 12.

Monitoring is likely to include Cryptosporidium (or a surrogate organism), other regulated contaminants, and may include contaminants on the USEPA CCL, including ECCs and PPCPs.

Other Issues

Due to the nature of the project, a public outreach plan will be essential for successful implementation of the proposed reuse project.

Advanced treatment design considerations should include:

- multiple process barriers;
- redundancy and backup power sources;
- alternate storage or discharge locations to divert reclaimed water from the potable distribution system during an acute episode; and
- real-time monitoring and regular sampling to ensure process performance and avoid any acute episode of pathogens in the reclaimed water.

7.9.3 Land Application Groundwater Potable Reuse

The City currently land applies reclaimed water from Plant 3 of the SEWRP at the LLAS. The City has constructed a number of groundwater wells in the LLAS as part of a nitrate mitigation project associated with the SEWRP Texas Pollutant Elimination System (TPDES) discharge permit. Currently, the City withdraws approximately 2 mgd of groundwater from the LLAS and discharges it into the Jim Bertram Lake System (JBLS). Rather than discharging this supply into the JBLS, this strategy will deliver 2 mgd of groundwater from an existing storage tank to an ATP for treatment prior to blending with other raw water sources at the

[11] City of Lubbock, "Potable Water Reuse Implementation Feasibility Study". March 2017. 7-9.

NWTP. Raw water supplies at the NWTP will be blended with the treated groundwater at a ratio of 10:1 to provide an adequate total dissolved solids (TDS) concentration.

The major design features of this strategy include:

- Expand existing pump station to deliver the reclaimed water from the existing ground storage tank to the advanced water treatment facility;
- A new 16-in, 7.5 mile pipeline to deliver the recovered water to the NWTP; and
- A 2 mgd ATP at the NWTP.

Figure 7.13 depicts the relative locations of the Land Application Groundwater Potable Reuse and associated infrastructure.

Quantity of Available Water

This groundwater reuse strategy assumes that up to 2 mgd of reclaimed water will be sent to the NWTP.

Strategy Costs

Costs associated with this strategy are presented in Table 7.8. Assumptions and conditions associated with these costs include:

- The costs are based on information provided by Alan Plummer Associates, Inc. (APAI);
- Engineering, legal, and contingency costs is 30% of pipelines and 35% for other facilities;
- Power is available at $0.09 per kwh;
- Interest during construction is 4%, and a 1% return on investments;
- The project will be financed for 20-years at a 5.5% interest rate; and
- The project is assumed to have a 1-year construction period.

Figure 7.13. Land Application Groundwater Potable Reuse Infrastructure

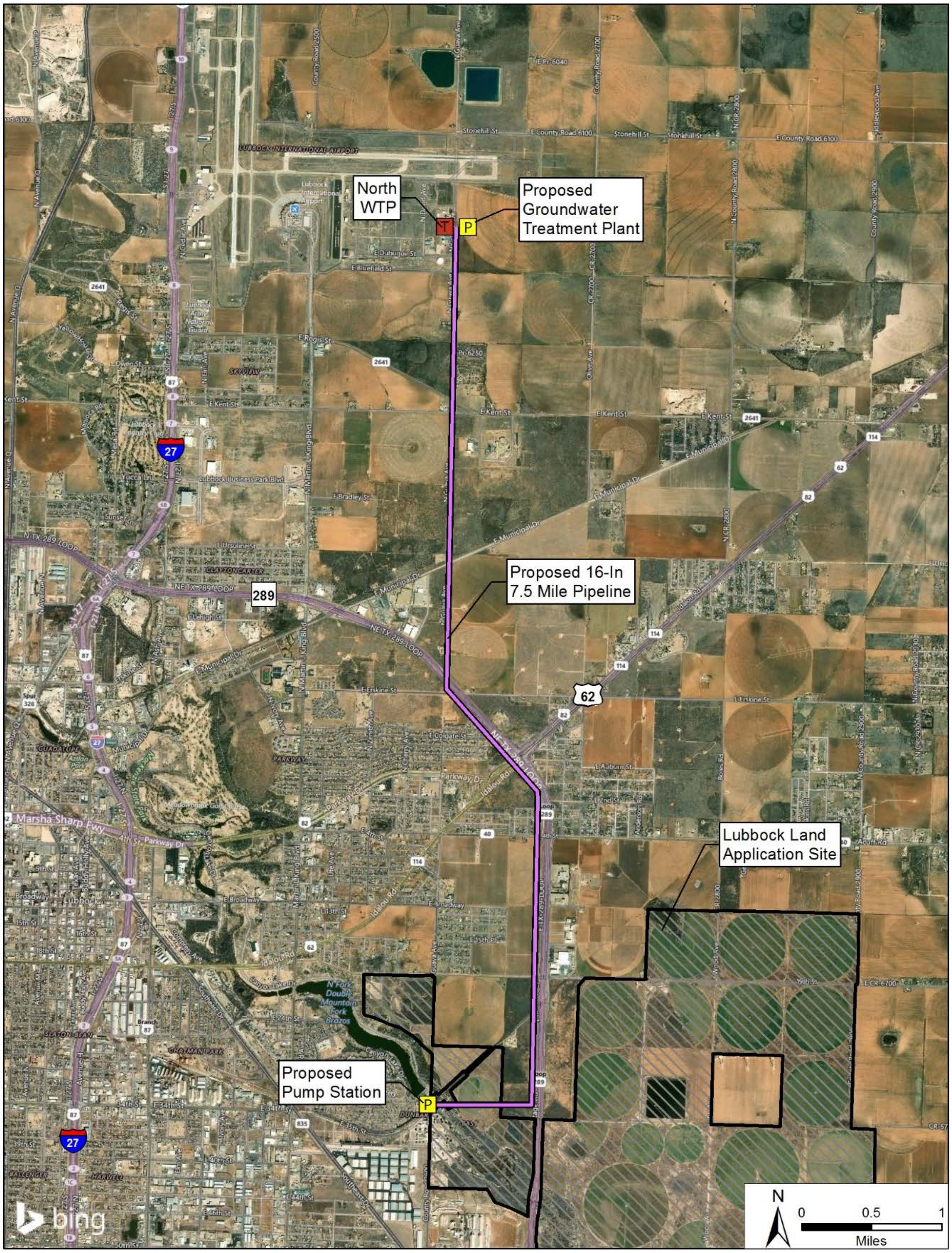

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Table 7.8. LLAS Groundwater Reuse Costs (January 2017 Prices)[1]

Item	Estimated Costs for Facilities
Pump Station Expansion (2 mgd)	$1,446,000
Transmission Pipeline (16 in dia., 7.5 miles)	$4,387,000
Advanced Groundwater Treatment Plant (2 mgd)	$4,890,000
TOTAL COST OF FACILITIES	**$10,723,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$3,534,000
Environmental & Archaeology Studies and Mitigation	$204,000
Land Acquisition and Surveying (52 acres)	$143,000
Interest During Construction (4% for 1 years with a 1% ROI)	$512,000
TOTAL COST OF PROJECT	**$15,116,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$1,265,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$44,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$36,000
Water Treatment Plant	$353,000
Pumping Energy Costs (449,000 kW-hr @ 0.09 $/kW-hr)	$40,000
TOTAL ANNUAL COST	**$1,738,000**
Available Project Yield (ac-ft/yr)	2,240
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1.0	$776
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1.0	$2.38

Note: Costs based on 11/13/17 Land Application Groundwater Potable Reuse Evaluation.

As shown, the total cost is estimated to be $15,116,000. Annual debt service is $1,265,000; and, annual operational cost, including power, is $473,000. This results in a total annual cost of $1,738,000. The unit cost for 2,240 ac-ft/yr of supply at the SWTP is estimated to be $776 per ac-ft, or $2.38 per 1,000 gallons. This cost does not include the distribution of the potable water from the NWTP to potential customers.

Implementation Issues

Environmental Issues

Since the advanced treatment facilities are being constructed on property owned by Lubbock that is currently being used for similar purposes, environmental issues should be minimal. The transmission line corridor that will convey the reclaimed water should be selected to avoid potentially sensitive areas.

Permitting Issues

The water produced for the project will meet or exceed all state and federal drinking water standards. The TCEQ is currently developing potable reuse guidance requirements to be applied to proposed projects and to be used as the basis for reviewing permit applications. TCEQ will require a pilot study prior to regulatory approval and for determining design values for the treatment technologies. Treatment requirements for any reclaimed water as a drinking water source may consider the pretreatment program, influent wastewater quality, vulnerability assessment of the collection system, results of effluent quality sampling/monitoring data, and wastewater treatment process.

Any potential stream crossings would be subject to Section 404 of the Clean Water Act. Due to the minimal and temporary impacts associated with the pipeline installation, it is likely that any such crossings would be authorized by Nationwide Permit 12.

Monitoring is likely to include Cryptosporidium (or a surrogate organism), other regulated contaminants, and may include contaminants on the USEPA CCL, including ECCs and PPCPs.

Other Issues

Due to the nature of the project, a public outreach plan will be essential for successful implementation of the proposed reuse project.

Advanced treatment design considerations should include:

- multiple process barriers;
- redundancy and backup power sources;
- alternate storage or discharge locations to divert reclaimed water from the potable distribution system during an acute episode; and
- real-time monitoring and regular sampling to ensure process performance and avoid any acute episode of pathogens in the reclaimed water.

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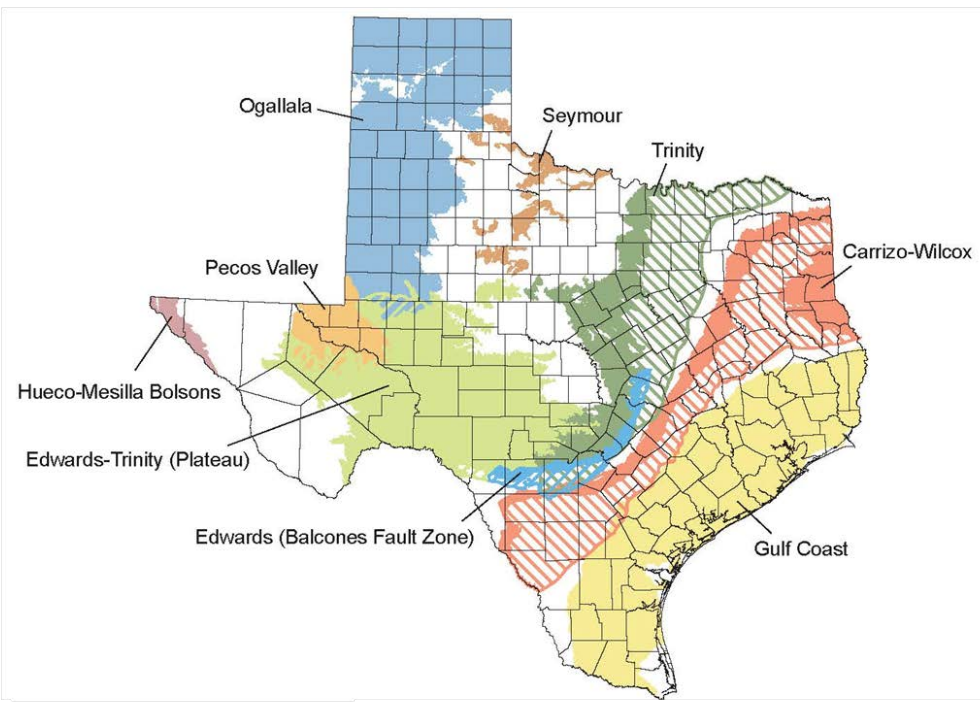
8 Groundwater Strategies

Aquifers have always been a vital source of water for Lubbock. The first municipal water system constructed in 1911 consisted of one Ogallala Aquifer well. The City of Lubbock (City) relied solely upon groundwater until 1968 when surface water from Lake Meredith was made available (see Figure 3.1).

8.1 Groundwater Sources

The Texas Water Development Board (TWDB) recognizes 30 major and minor aquifers in the State of Texas. Aquifers that supply large quantities of water over large areas of the state are defined as major aquifers. Aquifers that supply relatively small quantities of water over large areas of the state or supply large quantities of water over small areas of the state are defined as minor aquifers. Each aquifer has unique characteristics.[1] The major aquifers in Texas are shown in Figure 8.1, and the minor aquifers are shown in Figure 8.2. The Ogallala and Seymour Aquifers are the major aquifers in Lubbock's region. The Edwards-Trinity (High Plains) and the Dockum Aquifers are the minor aquifers in the Lubbock region.

Figure 8.1. Major Aquifers

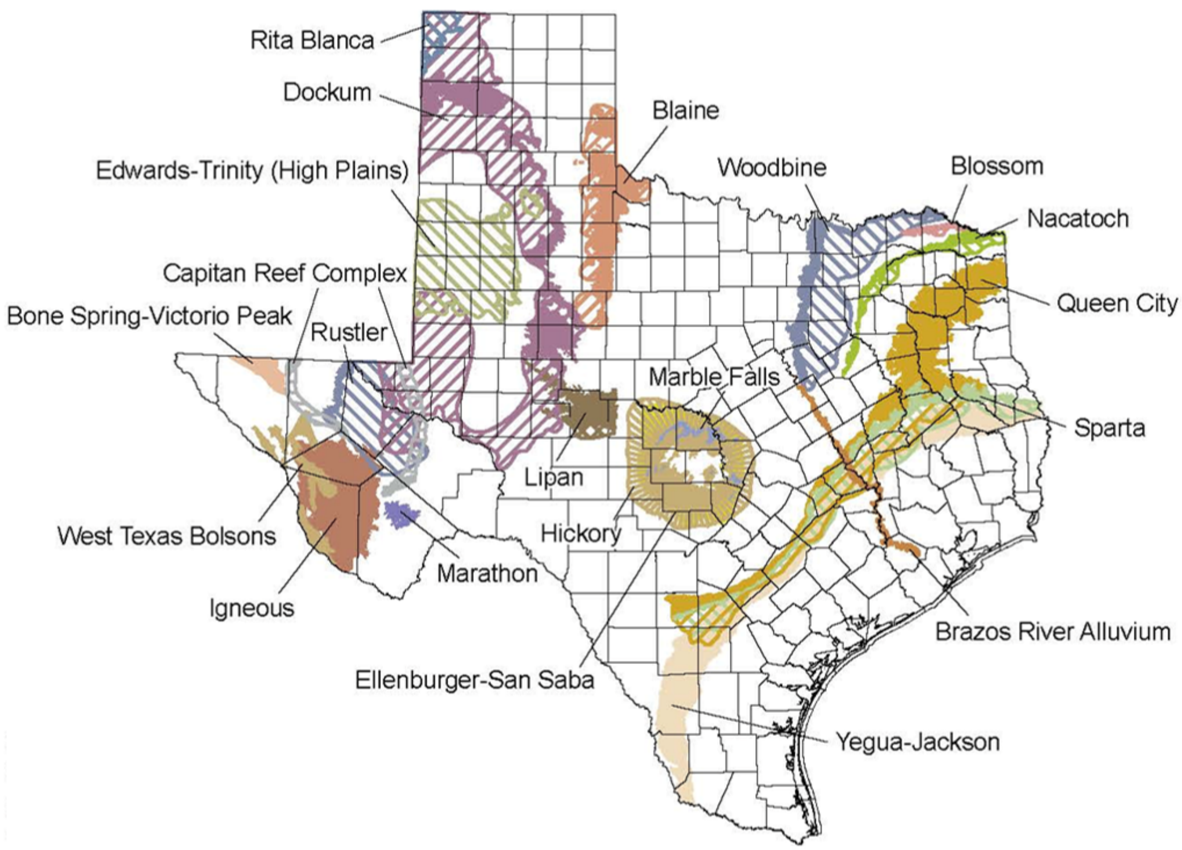


(Map courtesy of TWDB)[2]

[1] Water for Texas: 2017 State Water Plan.

[2] Ewing, J.E. and others. October 2008. Final Report: Groundwater Availability Model for the Dockum Aquifer. Texas Water Development Board Report. October 2008: Figure 4.2.2.

Figure 8.2. Minor Aquifers



(Map courtesy of TWDB)[3]

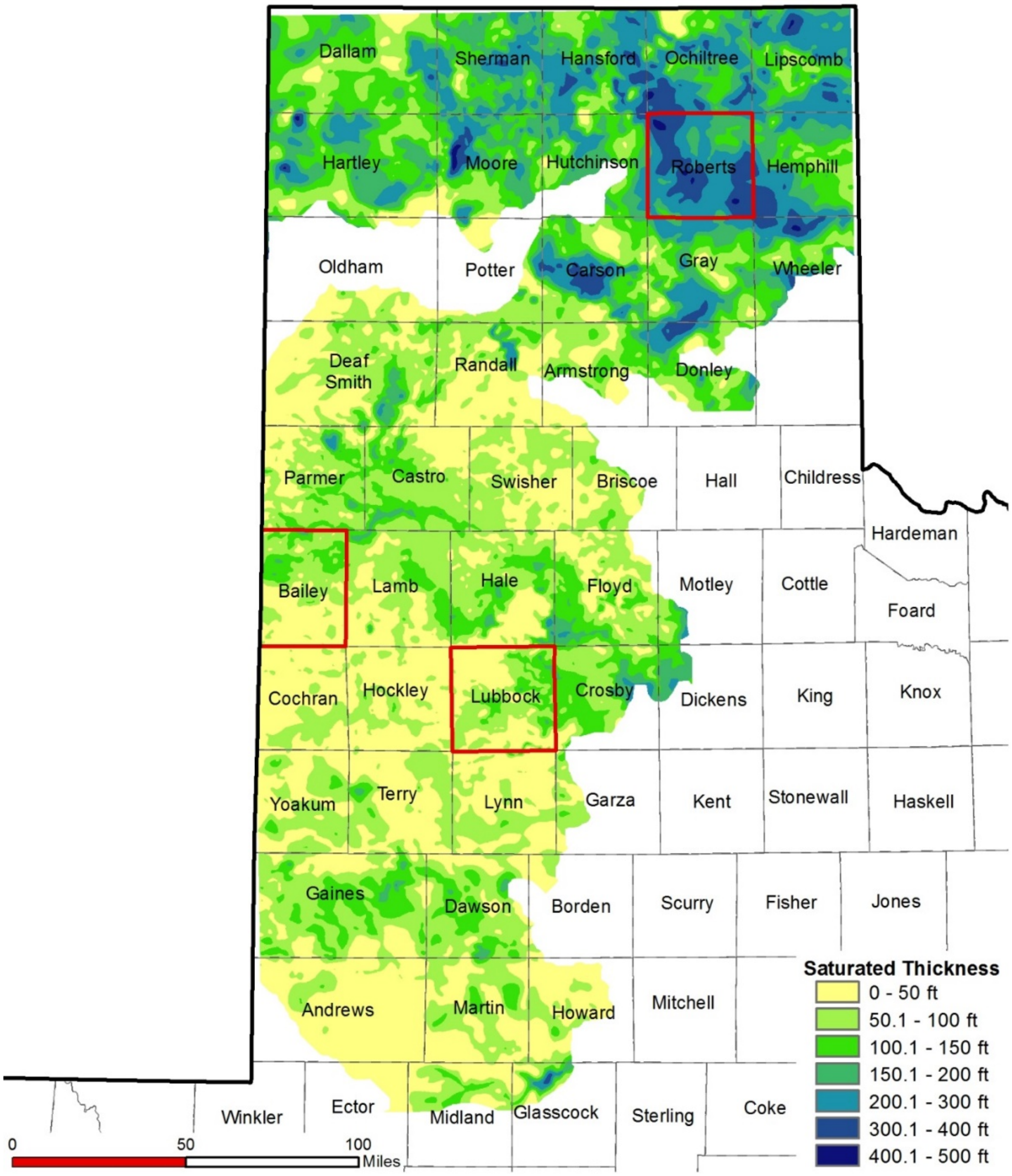
8.1.1 Ogallala Aquifer

The High Plains of Texas lies above the largest groundwater formation in the State of Texas, known as the Ogallala Aquifer. The Ogallala Aquifer has been the main source of potable and agriculture water in the Lubbock region since the early 1900s. Most of the water is used for irrigating crops. Only 5% of the Ogallala Aquifer groundwater on the Southern High Plains is used for domestic purposes.[4] Because of the heavy agricultural pumping on the Southern High Plains for over 100 years, the saturated thickness levels have dropped significantly. Figure 8.3 shows the saturated thickness of the Ogallala Aquifer as of 2008, which is the latest map that is readily available. The figure demonstrates that the portion of the Ogallala Aquifer to the north of Lubbock near Amarillo contains the greatest volumes of groundwater in the Texas portion of the aquifer. Historically, groundwater use in this region has been minor, primarily for cattle operations with windmills pumping relatively small quantities of water into stock tanks.

[3] Ewing, J.E. and others. October 2008. Final Report: Groundwater Availability Model for the Dockum Aquifer. Texas Water Development Board Report. October 2008: Figure 4.2.2.

[4] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: 3-1.

Figure 8.3. Saturated Thickness of the Ogallala Aquifer

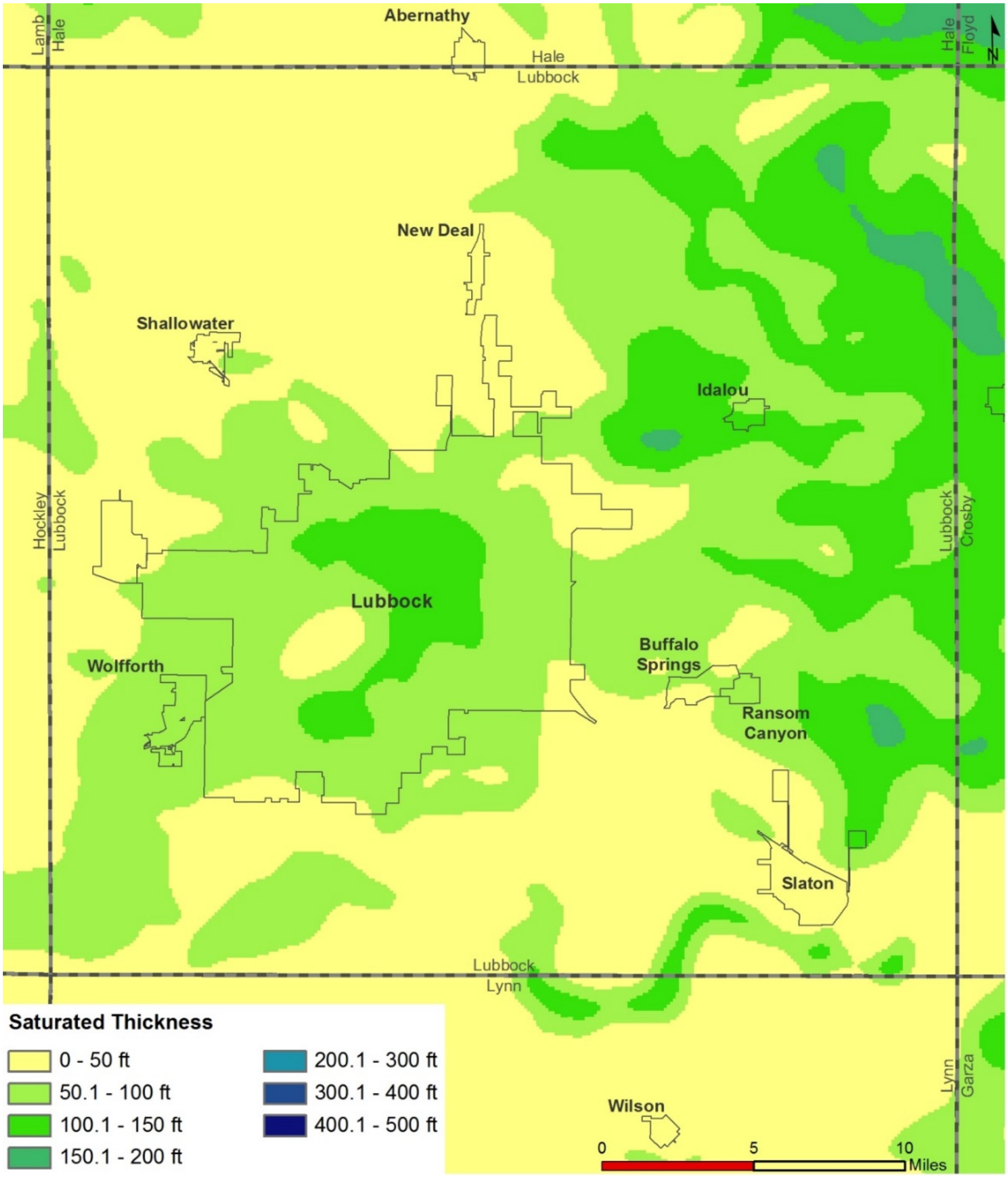


(Data courtesy of the Center for Geospatial Technology at Texas Tech University, 2008)[5]

Figure 8.4 shows the saturated thicknesses of groundwater in Lubbock County. Several studies have evaluated the potential for using the groundwater underlying the City and Lubbock County. However, the saturated thickness of the groundwater in in this area has declined greatly from heavy agricultural irrigation over the past 100 years, and wells in many areas of the county produce less than 30 gallons per minute (gpm). As a result, very little potential exists for long-term and significant development of local groundwater supplies.

[5] Center for Geospatial Technology, Texas Tech University. 2008.

Figure 8.4 Saturated Thickness of the Ogallala Aquifer in Lubbock County

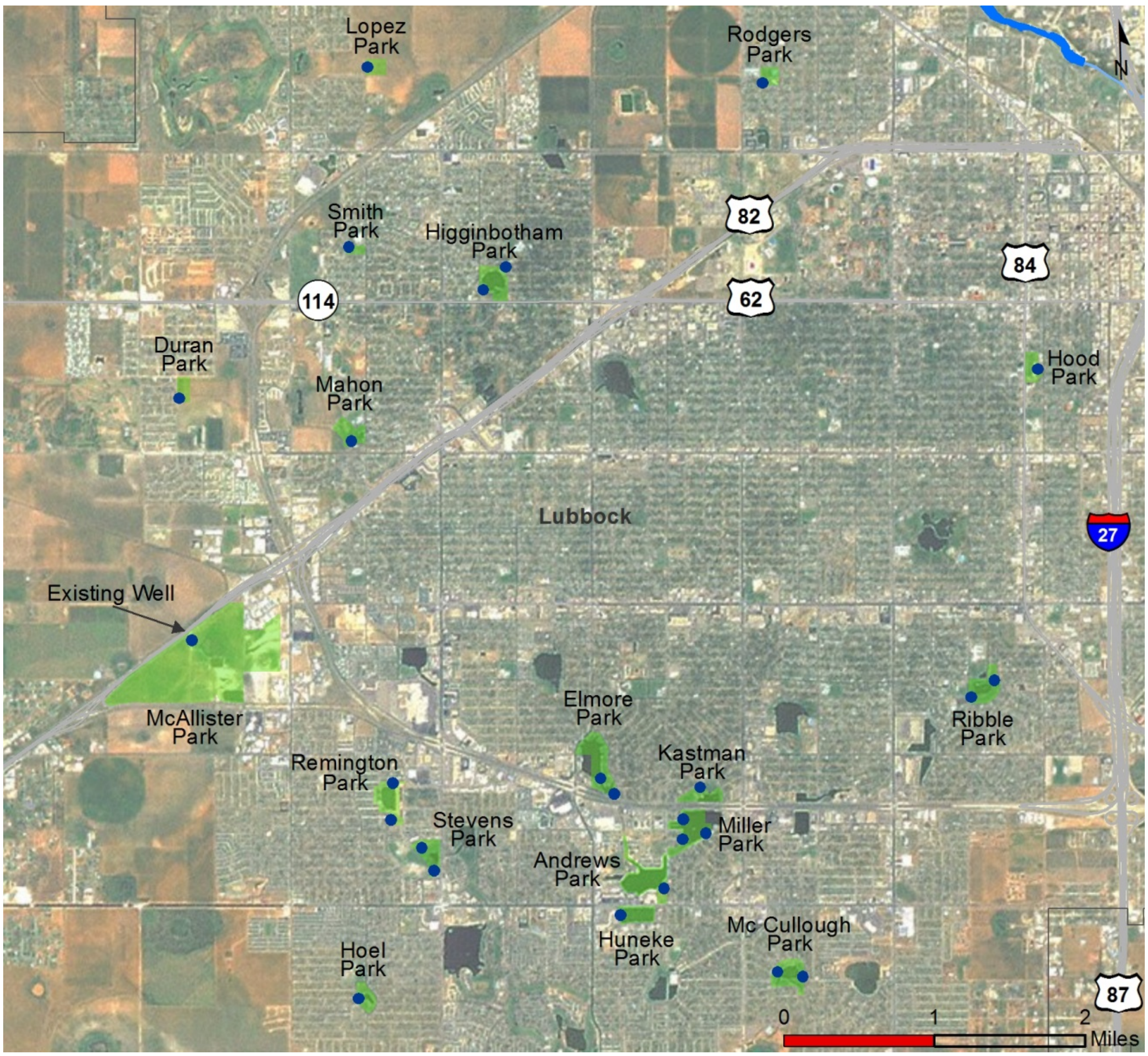


(Data courtesy of the Center for Geospatial Technology at Texas Tech University, 2008)[6]

[6] Center for Geospatial Technology, Texas Tech University. 2008.

The Parks and Recreation Department has historically been among the City's top water users. In 2006, the City evaluated ways to reduce the amount of potable water used to irrigate its parks. Currently (2018), there are 78 City parks with an estimated total water demand of 1.356 billion gallons per year or 4,161 acre-feet per year (ac-ft/yr).[7] Water diverted from the Jim Bertram Lake System (Lake 1) is used to irrigate the Berl Huffman Soccer Complex, as discussed in Section 10.1. It is not feasible to irrigate from the Ogallala Aquifer in 20 of the 78 parks. From 2007 and 2008, 26 water wells were installed throughout 18 City-owned parks (encompassing 319 acres) as depicted in Figure 8.5.

Figure 8.5. Location of Parks with Groundwater Wells



[7] 2007 Strategic Water Supply Plan, City of Lubbock, Section 9.

Due to the production rates of these wells and time-of-day irrigation restrictions at City parks, irrigation of the parks requires supplemental supply from the City's potable water system to operate properly. Over the last five years, this initiative has helped conserve roughly half of the potable water used to irrigate the 18 parks in which wells were installed. The total annual amount of water conserved represents less than 1% of the City's total potable water demand. Table 8.1 shows the volumes of water saved each year since 2008.

Table 8.1. Potable Water Conserved at City Parks

Year	Potable Water Conserved (Well Water Used, ac-ft/yr)	Percent of Total Annual Demand
2008	70.8	0.2%
2009	100.7	0.3%
2010	249.4	0.7%
2011	218.6	0.5%
2012	147.6	0.4%
2013	190.3	0.5%
2014	102.7	0.3%
2015	71.0	0.2%
2016	59.0	0.2%
2017	76.5	0.2%

Note: ac-ft/yr = acre-feet per year

8.1.2 Edwards-Trinity Aquifer

The Edwards-Trinity (High Plains) Aquifer is a Cretaceous-aged minor aquifer located on the Southern High Plains of Texas and New Mexico (see Figure 8.6). The Edwards-Trinity (High Plains) Aquifer spans approximately 9,000 square miles[8] and lies just underneath the Ogallala Aquifer and above the Dockum Aquifer. Approximately 95% of the water pumped from this aquifer is used for irrigation.[9]

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[8] George, P.G., R.E. Mace, and R. Petrossian. Aquifers of Texas. Texas Water Development Board: Report 380. 2011: 101.

[9] George, P.G., R.E. Mace, and R. Petrossian. Aquifers of Texas. Texas Water Development Board: Report 380. 2011: 101.

Figure 8.6. Edwards Trinity Aquifer

(Map courtesy of TWDB)[10]

Figure 8.7 shows a cross-section of the Southern High Plains. The Edwards-Trinity (High Plains) Aquifer is located within the blue Cretaceous layer (for reference, the Ogallala is yellow and the Dockum is purple). In certain locations where the soils are permeable and the dividing formations are thin, water will readily move between the Edwards-Trinity (High Plains) and the Ogallala Aquifers, constituting the main source of recharge for the Edwards-Trinity (High Plains) Aquifer.[11]

There is a limited quantity of water in the Edwards-Trinity (High Plains) Aquifer. The average yield for an Edwards-Trinity (High Plains) well is between 50-200 gpm, with maximum yields reported at over 1,000 gpm.[12] In 2010, the total estimated yield from the Edwards-Trinity (High Plains) was 4,160 ac-ft/yr. This is expected to diminish to 2,065 ac-ft/yr by 2060.[13]

[10] Ewing, J.E. and others. October 2008. Final Report: Groundwater Availability Model for the Dockum Aquifer. Texas Water Development Board Report. October 2008: Figure 4.2.2.

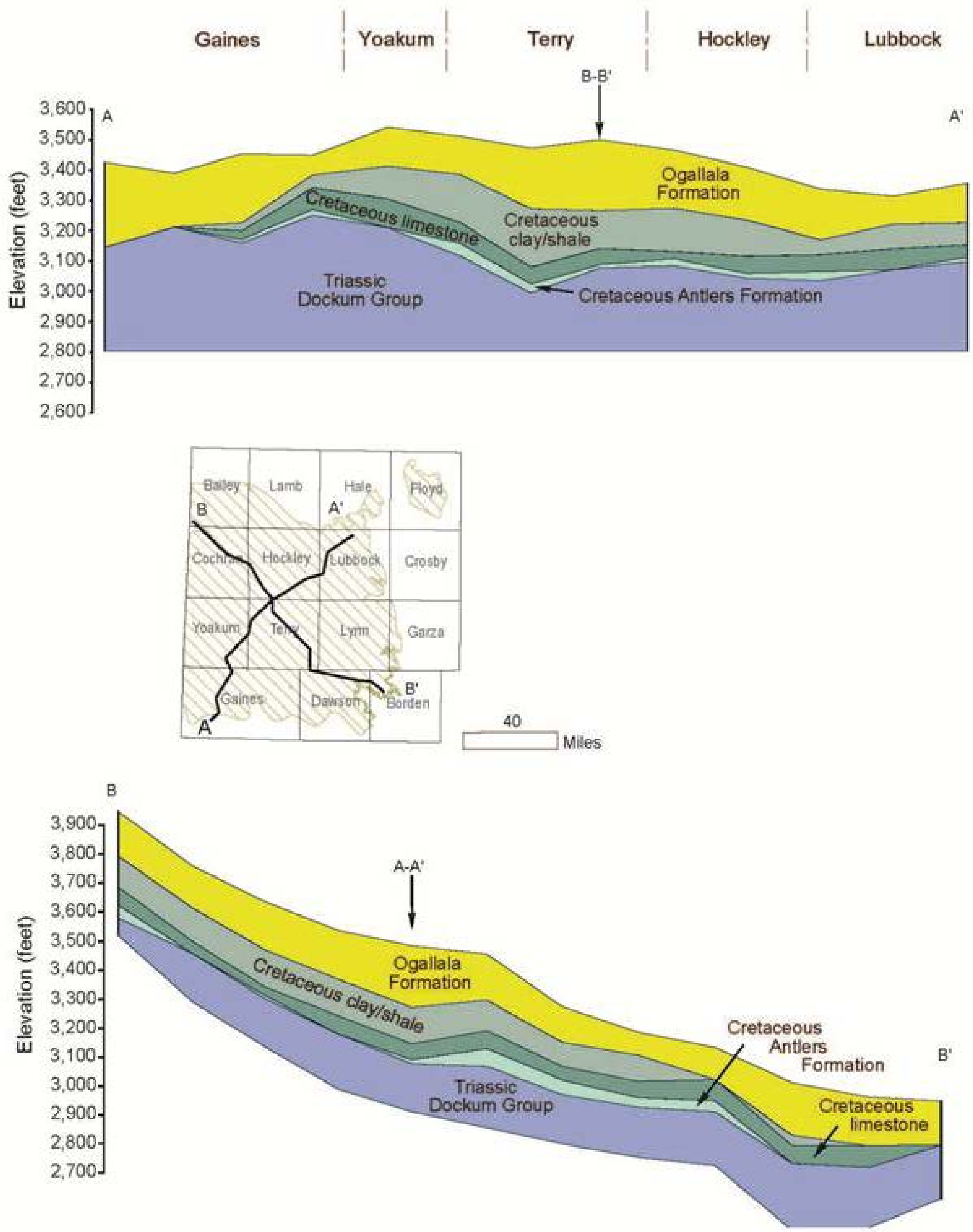
[11] Blanford, T.N., M. Kuchanur, A Standen, K.C. Calhun, P. Kirby, and G. Shah. Edwards-Trinity (High Plains) Groundwater Availability Model. Texas Water Development Board. 2008: 12-13.

[12] Brackish Groundwater Manual for Texas Regional Water Planning Groups. Texas Water Development Board. 2003: 91.

[13] Water for Texas: 2007 State Water Plan. 2007: 169.

Water quality in the Edwards-Trinity (High Plains) varies by location, ranging from fresh to slightly brackish. The typical range for total dissolved solids (TDS) is from 1,000 to 2,000 milligrams per liter (mg/L).[14] However, maximum TDS values can reach 20,000 mg/L in extremely low-quality areas.[15]

Figure 8.7. Cross-Sections of the Southern High Plains

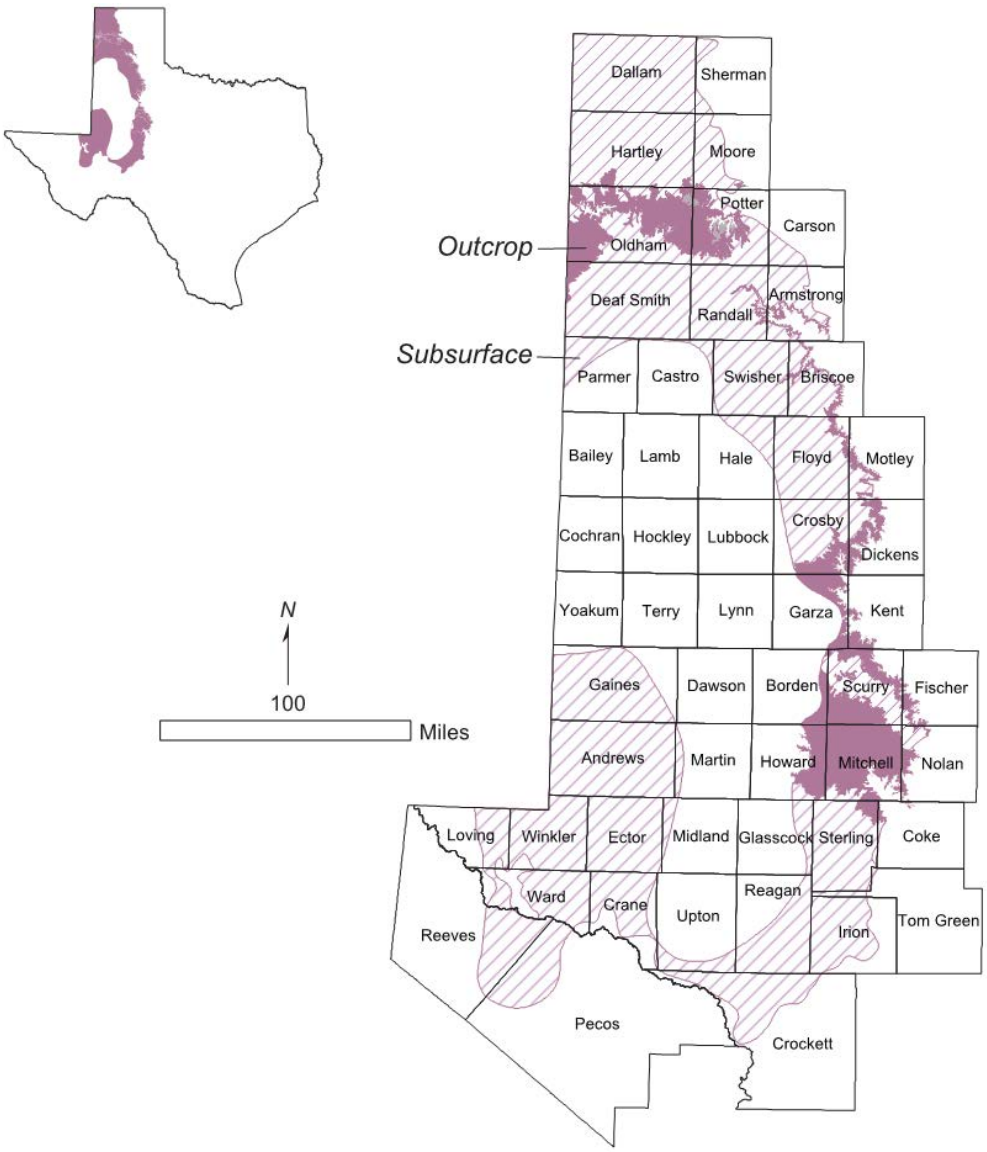


(Map courtesy of TWDB)[16]

8.1.3 Dockum Aquifer

The Dockum Aquifer is a minor aquifer found in the northwest part of Texas, as shown in Figure 8.8. The formation underlies all counties from Castro to Upton, including Bailey and Lubbock counties. However, the figure does not depict the formation under these two counties as being part of the Dockum Aquifer because water quality data shows that the TDS concentrations are greater than 25,000 mg/L. Water of this salinity is not considered to be a potential water supply for most uses.

Figure 8.8. Dockum Aquifer



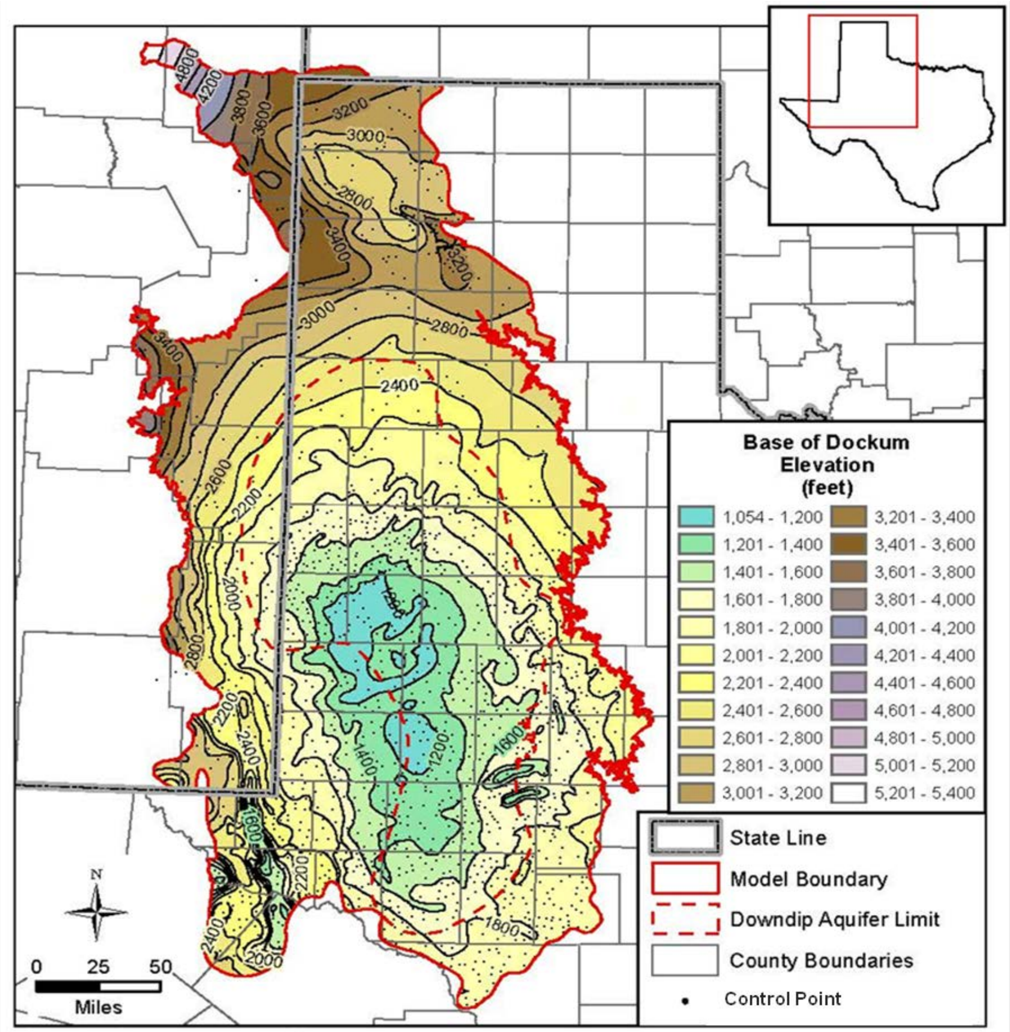
(Map courtesy of TWDB)[17]

[17] George, Peter G. and others. July 2011. Aquifers of Texas. Texas Water Development Board Report 380: 97.

This aquifer is defined stratigraphically as the Dockum Group and includes four formations (from oldest to youngest): the Santa Rosa, the Tecovas, the Trujillo Sandstone, and the Cooper Canyon. The highest groundwater yields come from the Santa Rosa sandstones, which is at the base of the Dockum. The City of Lubbock installed a Dockum test well during 2017 in efforts to further explore this formation as a potential drinking water supply. Data collected from the Dockum test well located at Lubbock's South Water Treatment Plant (SWTP) shows that the base of the aquifer is about 1,420 deep, potential well yields are about 60 gpm, and the concentration of TDS is about 45,000 mg/L. The TWDB's *Final Report: Groundwater Availability Model for the Dockum Aquifer* indicates that there "has not been widespread use of the Dockum Aquifer because of poor water quality, low yields, and deep pumping depth."[18] Because of low use of this aquifer, very little water quality and quantity data exist for the Lubbock region for this formation. Figure 8.9 depicts the base of the Dockum Aquifer, which was prepared during the development of a Groundwater Availability Model (GAM) for the Dockum Aquifer[xix] and is the latest available map.

[18] Final Report: Groundwater Availability Model for the Dockum Aquifer. Texas Water Development Board. October 2008: 1-1.

Figure 8.9. Base of the Dockum Aquifer



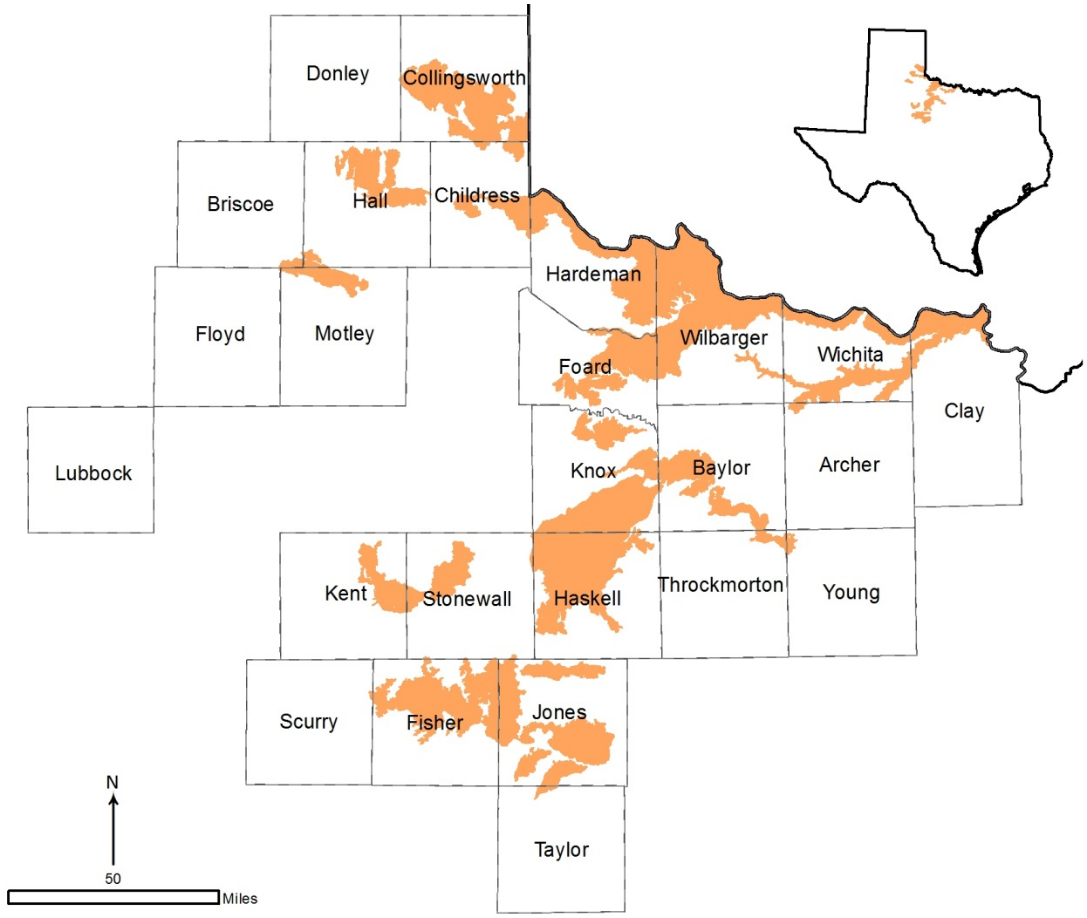
(Map courtesy of TWDB)[19]

8.1.4 Seymour Aquifer

The Seymour Formation is one of the nine major aquifers in Texas, and as shown in Figure 8.10, the formation is located a considerable distance to the east of Lubbock. The water quality and yield of the Seymour Aquifer are inconsistent.

[19] Ewing, J.E. and others. October 2008. Final Report: Groundwater Availability Model for the Dockum Aquifer. Texas Water Development Board Report. October 2008: Figure 4.2.2.

Figure 8.10. Seymour Aquifer



(Map courtesy of TWDB)[20]

8.2 Groundwater Management

8.2.1 Groundwater Conservation Districts

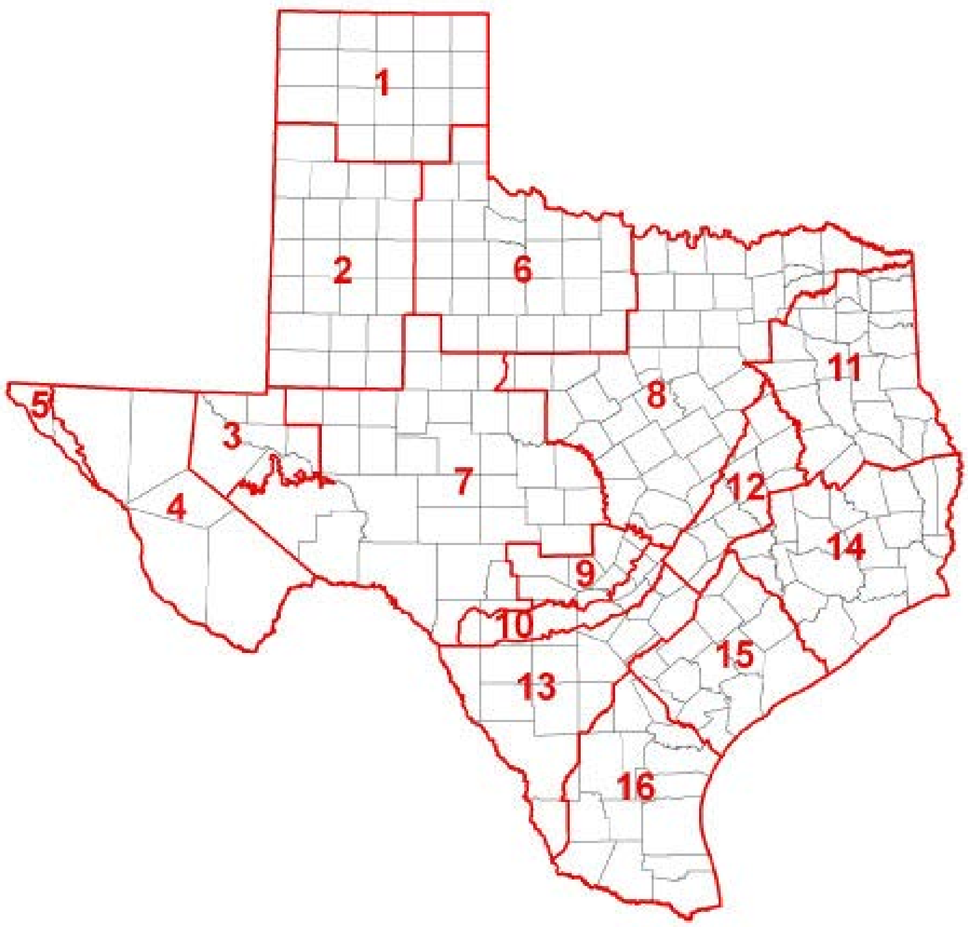
In Texas, groundwater usage is legally recognized as a private property interest subject to the rule of capture and limited by regulation by local Groundwater Conservation Districts (GCDs). There are 98 GCDs in Texas, and GCDs cover nearly 70 percent of the area of the state, including 173 of the 254 Texas counties. Because of the size of many of the aquifers in Texas, numerous conservation districts manage the resources of a given aquifer. For example, Lubbock and Bailey Counties are part of the High Plains Underground Water Conservation District No. 1, while Roberts County is part of the Panhandle GCD.

[20] George, P.G., R.E. Mace, and R. Petrossian. Aquifers of Texas. Texas Water Development Board: Report 380. 2011: 63.

8.2.2 Groundwater Management Areas

In 1995, Groundwater Management Areas (GMAs) were created "in order to provide for the conservation, preservation, protection, recharging, and prevention of waste of the groundwater, and of groundwater reservoirs or their subdivisions, and to control subsidence caused by withdrawal of water from those groundwater reservoirs or their subdivisions, consistent with the objectives of Section 59, Article XVI, Texas Constitution…" (Texas Water Code §35.001). Added by Acts 1995, 74th Leg., ch. 933, §2, eff. Sept. 1, 1995, GMAs made it feasible to establish common groundwater management goals among multiple GCDs. The TWDB was delegated responsibility to delineate GMAs, and subsequently divided Texas into 16 GMAs in 2002 (Figure 8.11). These areas correspond roughly to aquifer boundaries in the State and help State agencies regulate different aspects of groundwater usage.

Figure 8.11. Groundwater Management Areas in Texas



(Map courtesy of TWDB)[21]

[21] Texas Water Development Board Groundwater Management Areas. Online: http://www.twdb.state.tx.us/groundwater/management_areas/

The Texas Legislature mandated that by September 1, 2010, GCDs must establish Desired Future Conditions (DFCs) for aquifers in each GMA. These DFCs may differ across GMAs and impact the amount of groundwater that can be pumped from a given aquifer on an annual basis. Most of Lubbock's current or potential groundwater supplies are located within GMA #1 or #2. In October 2016 GMA #2 officials adopted a DFC for the Ogallala and Edwards-Trinity (High Plains) Aquifers to be an average drawdown between 23 and 27 ft. The drawdown is calculated from the end of 2012 conditions to the year 2070. In Roberts County, GMA #1 officials adopted a DFC of "At least 50 percent of volume in storage remaining in 50 years, for the period 2012-2062".

8.3 Roberts County Well Field Capacity Maintenance Strategy

The Roberts County Well Field (RCWF) produces water from the Ogallala Aquifer. For operational sustainability and flexibility, Canadian River Municipal Water Authority (CRMWA) has a production capacity in the RCWF that is about 30% greater than the capacity of the transmission line from the RCWF to the main CRMWA Aqueduct. The capacity of the RCWF is 84 million gallons per day (mgd); and, the maximum capacity of the transmission line is 65 mgd. As is common in Ogallala well fields, the RCWF's capacity from existing wells declines over time with continued utilization. Eventually, replacement wells become necessary to maintain a given well field capacity.

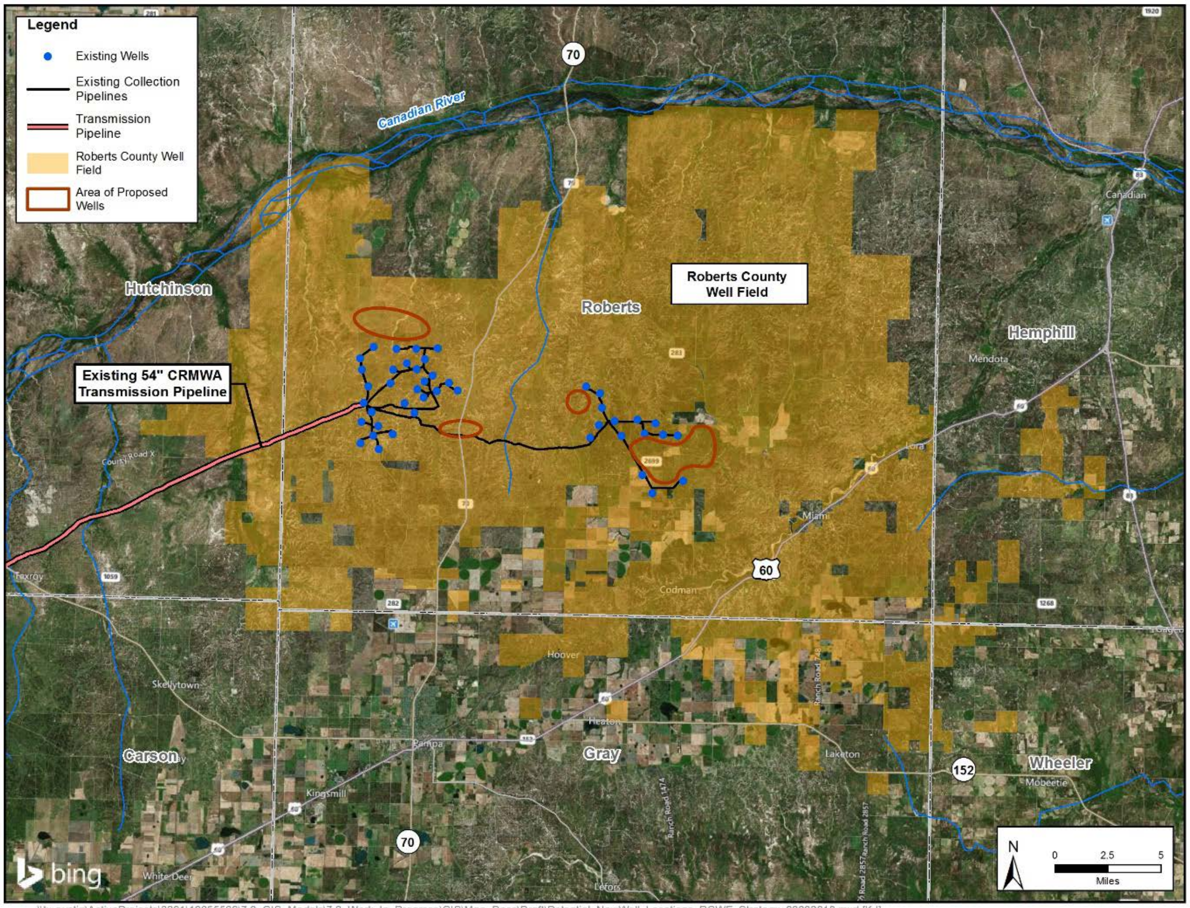
This RCWF Capacity Maintenance (CM) strategy is designed to maintain the RCWF's capacity at 84 mgd. Modeling by Lee Wilson & Associates (a consultant under contract with CRMWA) estimates that 11 replacement wells will be needed approximately every 30 years in order to sustain an average production of 65 mgd and maintain a RCWF peak production capacity of 84 mgd.

The major design features of this strategy include:

- Eleven new wells are constructed to the top of the Red Beds. Overall, they are expected to average about 950 feet deep;
- On average, each well will operate at 1,750 gpm;
- New wells will be located on property where CRMWA holds the interest in groundwater rights; and
- No additional treatment is included in the costs.

Figure 8.12 shows the relative locations of the well field and associated infrastructure needed.

Figure 8.12. Potential New Well Locations for the RCWF Capacity Maintenance Strategy



\\tx-austin\ActiveProjects\3291\10055566\7.0_GIS_Models\7.2_Work_In_Progress\GIS\Map_Docs\Draft\Potential_NewWell_Locations_RCWF_Strategy_08082018.mxd [KJ]

8.3.1 Quantity of Available Water

The RCWF CM strategy is designed to maintain the target RCWF production capacity of 84 mgd. Under this strategy, the City's allocation from CRMWA will remain at 25,570 ac-ft/yr and the transmission line from the RCWF to the CRMWA Aqueduct will remain near capacity (65 mgd) at all times. The wells in this strategy restore the diminished RCWF production capacity by 28 mgd (11 wells producing an average of 1,750 gpm each) before the end of the planning period.

8.3.2 Strategy Costs

Costs associated with this strategy are presented in Table 8.2. Assumptions and conditions associated with these costs include:

- City of Lubbock will pay for 37.058% of the costs for this project, which is the City's allocation of water from CRMWA;
- Engineering, legal, and contingency costs are 35% for facilities required by this strategy;
- Power is available at $0.09 per kilowatt-hour (kwh);

- Interest during construction is 4.0%, and a 1.0% return on investments; and
- The project will be financed for 20-years at a 5.5% interest rate.

As shown, the total project cost is estimated to be $23,603,000. Annual debt service is $1,975,000; and, annual operational cost, including power, is $1,608,000. This results in a total annual cost of $3,583,000. CRMWA project and operational costs are shared amongst the 11 member cities. Lubbock's share of the project is 37.058%, which will result in an annual cost estimated at $1,328,000 and 11,630 ac-ft/yr. This results in a unit cost of $114 per ac-ft, or $0.35 per 1,000 gallons.

8.3.3 Implementation Issues

Environmental Issues

The installation of wells and collection pipelines should be planned so that sensitive habitats, cultural resources, and other environmentally sensitive areas are avoided.

Permitting Issues

Currently, CRMWA owns the groundwater interests in over 450,000 acres of property. Wells will be drilled within this area. CRMWA will need to secure well drilling permits from the Panhandle GCD. The design and construction of public water supply wells and water transmission facilities must be approved by the Texas Commission on Environmental Quality (TCEQ).

Other

Wells will be placed on properties where CRWMA owns the water rights, which include the rights to surface improvements to extract and convey their groundwater.

Table 8.2. RCWF Capacity Maintenance Costs (January 2017 Prices)

Item	Estimated Costs for Facilities	City's portion (37.058%)
CAPITAL COST		
Well Field (11 Wells, Pumps and Piping)	$16,782,000	
TOTAL COST OF FACILITIES	**$16,782,000**	
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$5,874,000	
Environmental & Archaeology Studies and Mitigation	$133,000	
Land Acquisition and Surveying (6 acres)	$15,000	
Interest During Construction (4% for 1 years with a 1% ROI)	$799,000	
TOTAL COST OF PROJECT	**$23,603,000**	**$8,747,000**
ANNUAL COST		
Debt Service (5.5 percent, 20 years)	$1,975,000	$732,000
Operation and Maintenance		
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$168,000	$62,000
Pumping Energy Costs (15,998,442 kwh @ 0.09 $/kwh)	$1,440,000	$534,000
TOTAL ANNUAL COST	**$3,583,000**	**$1,328,000**
Available Project Yield (ac-ft/yr)	31,360	11,630
Annual Cost of Water ($/ac-ft), based on a Peak Factor of 1.0	$114	$114
Annual Cost of Water ($/1,000 gallons), based on a Peak Factor of 1.0	$0.35	$0.35

Notes: ROI = return on investment; kwh = kilowatt-hour; ac-ft/yr = acre-feet per year; $/ac-ft = dollars per acre-foot.

8.4 Bailey County Well Field Capacity Maintenance Strategy

The Bailey County Well Field (BCWF) produces water from the Ogallala Aquifer. The BCWF's production capacity has decreased sharply the last few years because the City has needed to produce more from the BCWF than desired in order to compensate for a reduction in supply originating through the CRMWA system. In 2010, the BCWF's production capacity was 50 mgd. By 2017, the well field's production capacity had dropped to about 30 mgd. The transmission line from the BCWF to the City's distribution system can deliver a peak flow of 40 mgd.

The City has two goals for the BCWF. The first goal is to maintain the 2017 BCWF capacity of 30 mgd. The City's second goal is to reserve the BCWF for meeting peak demand during summer months. In order to effectively meet these goals, it is recommended that the City produce no more than 5,000 ac-ft/yr on a long-term average.[22] The City plans to continually produce 2 mgd from the BCWF to keep the transmission line operational. Under this base load production amount, the City is able to use the BCWF full capacity of 30 mgd for 32 days to meet peaking demands during the summer without exceeding the annual maximum production target of 5,000 ac-ft.

The proposed BCWF CM strategy is intended to replace capacity that is expected to be lost in the future and assist the City in achieving its BCWF goals. It is anticipated that each CM phase will maintain the 30 mgd capacity for 6 years, after which time additional well field maintenance will be needed. The CM phase is based on an HDR analysis completed in 2017, which updated the results from a Daniel B. Stephens & Associates' (DBS&A) October 2012 modeling report.[23] Assuming that new wells will have a production capacity of 200 to 250 gpm, and based on the expected production decline curve from the DBS&A and HDR analyses, 10 replacement wells will be required every 6 years to maintain the production capacity in the BCWF while producing about 5,000 ac-ft/yr. This strategy considers only a 20-year project period for comparison to other strategies in this Plan.

The major design features of this strategy include:

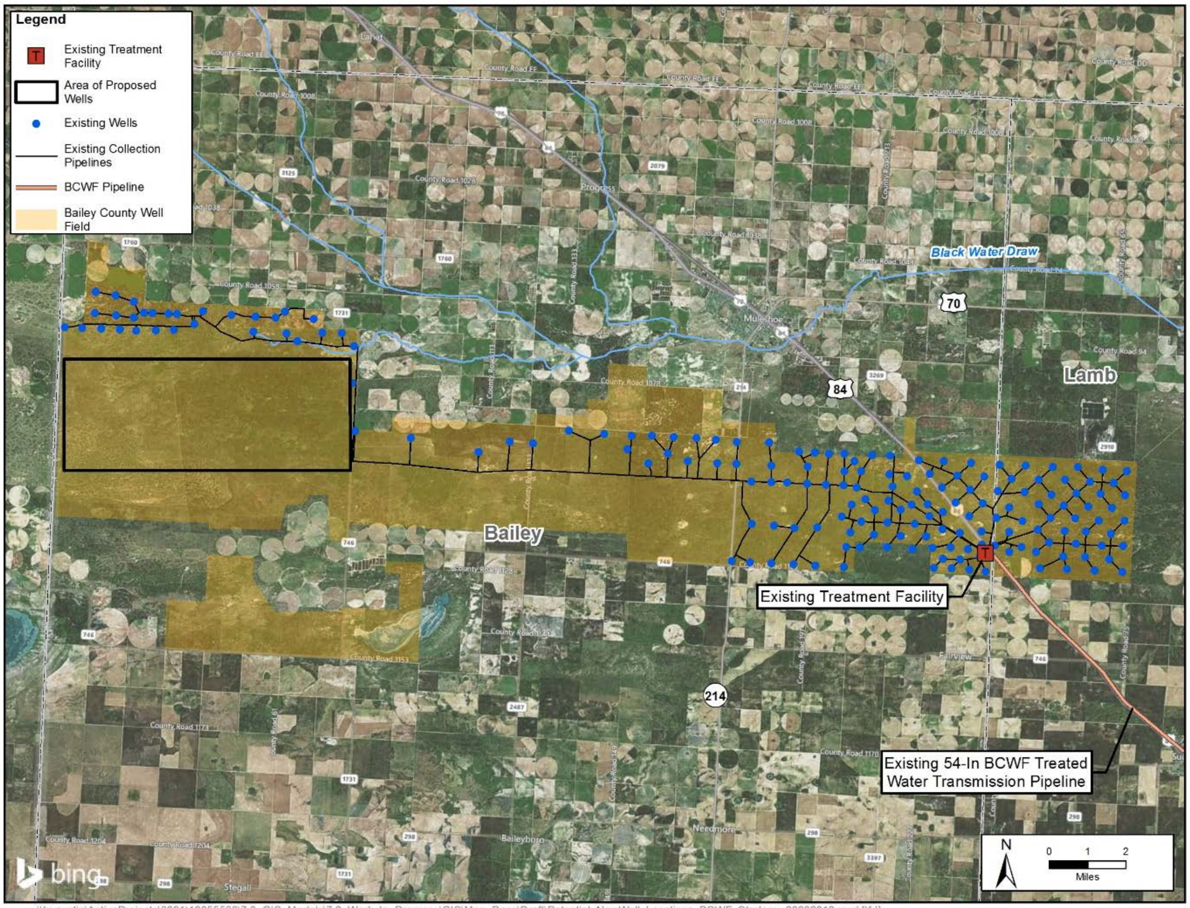
- Construction of ten 200-gpm wells every 6 years;
- Wells are assumed to be constructed to a depth of 220 feet and operate at an average of 200 gpm;
- Wells are located on properties where the City holds existing water rights;
- No additional treatment is required;
- Approximately 5.3 miles of 6-inch to 16-inch diameter collection pipe is required for each CM phase; and Well pumps will be sized to deliver the water to terminal storage at the east end of the well field, with a delivery pressure of 30 pounds per square inch (psi) at the connection to the original well field.

Figure 8.13 shows the relative locations of the well field and associated infrastructure needed.

[22] Updated Bailey County Well Field Modeling Report, Daniel B. Stephens & Associates. September 2012: 6.

[23] Updated Bailey County Well Field Modeling Report, Daniel B. Stephens & Associates. September 2012: 7.

Figure 8.13. Potential New Well Locations for BCWF Capacity Maintenance Strategy



\\tx-austin\ActiveProjects\3291\10055566\7.0_GIS_Models\7.2_Work_In_Progress\GIS\Map_Docs\Draft\Potential_NewWell_Locations_BCWF_Strategy_08082018.mxd [KJ]

8.4.1 Quantity of Available Water

The BCWF CM strategy is designed to maintain the current BCWF production capacity of 30 mgd. Under this strategy, the City will produce an average of 5,000 ac-ft/yr of water from the BCWF, consisting of 2 mgd base load throughout the year, and peaking supply of 30 mgd for about 30 days each year. Each CM phase will consist of installing 10 wells, providing 2.88 mgd (10 wells at approximately 200 gpm each) of capacity to offset overall capacity declines from the system. The current well field consists of 175 active wells. By cycling the wells and not overpumping any single well, an average of 28.6 ac-ft/yr can be considered to be supplied from each well. Assuming that some wells will go out of service as water levels decline, then the future supply made available by each new well can conservatively be estimated to be 28.6 ac-ft/yr. Therefore, each set of 10 new wells will provide an average supply of 286 ac-ft/yr.

8.4.2 Strategy Costs

Costs associated with this strategy are presented in Table 8.3. Assumptions and conditions associated with these costs include:

- Capital cost for wells and related infrastructure is based on estimates provided by Parkhill, Smith and Cooper engineer;
- Capital cost of collector pipelines is calculated by the unified costing model that is used for strategies in the Regional Water Plans;
- Engineering, legal, and contingency costs are 35% for facilities constructed for this strategy;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

As shown in Table 8.3, the total project costs every 6 years for CM is estimated to be $4,328,000. Annual debt service is $362,000; and, annual operational cost, including power, is $39,000, resulting in a total annual cost of $401,000 for the 6 wells. The unit cost for the 2.88 mgd peak capacity and 286 ac-ft/yr supply is estimated to be $1,402 per ac-ft, or $4.30 per 1,000 gallons.

Table 8.3. BCWF Capacity Maintenance Costs (January 2017 Prices)

Item	Estimated Costs for Facilities
CAPITAL COST	
Wells (10 Wells at 200 gpm)[1]	$1,821,000
Well Collection System (5.3 mi - 6, 8, 12, 16-in dia)	$1,065,000
TOTAL COST OF FACILITIES	**$2,886,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies	$1,010,000
Env & Archaeology Studies and Mitigation	$133,000
Easement and Surveying	$15,000
Interest During Construction (4% for 2 yrs 1% ROI)	$284,000
TOTAL COST OF PROJECT	**$4,328,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$362,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks	$29,000
Pumping Energy Costs (111,111 kwh @ 0.09 $/kwh)	$10,000
TOTAL ANNUAL COST	**$401,000**
Available Project Yield (ac-ft/yr)	286
Annual Cost of Water ($ per ac-ft)	$1,402
Annual Cost of Water ($ per 1,000 gallons)	$4.30

Notes: ROI = return on investment; kwh = kilowatt-hour; ac-ft/yr = acre-feet per year; $/ac-ft = dollars per acre-foot.

1. Unit cost for wells and related infrastructure is based on estimate provided by Parkhill, Smith and Cooper, Inc.

8.4.3 Implementation Issues

Environmental Issues

The installation of wells and collection pipelines should be planned and installed so that sensitive habitats, cultural resources, and other environmentally sensitive areas are avoided.

Permitting Issues

The City already owns groundwater rights on 83,305 acres of contiguous property, and wells will be drilled within this area. The City will need to acquire permits from the High Plains Underground Conservation District No. 1, and the design and construction of public water supply wells and water transmission facilities must be approved by the TCEQ.

Other

Wells will be placed on properties where the City owns the water rights, which include the rights to surface improvements to extract and convey the groundwater. The City will need to negotiate work with surface owners to accommodate the surface operations and plans. Future CMs (CM-1, CM-2, etc.) would be implemented every six years to maintain the BCWF capacity.

8.5 Roberts County Well Field - New Transmission Line to Aqueduct Strategy

CRMWA is planning to expand its groundwater supplies through expansion of the RCWF by expanding the well field and well field transmission pipeline capacity for delivery to the CRMWA Aqueduct. Currently a 54-inch diameter transmission line with a 65-mgd capacity delivers water from the RCWF west toward Borger and then south to Amarillo. The capacity of the CRMWA Aqueduct between Amarillo and Lubbock is 53 mgd. A proposed new 54-inch diameter transmission line is being planned using a new right-of-way to deliver water to the CRMWA Aqueduct on the north side of Amarillo. Additional wells will be necessary to increase the RCWF production capacity to fully utilize the increased pipeline capacity. Eventually, replacement wells will be necessary to maintain the proposed RCWF production capacity. For purposes of this strategy, Lee Wilson & Associates, a consultant under contract with CRMWA, states that 19 wells will initially be required; and, by 2045, an additional 17 wells in three increments will be required to maintain the target production capacity of 63,000 ac-ft/yr.

Two 54-inch diameter transmission lines (one existing and one planned) delivering water from the RCWF could deliver a peak supply of 130 mgd to the CRMWA Aqueduct (65 mgd from each pipeline). The City’s portion would be 48.2 mgd (37.058% of the total CRMWA-produced water available). The City’s current allocation is approximately 42 mgd.

The major design features of this strategy include:

- Thirty-six new Ogallala Aquifer wells constructed to the top of the Red Beds, which is estimated to average about 950 feet and operating at 1,750 gpm per well. Nineteen (19) wells will be drilled in the initial construction phase. Seventeen (17) wells will be added in three increments;
- Collector pipelines and ground storage tank at pump station to beginning of transmission pipeline;
- Approximately 67 miles of 54-inch diameter transmission pipeline; and
- A ground storage tank and pump station at the well field and at one booster pump station. Both are sized for 65 mgd.

Figure 8.14 depicts the relative locations of the well field, new wells, transmission lines, and associated infrastructure needed.

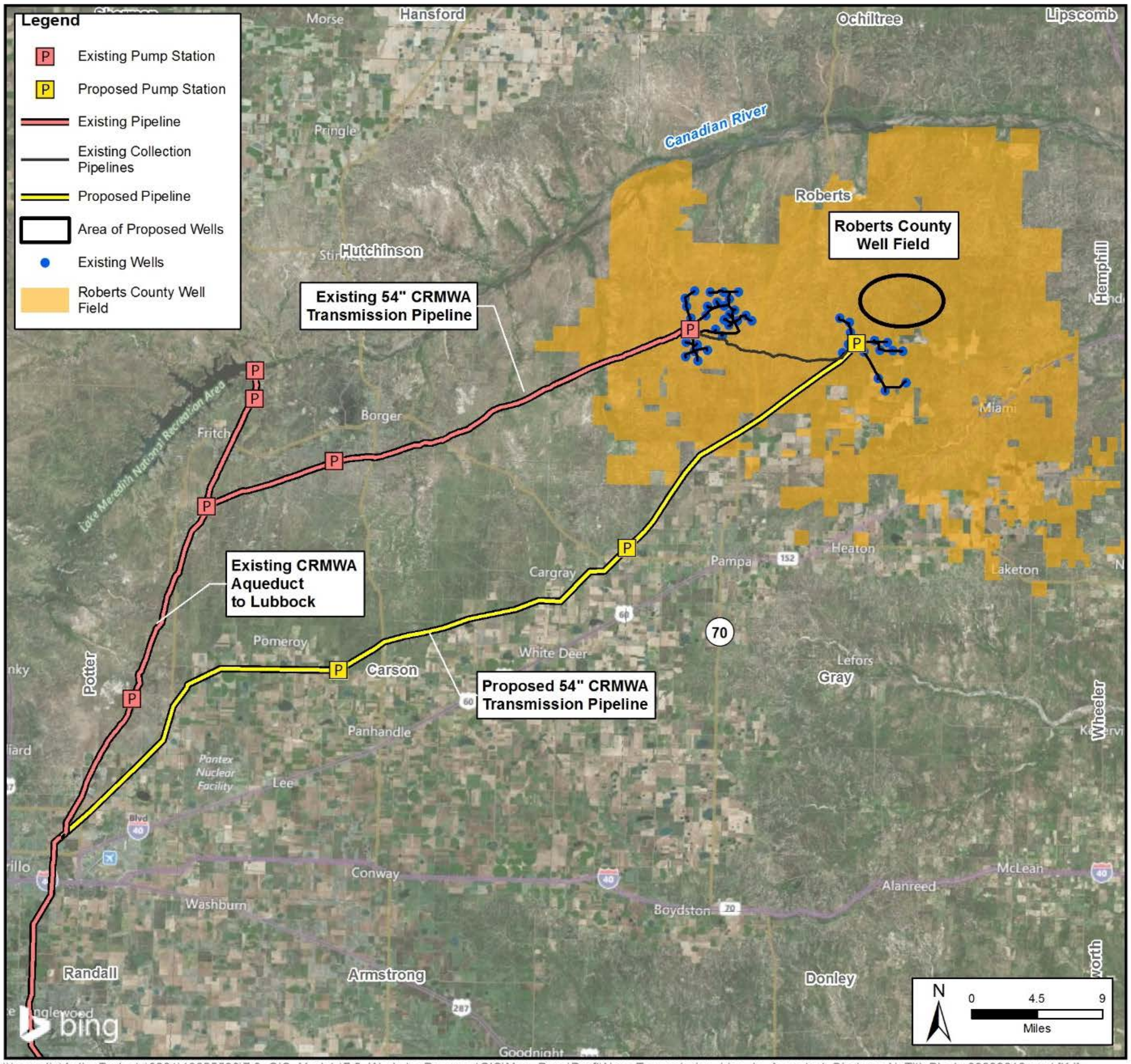
8.5.1 Quantity of Available Water

It is assumed that CRMWA will operate the new transmission line between RCWF and the CRMWA Aqueduct at 80% of its 65-mgd capacity (58,240 ac-ft/yr). Therefore, the City’s incremental increase in annual allocation from CRMWA will be 21,583 ac-ft/yr (65 mgd x 1120 ac-ft/yr/mgd x 0.8 x 0.37058). The City's portion of the total CRMWA-produced water available is 37.058%. Consequently, the CRMWA Aqueduct between Plainview and Lubbock will be flowing near its peak capacity of 53 mgd with the City's portion of the peak capacity of 42 mgd. Under this strategy, Lubbock's total CRMWA allocations are as follows:

Lubbock's current CRMWA allocation:	24,088 ac-ft/yr
Additional supply with new transmission line:	21,583 ac-ft/yr
Lubbock's updated CRMWA supply:	45,671 ac-ft/yr

Maintaining the target quantity of water in the future will require a production CM program of adding new wells to account for reduced wells yields due to declining groundwater levels. For purposes of this strategy, estimated CM costs are included for a 50-year planning period.

Figure 8.14. RCWF – New Transmission Line to Aqueduct Strategy



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8.5.2 Strategy Costs

Costs associated with this strategy are presented in Table 8.4. Assumptions and conditions associated with these costs include:

- The City will pay for 37.058% of the costs for this project;
- Capital costs provided by CRMWA were used instead of the Unified Costing Model. A review of the capital costs indicates that they are very similar to those that would be developed by the Unified Costing Model.
- All new wells are located on property for which CRMWA owns the water rights, and the authority to build facilities on the surface to develop and transport the water;

- Engineering, legal, and contingency costs are 35% for facilities required by this strategy;
- Power is available at $0.09 per kwh;
- Interest during construction is 4.0%, and a 1.0% return on investments; and
- The project will be financed for 20-years at a 5.5% interest rate.

Table 8.4. RCWF New Transmission Line to Aqueduct Costs (Jan 2017 Prices)

Item	Estimated Costs for Facilities	City's portion (37.058%)
CAPITAL COST		
Pump Stations (65 mgd)	$34,696,000	
Transmission Pipeline (54 in dia.)	$137,924,000	
Transmission Storage Tank(s)	$4,283,000	
Well Fields (36 Wells, Pumps, and Piping)	$55,189,000	
TOTAL COST OF FACILITIES	**$232,092,000**	
Engineering Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$74,336,000	
Environmental & Archaeology Studies and Mitigation	$2,050,000	
Land Acquisition and Surveying (468 acres)	$1,242,000	
Interest During Construction (4% for 2 years with a 1% ROI)	$21,681,000	
TOTAL COST OF PROJECT	**$331,401,000**	**$122,811,000**
ANNUAL COST		
Debt Service (5.5 percent, 20 years)	$27,731,000	$10,277,000
Operation and Maintenance		
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$1,974,000	$732,000
Pump Stations (2.5% of Cost of Facilities)	$867,000	$321,000
Pumping Energy Costs (191,408,704 kwh @ 0.09 $/kwh)	$17,227,000	$6,384,000
TOTAL ANNUAL COST	**$47,799,000**	**$17,713,000**
Available Project Yield (ac-ft/yr)	58,240	21,583
Annual Cost of Water ($/ac-ft), based on a Peaking Factor of 1.0	$821	$821
Annual Cost of Water ($/1,000 gallons), based on a Peaking Factor of 1.0	$2.52	$2.52

Notes: mgd = million gallons per day; ROI = return on investment; kwh = kilowatt-hour; ac-ft/yr = acre-feet per year; $/ac-ft = dollars per acre-foot.

As shown, the total project cost is estimated to be $331,401,000 for facilities to provide the full capacity of 65 mgd. Annual debt service is $27,731,000, and annual operational cost, including power, is $20,068,000. This results in a total annual cost of $47,799,000. The unit cost for the average annual supply is $821/ac-ft or $2.52 per 1,000 gallons.

These costs are for delivery of water to Lubbock's terminal storage reservoir and not for any subsequent treatment or transmission from the North Water Treatment Plant (NWTP). The supply and costs from this strategy will be shared by other CRMWA members. Lubbock's annual cost will be $17,713,000.

8.5.3 Implementation Issues

Environmental Issues

The installation of wells and collection pipelines should be planned so that sensitive habitats, cultural resources, and other environmentally sensitive areas are avoided. CRMWA should seek to minimize environmental impact when planning the route for the new 54-inch transmission pipeline.

Permitting Issues

Currently, CRMWA owns the groundwater interests in over 450,000 acres of property and wells will be drilled within this area. CRMWA will need to secure permits from the Panhandle GCD and the design and construction of public water supply wells and water transmission facilities must be approved by the TCEQ.

Other

Wells will be placed on properties where CRWMA owns the water rights, which include the rights to surface improvements to extract and convey their groundwater. An easement is currently being acquired for the new transmission pipeline.

9 Aquifer Storage and Recovery

Aquifer storage and recovery (ASR) can generally be defined as increasing recharge into an aquifer system and subsequently recovering all or a portion of the amount recharged into the aquifer system at a later date. An effective ASR program requires a source of supply to be recharged and a compatible aquifer system in which to store the water. Sources of supply may include surface water, groundwater, or reclaimed water.

ASR is a water supply strategy that can be used to 1) work around seasonal bottlenecks in the delivery system; 2) protect surface water from high evaporation rates (water loss); and 3) provide an engineered buffer for potable reuse of reclaimed water. ASR can be used for long-term storage of water, with recovery occurring during times of drought to supplement or replace existing supplies, or it can be used for short-term storage and used to supplement existing supplies during peak demand periods.

The source water must be treated to a level so as not to impair the water quality of the receiving aquifer and to avoid subsequent fouling of ASR well screens and the subsurface formation of the receiving aquifer. The source water and receiving aquifer must also be chemically compatible to avoid unwanted chemical reactions. ASR typically is accomplished using dual-purpose wells, which both inject and recover the stored water, but can also be accomplished with a combination of injection and separate recovery wells depending on the goals of the system and the hydrogeologic setting.

9.1 CRMWA to Aquifer Storage & Recovery Strategy

This ASR strategy will store water purchased from Canadian River Municipal Water Authority (CRMWA) during the fall, winter, and spring in the Ogallala Aquifer and recover the water during summer months. The ASR project aids in balancing the CRMWA deliveries by increasing the deliveries during periods of relatively low winter demands and decreasing demands on the CRMWA system during the summer. The raw CRMWA water will be delivered to the North Water Treatment Plant (NWTP), treated, delivered, and injected into a new ASR well field about two miles east of the NWTP. Later, this water will be recovered and delivered to the NWTP site, disinfected, and blended with other treated water from CRMWA for distribution. The framework for this option follows a 2011 CDM Smith report titled *Canadian River Municipal Water Authority Aquifer Storage and Recovery Facility: Project Delivery Plan.*[1] The strategy is also discussed in detail in the City of Lubbock's (City's) 2015 *Aquifer Storage and Recovery (ASR) Evaluation*[2] report prepared by HDR.

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[1] Canadian River Municipal Water Authority Aquifer Storage and Recovery Facility: Project Delivery Plan. CDM Smith. 2011.

[2] HDR Engineering, 2015. Aquifer Storage and Recovery (ASR) Evaluation, Engineering Report for City of Lubbock.

The major design features of this strategy include:

- Raw water from CRMWA sources are treated at NWTP;
- A new pump station at the NTWP delivers treated water directly to ASR wells in the well field for injection;
- Installation of 45 Ogallala Aquifer ASR wells with an injection capacity of about 350 gallons per minute (gpm) and a production capacity of about 500 gpm. Six of the ASR wells are considered to be contingency or standby wells;
- Installation of 34 Ogallala Aquifer production wells with a capacity of about 500 gpm. Five of the production wells are considered to be contingency or standby wells;
- ASR and production wells spacing is about ¼ mile or greater;
- Distribution of ASR wells is more concentrated on west side of well field to compensate for the slight easterly downdip in aquifer storage zone;
- Well pumps delivering recovered water to the NWTP; and
- Recovered water is disinfected and blended with treated water from the CRMWA supply and pumped into the distribution system.

Figure 9.1shows the relative locations of the ASR and production wells and associated infrastructure. Figure 9.2 shows a schematic of the ASR system.

Figure 9.1. CRMWA to Aquifer Storage and Recovery Infrastructure

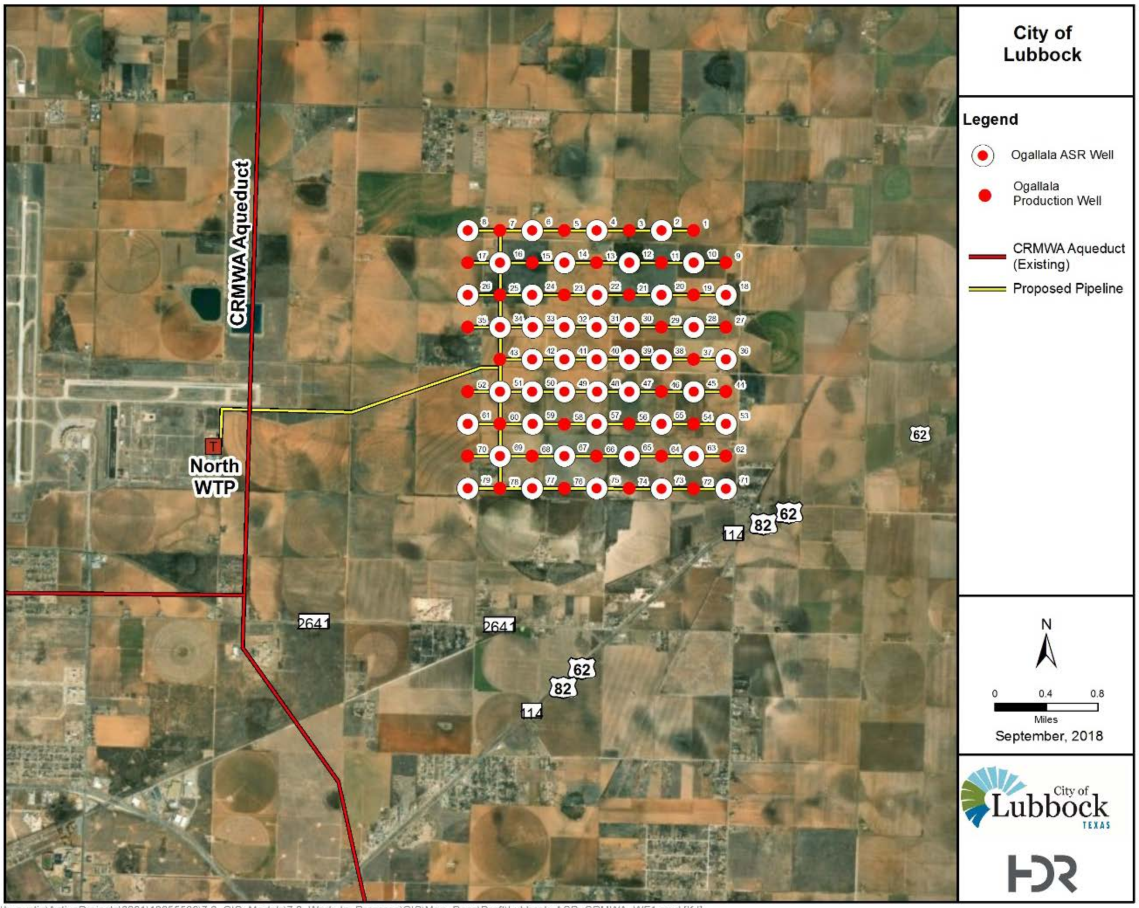

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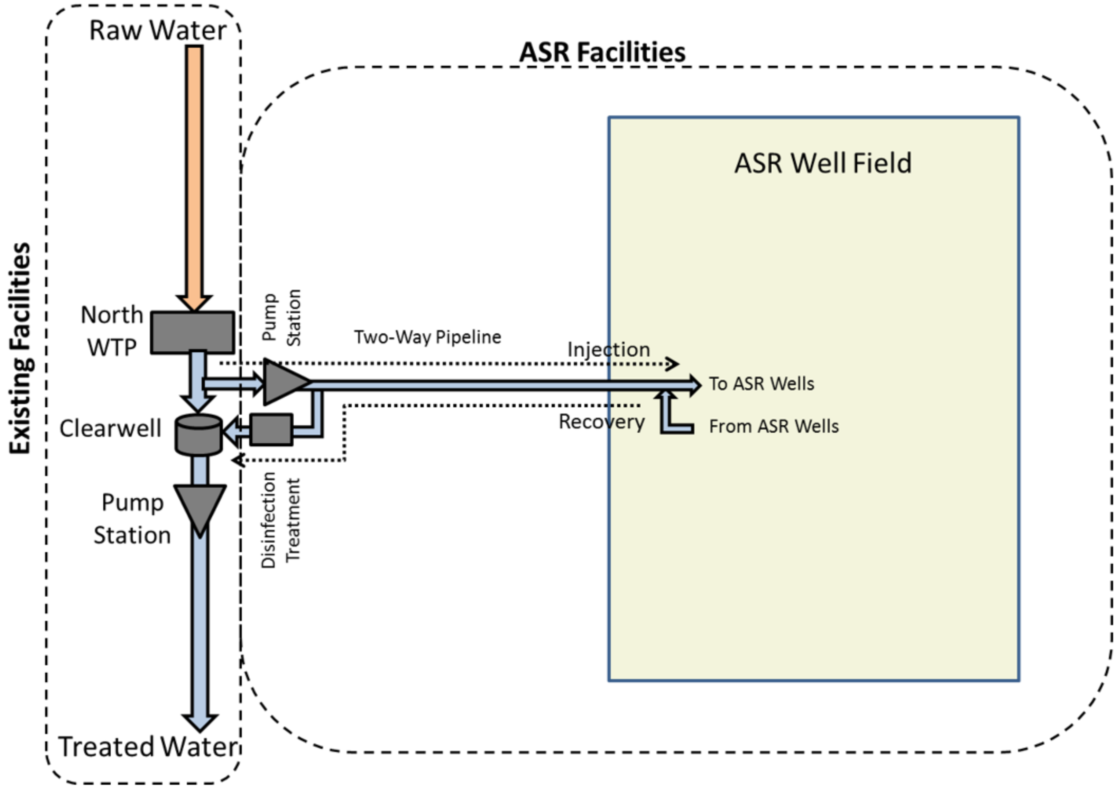
Figure 9.2. ASR System Schematic



9.1.1 Quantity of Available Water

The option assumes that the new transmission line from the Roberts County Well Field (RCWF) to the CRMWA Aqueduct will be built (see Section 8.5). It also assumes that Lubbock's average unused seasonal capacity in the CRMWA aqueduct is 19.5 million gallons per day (mgd). For evaluation purposes, the system is assumed to operate under recharge conditions for six months of the year (November through April), recovery conditions for 2.5 months (mid-June through August) and remain idle for the remaining time (May to mid-June, September and October). This results in an average of 10,920 acre-feet per year (ac-ft/yr) of water available for ASR storage. To recover this same amount in 2.5 months, a 48.8-mgd system would be designed and would be used to supplement the City's peak-day supplies. The assumptions used in this evaluation will need to be revisited during a more detailed project-specific feasibility study.

Depending on groundwater levels, nearby pumping, and stored volume, some of this stored supply may be lost to other wells; however, the option assumes recovery operations will pump the same total volume as recharge. As a result, there may be a minor blend of native groundwater and stored treated CRMWA supplies near the end of the recovery cycle. This assumption is based on native groundwater being suitable for a public supply.

At many ASR sites, forming and maintaining a buffer zone around an ASR well or well field has been found effective at controlling subsurface geochemical reactions so that recovered water quality is similar to injected water quality. Initial ASR well testing in the Lubbock area would determine whether the same beneficial results would be achieved locally, minimizing or avoiding the need for pre- or post-treatment of the water in ASR storage.

9.1.2 Strategy Costs

Costs associated with this strategy are presented in Table 9.1. Assumptions and conditions associated with these costs include:

- On average a high-capacity Ogallala Aquifer production well for the target area is expected to be able to produce about 500 gpm and have an injection capacity of about 350 gpm;
- The depth to the base of the Ogallala Aquifer is about 160 feet;
- CRMWA raw water treatment prior to ASR would occur during November to April when there is unused capacity in the NWTP;
- Property acquisition for the ASR well field will be approximately 3,200 acres;
- A new pump station at the NWTP will deliver the treated water to the ASR well field through a two-way transmission pipeline;
- The well field will include 45 Ogallala Aquifer ASR wells. Six of the wells are considered to be contingency or standby wells;
- The well field will include 34 Ogallala Aquifer production wells. Five of the production wells are considered to be contingency or standby wells;
- The well spacing is 1,320 feet or greater;
- Well pumps would deliver recovered water back to the NWTP through the two-way transmission pipeline;
- The recovered water would be disinfected and delivered to the NWTP clearwell for blending with treated water from the CRMWA supply. Then, the blended water would be pumped into the distribution system through the NWTP high service pump station;
- The ASR system would be operated with advanced Supervisory Control and Data Acquisition (SCADA) and variable speed well pumps. During peak recovery period, wells may be operated in rotation to maintain target groundwater levels in the well field;
- The well field will include 15 monitoring wells;
- The migration of the injected water is expected to be minimal;
- Costs for raw water treatment at the existing NWTP were not considered. Water will be treated and delivered from November through April when there is unused capacity in the NWTP;
- Property for the ASR well field can be purchased for $2,500 per acre (inclusive of water rights), which is twice the average of rural lands in this part of the state;
- Engineering, legal, and contingency costs is 30% of pipelines and 35% for other facilities;
- Power is available at $0.09 per kilowatt-hour (kwh);
- Interest during construction is 4.0%, and a 1.0% return on investments; and
- The project will be financed for 20-years at a 5.5% interest rate.

Table 9.1. CRMWA to Aquifer Storage and Recovery Costs (January 2017)

Item	Estimated Costs for Facilities
CAPITAL COST	
Pump Station at Water Treatment Plant (19.5 mgd)	$2,459,000
Transmission Pipeline (54 in dia., 2 miles)	$3,564,000
Well Field (48 Combination Wells, 31 Production Wells, Pumps, and Piping)	$46,266,000
Disinfection Treatment	$948,000
SCADA and Integration	$1,669,000
TOTAL COST OF FACILITIES	**$54,906,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$19,039,000
Environmental & Archaeology Studies and Mitigation	$8,662,000
Land Acquisition and Surveying (3,227 acres)	$8,860,000
Interest During Construction (4% for 2 years with a 1% ROI)	$6,403,000
TOTAL COST OF PROJECT	**$97,870,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$8,190,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$499,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$61,000
Water Treatment Plant	$569,000
Pumping Energy Costs (0.09 $/kwh)	$398,000
TOTAL ANNUAL COST	**$9,717,000**
Available Project Yield (ac-ft/yr)	10,920
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 5.0	$890
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 5.0	$2.73

Notes: mgd = million gallons per day; SCADA = Supervisory Control and Data Acquisition; ROI = return on investment; kwh = kilowatt-hour; ac-ft/yr = acre-feet per year.

As shown, the total project cost is estimated to be $97,870,000. Annual debt service is $8,190,000; and, annual operational cost, including power, is $1,527,000. This results in a total annual cost of $9,717,000. The unit cost for a 10,920 ac-ft/yr peaking supply is estimated to be $890 per ac-ft, or $2.73 per 1,000 gallons. This cost does not include the cost of water from CRMWA nor the water treatment prior to storage in the ASR well field, because the NTWP will require no expansion to provide this treatment.

9.1.3 Implementation Issues

Environmental Issues

The installation of wells and collection pipelines should be planned and installed so that sensitive habitats, cultural resources, and other sensitive areas are avoided.

Permitting Issues

The High Plains Underground Water Conservation District No. 1 (HPUWCD) likely would have no permitting authority of the ASR injection or production wells as long as there is a net positive balance of recoverable water in the storage zone.

Other

The City does not own groundwater rights in this area. Groundwater rights will need to be purchased so that water within the recharge area can be controlled by the City.

9.2 Reclaimed Water Aquifer Storage and Recovery to North WTP Strategy

The Reclaimed Water ASR to NWTP Strategy will treat and transport reclaimed water from the Southeast Water Reclamation Plant (SEWRP) to an ASR facility located northeast of the City, near the NWTP. Treated supplies would be conveyed through a new 20-inch diameter, 7.3 mile pipeline to the ASR well field. The reclaimed water will then be injected into the Ogallala Aquifer and then recovered approximately 0.25 miles downgradient to the east. The recovered water will be delivered to the NWTP for disinfection and blending with other treated water from CRMWA for distribution to customers. Recharge into ASR is assumed to occur uniformly throughout the year. The injected water will be closely monitored as it migrates downgradient over 1-2 years to the recovery well field to allow for soil aquifer treatment and residence time.

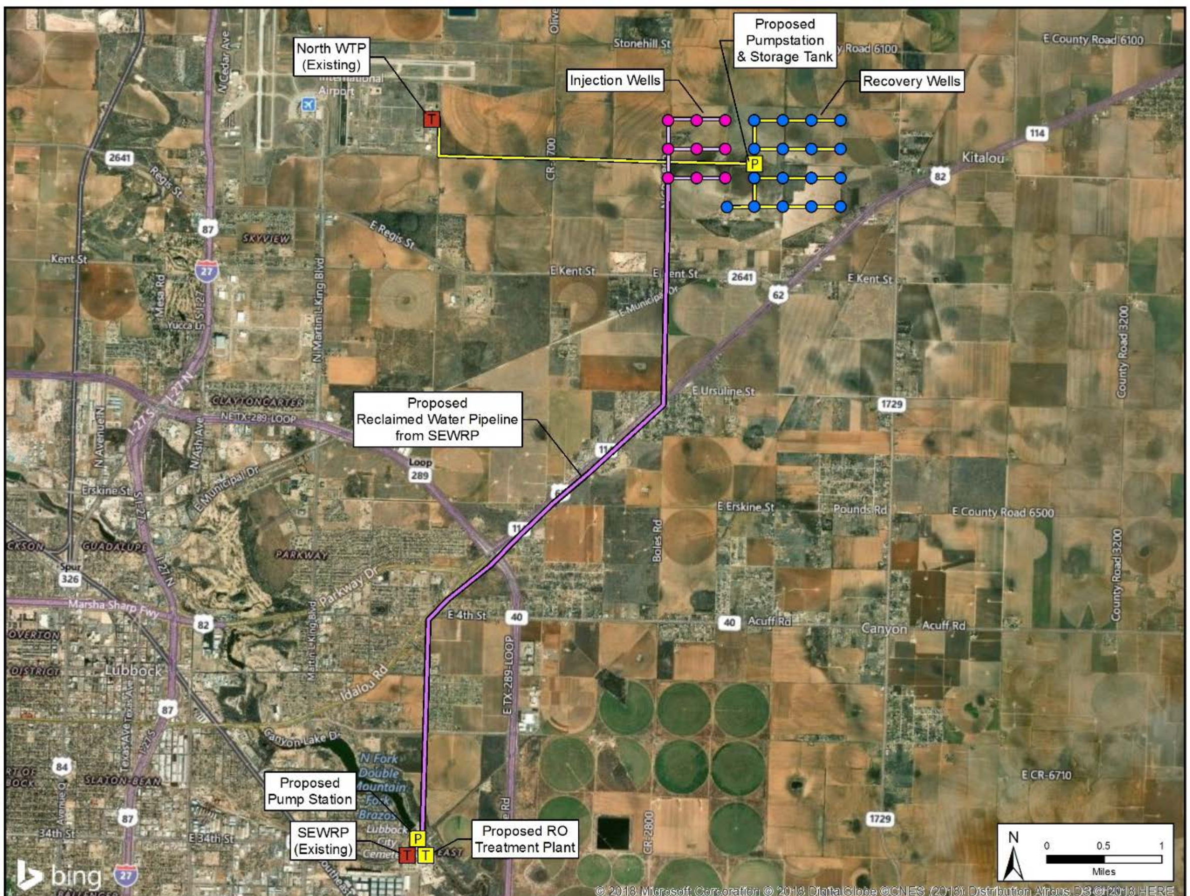
The major design features of this strategy include:

- Nine Ogallala ASR injection wells (500 gpm) with spacing of 1,320 feet or greater, including two contingency or standby wells;
- Seventeen 250 gpm ASR recovery wells constructed at about 160 feet deep with horizontal spacing of 1,320 feet or greater , including three contingency or standby wells;
- 7.3 mile pipeline from SEWRP to the ASR Well Field;
- A new 18-in, 2.5 mile pipeline to deliver the recovered water to the NWTP. A booster pump station and ground storage are included for delivery to the NWTP;
- An expansion of the NWTP is necessary for additional chlorine disinfection;
- Assume SEWRP upgrades for biological nutrient removal (BNR) have been completed;

- 3.5 mgd reverse osmosis (RO) treatment to reduce total dissolved solids (TDS) to less than 500 milligrams per liter (mg/L) from the SEWRP effluent prior to injection in the Ogallala;
- RO concentrate (0.5 mgd) will be stream discharged; and
- Requires a two year piloting program prior to Texas Commission on Environmental Quality (TCEQ) acceptance of the soil aquifer treatment. Piloting project will include treatment to reduce nitrate and TDS, one 500 gpm recharge well, one recovery well, and one monitoring well. The location of the recovery well will provide a travel time of 30 days to evaluate water quality through soil aquifer treatment.

Figure 9.3 depicts the relative locations of the Reclaimed Water ASR wells and associated infrastructure.

Figure 9.3. Reclaimed Water Aquifer Storage and Recovery to NWTP Infrastructure



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9.2.1 Quantity of Available Water

This Reclaimed Water ASR to NWTP Strategy assumes that up to 5 mgd of reclaimed water will be sent to the ASR and recovered. The final supply of 5 mgd (5,600 ac-ft/yr) will be blended and distributed at the NWTP.

9.2.2 Strategy Costs

Costs associated with this strategy are presented in Table 9.2. Assumptions and conditions associated with these costs include:

- Property for the well field can be purchased for $2,500 per acre, which is twice the average of rural lands in this part of the state;
- The depth to the base of the Ogallala Aquifer is about 160 feet;
- Additional costs for well field SCADA, valves and pump controls were included in the strategy costs;
- Engineering, legal, and contingency costs is 30% of pipelines and 35% for other facilities;
- Power is available at $0.09 per kwh;
- Interest during construction is 4%, and a 1% return on investments;
- The project will be financed for 20-years at a 5.5% interest rate; and
- The project is assumed to have a 2-year construction period.

As shown, the total cost is estimated to be $54,806,000. The pilot project costs for two years are estimated at $4,762,000. Annual debt service is $4,586,000; and, annual operational cost, including power, is $2,904,000. This results in a total annual cost of $7,490,000. The unit cost for 5,600 ac-ft/yr of supply at the NWTP is estimated to be $1,388 per ac-ft, or $4.10 per 1,000 gallons. This cost does not include the distribution of the potable water from the NWTP to potential customers.

Table 9.2. Reclaimed Water Aquifer Storage and Recovery to NWTP Costs

Item	Estimated Costs for Facilities
Pump Stations (5.3 mgd)	$4,309,000
Transmission Pipeline (20 in dia., 7 miles, and 18 in dia., 2.5 miles)	$5,749,000
Well Fields (Wells, Pumps, and Piping)	$10,314,000
RO Treatment (3.5 mgd) and Disinfection (5 mgd)	$10,766,000
SCADA and Integration	$714,000
TOTAL COST OF FACILITIES	**$31,852,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$10,884,000
Pilot Project (Infrastructure and Program costs)	$4,762,000
Environmental & Archaeology Studies and Mitigation	$2,070,000
Land Acquisition and Surveying (714 acres)	$1,964,000
Interest During Construction (4% for 2 years with a 1% ROI)	$3,274,000
TOTAL COST OF PROJECT	**$54,806,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$4,586,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$162,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$108,000
Water Treatment Plant	$2,065,000
Pumping Energy Costs (6316900 kwh @ 0.09 $/kwh)	$569,000
TOTAL ANNUAL COST	**$7,490,000**
Available Project Yield (ac-ft/yr)	5,600
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1	$1,338
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$4.10

Notes: mgd = million gallons per day; SCADA = Supervisory Control and Data Acquisition; ROI = return on investment; kwh = kilowatt-hour; ac-ft/yr = acre-feet per year.

9.2.3 Implementation Issues

Environmental Issues

The installation of wells and collection pipelines should be planned and installed so that sensitive habitats, cultural resources, and other sensitive areas are avoided.

Permitting Issues

TCEQ requires a Direct Potable Reuse (DPR) process that provides 5.5, 6, and 8 log reduction for crypto, giardia, viruses,[3] respectively at the recharge wellhead. For the proposed ASR to be permitted, TCEQ will require a demonstration project to claim soil aquifer treatment credits. The recharge well will require an Experimental Class V injection well authorization for piloting the treatment effectiveness.

The recharge piloting would likely take 2 years to accumulate the operational and sampling data necessary to support a Class V ASR injection well permit for non-drinking water and for TCEQ approval to recover the water through water wells for treatment in the existing NWTP.

Because the recharge water would not reliably meet drinking water standards prior to injection, the ASR injection well would likely need an individual Class V authorization, which would require public notice and might require one or more public hearings. The HPUWCD would have no permitting authority of the ASR injection or production wells as long as there is a net positive balance of recoverable water in the storage zone.

The design and construction of public water supply wells and water transmission facilities must be approved by the TCEQ. There may also be permitting obligations pursuant to Texas Water Code depending upon regulatory characterization of the associated return flows.

9.3 Reclaimed ASR to SWTP

The Reclaimed Water ASR to South Water Treatment Plant (SWTP) Strategy will treat and transport reclaimed water from the SEWRP to an ASR facility located near the SWTP. Treated supplies would be conveyed through the existing transmission system to the Hancock Land Application Site (HLAS) after the site is decommissioned then delivered to the ASR well field. The reclaimed water will be injected into the Edwards-Trinity High Plains (ETHP) Aquifer and recovered approximately 1 mile downgradient to the east. The recovered water will be delivered to the SWTP for disinfection and blending with other treated water from Lake Alan Henry for distribution to customers. Recharge into ASR is assumed to occur uniformly throughout the year. Losses will be minimal and it is assumed that nearly all of the original 5 mgd of reclaimed supply could be recovered down gradient after 1-2 years of residence time in the aquifer.

The major design features of this strategy include:

- Seventeen ETHP ASR recharge wells with spacing of 700 feet or greater , including three contingency or standby wells;

[3] TWDB, “Direct Potable Reuse Resource Document”. April 2015. 3-10

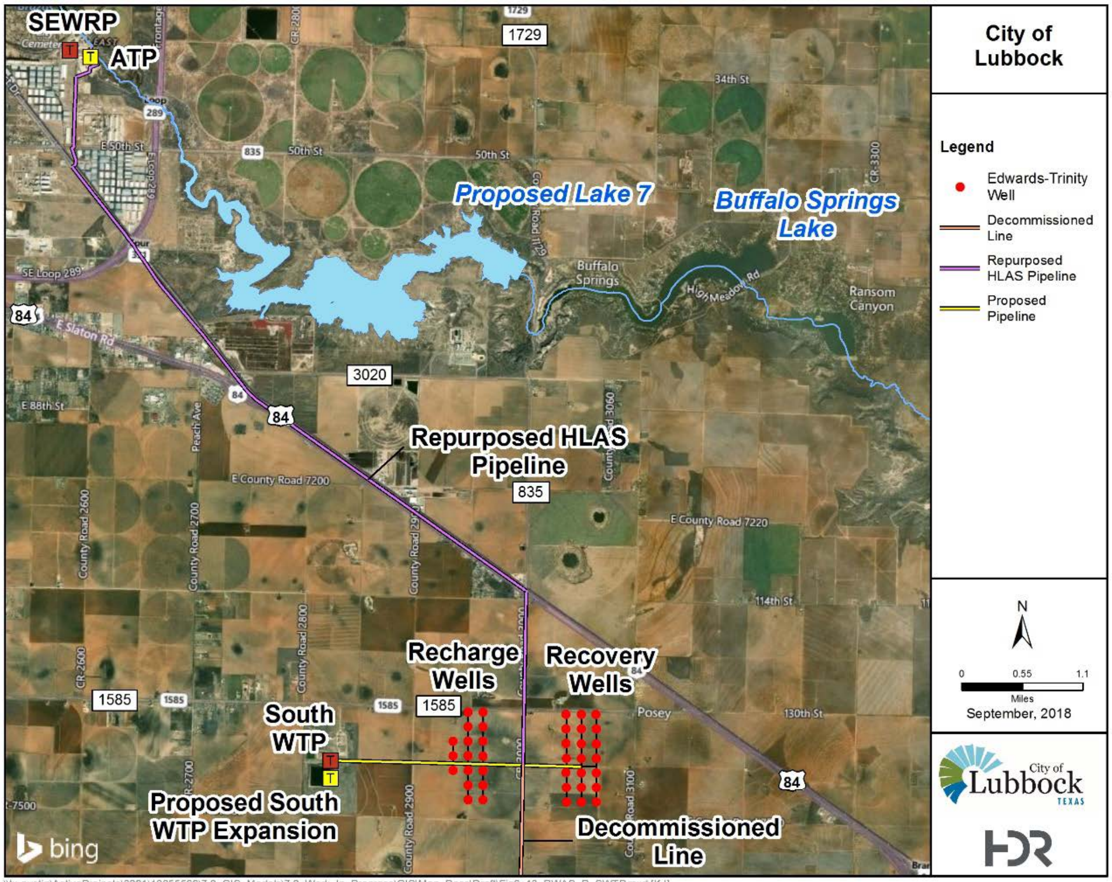
- Twenty-one ASR recovery wells with horizontal spacing of 700 feet or greater, including three contingency or standby wells;
- A total of 10 monitoring wells will be constructed within the recharge and recovery well fields;
- A 6 mgd advanced ATP at the Lubbock SEWRP with stream discharge of RO concentrate;
- A booster pump station to deliver the reclaimed water from the ground storage to ASR wells for injection;
- A new 18-in, 2mile pipeline to deliver the recovered water to the SWTP. Due to the relatively small quantity of water being recovered, a booster pump station and ground storage were not deemed necessary for delivery to the SWTP;
- A 5 mgd expansion of the SWTP and associated expansion of the high service pump station at the SWTP;
- A 4.5-mile, 30-in Low Head C Transmission pipeline to allow flow from the SWTP to reach Pumping Station (PS) 16 or Bailey County groundwater to flow to PS 14 (see Figure 4.11); and
- A 15 mgd Low Head C Pump Station to transfer water from the SWTP to PS 16.

Figure 9.4 depicts the relative locations of the Reclaimed Water ASR wells and associated infrastructure.

9.3.1 Quantity of Available Water

This Reclaimed Water ASR to SWTP Strategy assumes that up to 5 mgd (5,600 ac-ft/yr) of reclaimed water will be recovered from the ASR well field.

Figure 9.4. Reclaimed Water Aquifer Storage and Recovery to SWTP Infrastructure



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9.3.2 Strategy Costs

Costs associated with this strategy are presented in Table 9.3. Assumptions and conditions associated with these costs include:

- The existing transmission system for the decommissioned HLAS will be repurposed for delivery of purified water to the ASR project. This repurposed use is dependent on the future use of this line by Xcel Energy and for the existing outfall;
- Property for the well field can be purchased for $2,500 per acre, which is twice the average of rural lands in this part of the state;
- The depth to the base of the ETHP Aquifer is about 250 feet;
- Additional costs for well field SCADA, valves and pump controls were included in the strategy costs;
- Engineering, legal, and contingency costs is 30% of pipelines and 35% for other facilities;
- Power is available at $0.09 per kwh;
- Interest during construction is 4%, and a 1% return on investments;
- The project will be financed for 20-years at a 5.5% interest rate; and

- The project is assumed to have a 2-year construction period.

As shown, the total cost is estimated to be $133,592,000. Annual debt service is $11,179,000; and, annual operational cost, including power, is $3,847,000. This results in a total annual cost of $15,026,000. The unit cost for 5,600 ac-ft/yr of supply at the SWTP is estimated to be $2,683 per ac-ft, or $8.23 per 1,000 gallons.

Table 9.3. Reclaimed Water Aquifer Storage and Recovery to SWTP Costs (January 2017 Prices)

Item	Estimated Costs for Facilities
Transmission Pipeline (18 in dia., 2 miles)	$955,000
Low Head C Transmission Pipeline	$9,393,000
Low Head C Pump Station	$12,000,000
Well Fields (Wells, Pumps, and Piping)	$12,552,000
South Water Treatment Plant Expansion (5 mgd)	$12,058,000
Advanced Treatment Plant (5 mgd)	$41,443,000
SCADA and Integration	$1,751,000
TOTAL COST OF FACILITIES	**$90,152,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$31,036,000
Environmental & Archaeology Studies and Mitigation	$1,904,000
Land Acquisition and Surveying (663 acres)	$1,760,000
Interest During Construction (4% for 2 years with a 1% ROI)	$8,740,000
TOTAL COST OF PROJECT	**$133,592,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$11,179,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$230,000
Pump Stations (2.5% of Cost of Facilities)	$300,000
Water Treatment Plant	$2,506,000
Pumping Energy Costs (9007965 kwh @ 0.09 $/kwh)	$811,000
TOTAL ANNUAL COST	**$15,026,000**
Available Project Yield (ac-ft/yr)	5,600
Annual Cost of Water ($ per ac-ft), based on a Peaking Factor of 1	$2,683
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$8.23

Notes: mgd = million gallons per day; SCADA = Supervisory Control and Data Acquisition; ROI = return on investment; kwh = kilowatt-hour; ac-ft/yr = acre-feet per year.

9.3.3 Implementation Issues

Environmental Issues

The installation of wells and collection pipelines should be planned and installed so that sensitive habitats, cultural resources, and other environmentally sensitive areas are avoided.

Permitting Issues

The City does not own the land or groundwater rights in the area of interest. Groundwater rights and/or land will need to be purchased so wells can be drilled within the proposed ASR area. The HPUWCD would have no permitting authority of the ASR injection or production wells as long as there is a net positive balance of recoverable water in the storage zone.

The City will need to acquire an ASR permit through TCEQ (rules still under development) and notice the HPUWCD. The design and construction of public water supply wells and water transmission facilities must be approved by the TCEQ. There may also be permitting obligations pursuant to Texas Water Code depending upon regulatory characterization of the associated return flows.

The drinking water produced for the project will meet or exceed all state and federal drinking water standards. The TCEQ is currently developing potable reuse guidance requirements to be applied to proposed projects and to be used as the basis for reviewing permit applications. TCEQ will require a pilot study prior to regulatory approval and for determining design values for the treatment technologies. Treatment requirements for any reclaimed water as a drinking water source may consider the pretreatment program, influent wastewater quality, vulnerability assessment of the collection system, results of effluent quality sampling/monitoring data, and wastewater treatment process.

Disposal of residuals from the project would meet all state and federal requirements for discharge of waste. A Texas Pollutant Discharge Elimination System (TPDES) permit will be required to discharge RO concentrate. The water quality for RO concentrate discharged into the North Fork of the Double Mountain Fork (NFDMF) of the Brazos River will meet or exceed the stream standards for that segment.[4]

Stream crossings would be subject to Section 404 of the Clean Water Act. Due to the minimal and temporary impacts associated with the pipeline installation, it is likely that most of the proposed project would be authorized by Nationwide Permit 12.

Monitoring is likely to include Cryptosporidium (or a surrogate organism), other regulated contaminants, and may include contaminants on the U.S. Environmental Protection Agency (USEPA) Candidate Contaminate List (CCL), including Emerging Constituents of Concern (ECCs) and pharmaceuticals and personal care products (PPCPs).

[4] City of Lubbock, "Potable Water Reuse Implementation Feasibility Study". March 2017. 7-9.

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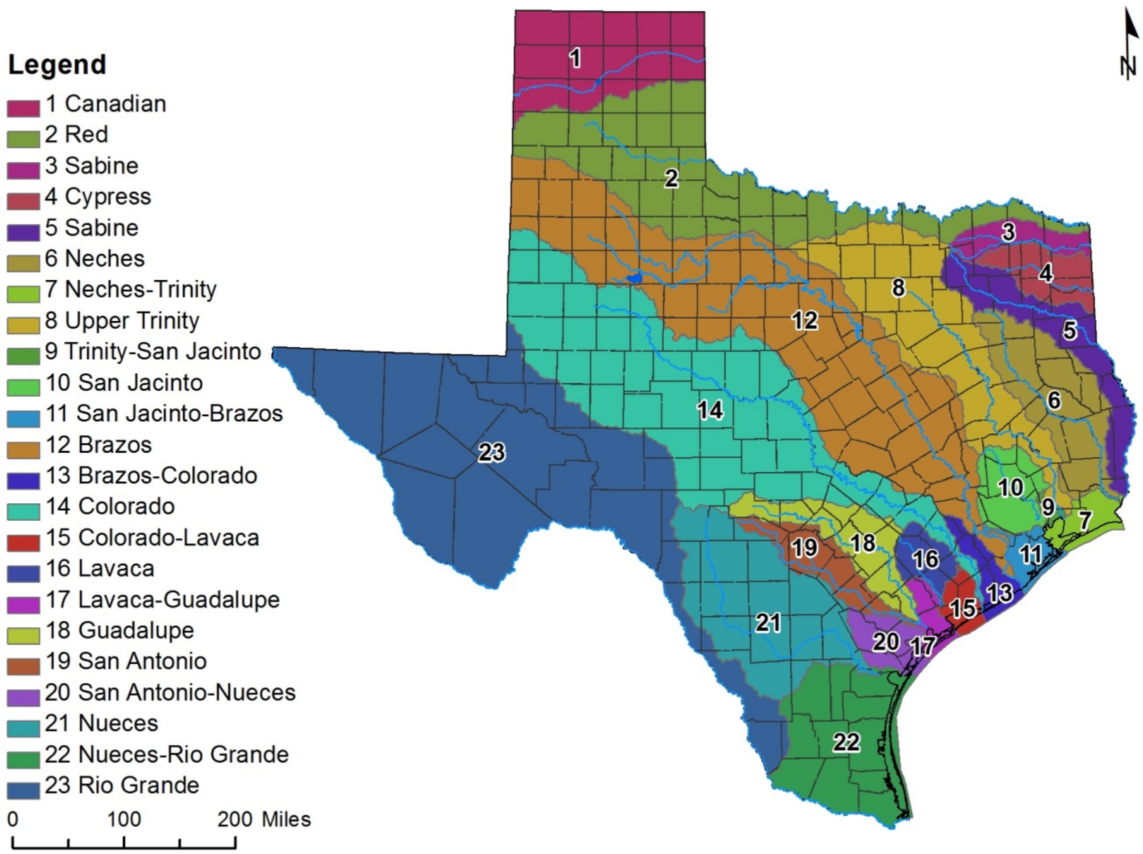
10 Surface Water Strategies

Surface water is an essential part of Lubbock's efforts to diversify its water supply portfolio in order to ensure a sustainable supply of water for the next 100 years. The State of Texas contains all or part of 23 river basins, as shown in Figure 10.1

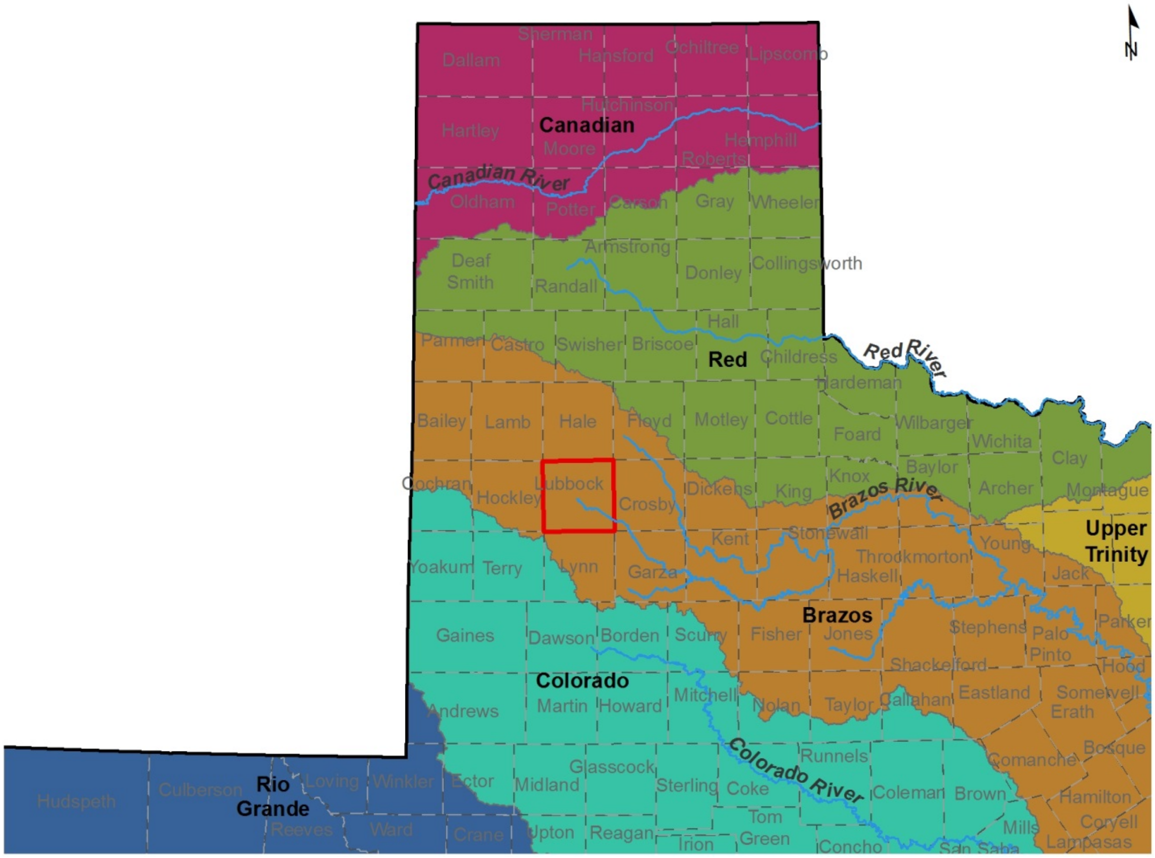
Figure 10.1. River Basins in Texas



Four of the river basins are within practical reach of Lubbock, including the Canadian River, Red River, Brazos River, and Colorado River basins as depicted in Figure 10.2. On the semi-arid High Plains of Texas, the average annual rainfall for the Lubbock region is only 19 inches[1], thus limiting surface water supply opportunities as most streams only receive intermittent flow. However, periodic flood events combined with developed water make surface water strategies a viable option in some cases.

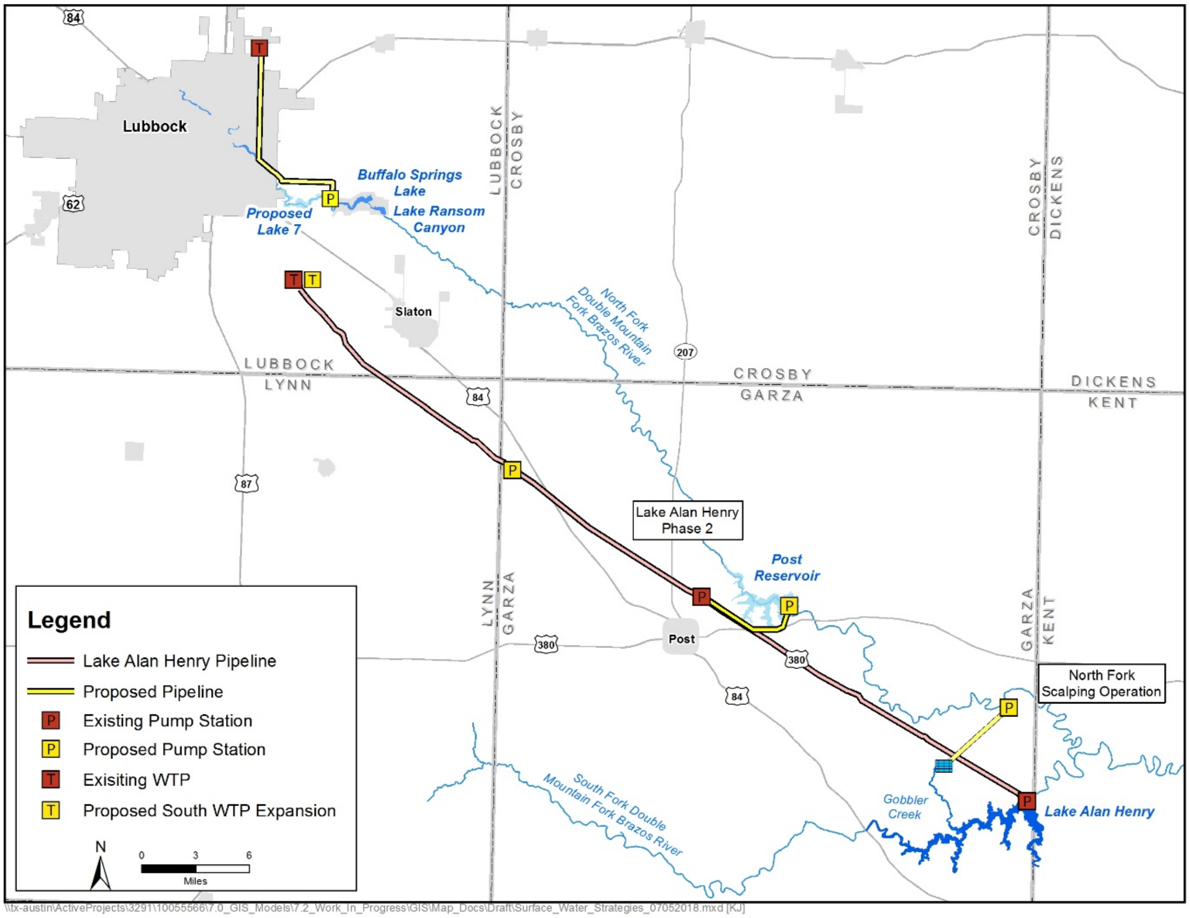
[1] Annual Water Highlights: Technical Summary. Brazos River Authority. 2000: III-6.

Figure 10.2. River Basins in the Lubbock Region



This section details the four surface water strategies identified that can potentially assist the City of Lubbock (City) in meeting its projected future water demand. These strategies include the expansion of the Lake Alan Henry (LAH) infrastructure (LAH Phase 2), Jim Bertram Lake 7, Post Reservoir, and the North Fork Scalping Operation. Figure 10.3 shows the location of the four surface water strategies in relation to Lubbock and its water treatment facilities.

Figure 10.3. Surface Water Strategies



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10.1 Developed Water – Supplements to Brazos River Basin

Since flows in the upper Brazos River Basin are limited, the addition of developed water is necessary to make new surface water projects viable. Developed water is defined as water that is non-native to the Brazos River Basin and includes groundwater, groundwater-based reclaimed water, and playa lake water. Developed water would not enter the Basin except for the City constructing facilities to convey the water to the Basin.

10.1.1 Supplemental Reclaimed Water

Reclaimed water that is treated to stream discharge standards and permitted to be discharged into a surface water body can become a supplemental component of a surface water strategy. Stand-alone reclaimed water supply strategies are described in Section 7.0. The Jim Bertram Lake 7 and Post Reservoir strategies, discussed in Sections 10.3 and 10.4, respectively, rely upon reclaimed water as a primary inflow component. The Northwest Water Reclamation Plant (NWWRP) is now operational and is discharging 1 to 1.5 million gallons per day (mgd) into Lake 1 under its Texas Pollutant Discharge Elimination System (TPDES) permit.

10.1.2 Supplemental Groundwater

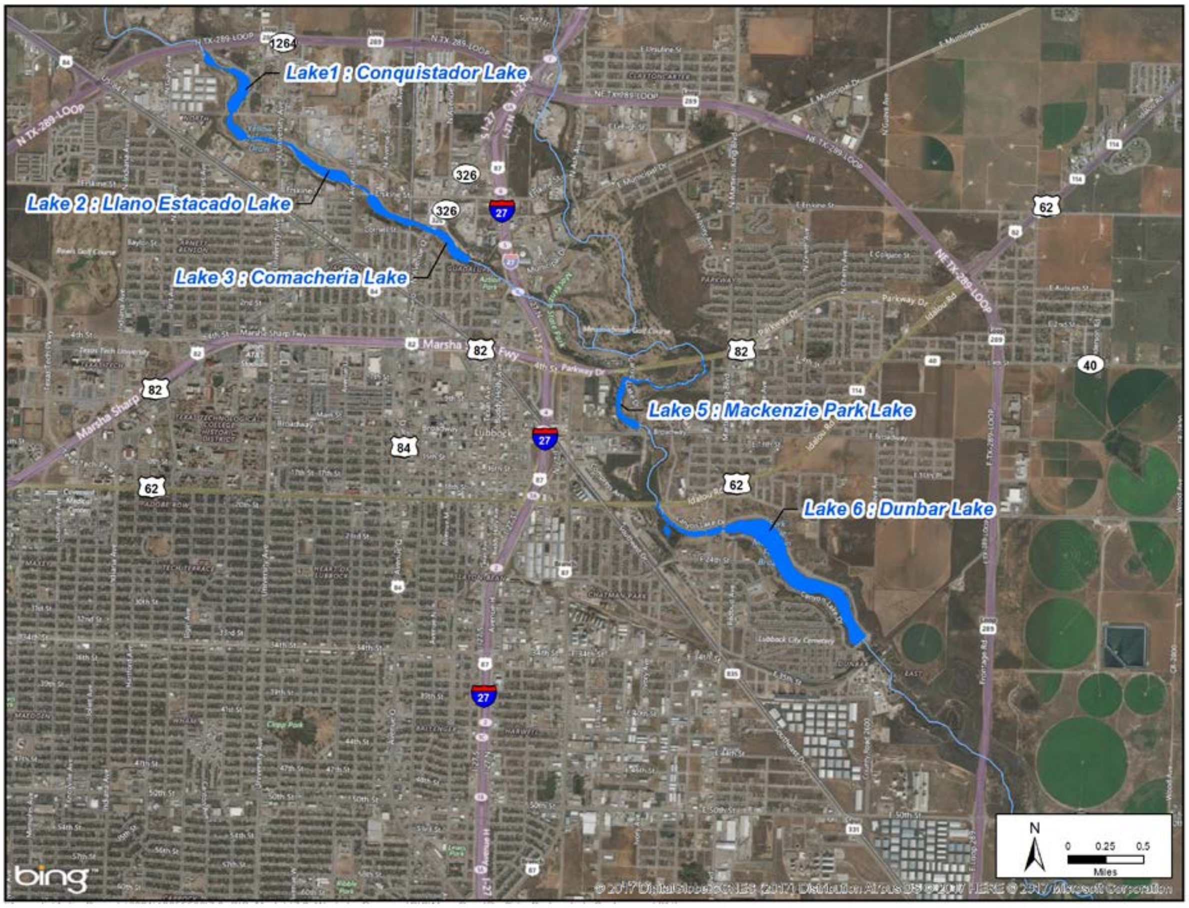
Yellow House Canyon and Blackwater Draw run through Lubbock and discharge into the North Fork. In 1969, the City hired a consultant to perform the initial planning for the Canyon Lakes Project, which consists of a series of eight dams and small reservoirs in the Yellow House Canyon. The City subsequently constructed a series of lakes in the Yellow House Canyon. These lakes were named as follows:

- Lake 1 Conquistador Lake
- Lake 2 Llano Estacado Lake
- Lake 3 Comacheria Lake
- Lake 4 Not Constructed
- Lake 5 Mackenzie Park Lake
- Lake 6 Dunbar Lake

This system of lakes was originally known as the Canyon Lake System but was later renamed the Jim Bertram Lake System (JBLS) and the City has developed a park system around these lakes. The JBLS is depicted in Figure 10.4.

These small lakes receive a constant flow of water each year from groundwater that is pumped from under the Lubbock Land Application Site (LLAS) just outside of East Loop 289 adjacent to the City. The pumping began in 1989 as part of an Agreed Order from the Texas Commission on Environmental Quality (TCEQ) to reduce a water mound and high levels of nitrate in the groundwater beneath the LLAS. TPDES Discharge Permit No. WQ00004599000, originally approved on December 31, 2003 (renewed March 32, 2014 with an expiration date on February 28, 2019), allows a maximum daily discharge of groundwater into Lake 1 of 4.3 mgd (4,817 acre-feet per year [ac-ft/yr]).

Figure 10.4. Jim Bertram Lake System



The City obtained a Certificate of Adjudication 12-3705 in February 1985, authorizing the impoundment of water in the JBLS for recreation purposes with no diversion authorization. Certificate 12-3705 was subsequently amended two times (12-7305A on February 28, 1997 and 12-7305B on May 11, 2007) to obtain the right to divert from Lakes 1, 2 and 6, and to gain more flexibility in using the water for agriculture, municipal, recreational, and industrial purposes in Lubbock and Lynn Counties. The maximum combined rate of the authorized diversion is 4.3 mgd (4,817 ac-ft/yr). However, the City can only divert the amount of groundwater that it discharges into the JBLS, less carriage losses. Currently, the City discharges an average of about 1.3 mgd (1,438 ac-ft/yr) into the JBLS. Groundwater production has declined over the past few years. The water discharged into Lake 1 is also diverted from Lake 1 to irrigate the Berl Huffman Soccer Complex. Before water is discharged into the JBLS, some of it is used to irrigate the City Cemetery. Until May 2018, the Meadowbrook Golf Course also used this water, but now relies upon two groundwater wells. Annual volumes of water used from the JBLS and pumped LLAS groundwater are shown in Table 10.1.

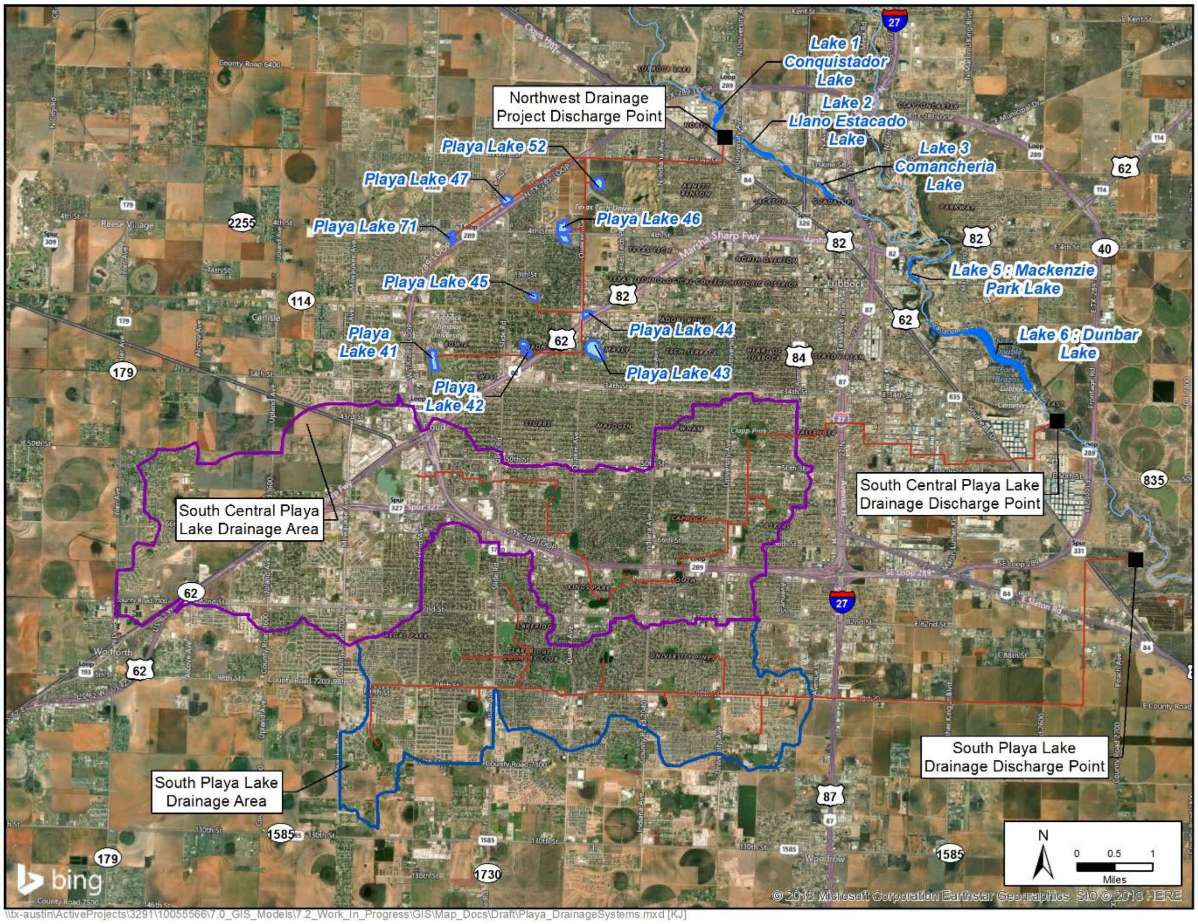
Table 10.1. JBLS and LLAS Pumped Groundwater Users

User	Annual Amount (acre-feet)
Berl Huffman Soccer Complex	155
City Cemetery	83
Total	**238**

10.1.3 Supplemental Playa Lake Water

Another source of surface water that supplements the natural flows of the Brazos River Basin is the water stored in playa lakes throughout the City. Storm water in the Lubbock area collects in playa lakes and can flood surrounding structures. Stormwater collected in these playas evaporates and percolates into local groundwater, but does not contribute flow naturally into the Brazos River Basin. Areas that drain to these playas are considered by the TCEQ to be "non-contributing" drainage areas within the Brazos River Basin. In an effort to reduce the potential for flooding around the playa lakes, the City completed the South Central Drainage System in 2003 and the South Drainage System in 2008, and has completed portions of the Northwest Drainage System, with several portions still under development. The South Central and South systems convey excess storm water into the Yellow House Canyon (a tributary to the North Fork) as shown in Figure 10.5, and the Northwest system collects stormwater from nine playa lakes and discharges into Llano Estacado Lake (Lake 2) of the JBLS. Stormwater discharges into the North Fork are authorized by the TCEQ pursuant to the City's Municipal Separate Storm Sewer System (MS4) TPDES permit no. WQ0004773000, which expires August 17, 2020.

Figure 10.5. Playa Lake Drainage Systems



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The quantity of water available from these systems will vary based on seasonal and annual rainfall events. According to a Municipal Precipitation Runoff study performed in October 2008 for the South Central and South systems[2] and an analysis by HDR based on data provided in a feasibility study of the Northwest system[3], the following volumes of storm water presented in Table 10.2 can be anticipated from the discharge points of the South Central, South and Northwest Playa Lake Drainage Systems.

[2] Municipal Precipitation Runoff Contributions to the North Fork of the Double Mountain Fork of the Brazos River (City of Lubbock Discharge Points 30 & 31). Parkhill, Smith & Cooper, Inc. August 2008: 20, 47.

[3] Feasibility Study, Northwest Lubbock Drainage Improvements. Parkhill, Smith & Cooper, Inc. September 2013.

Table 10.2. Anticipated Storm Water Discharges from the Playa Lake Drainage Systems

Facility	Maximum Annual (acre-feet)	Average Annual (acre-feet)	Maximum Daily (cubic feet per second [cfs])
South Central System	14,857	4,932	2,545
South System	8,934	2,958	1,524
Northwest System	7,103	2,344	1,832
Total Discharge	**30,894**	**10,234**	**5,901**

The impoundment and diversion of the storm water after its discharge from the South Central, South and Northwest Playa Lake Drainage Systems will ultimately require water use permits. In May 2009, the City entered into an Interlocal Agreement with the Brazos River Authority (BRA) where the BRA acknowledged discharges from these drainage systems as the City's developed water.[4] This agreement ensures that the BRA will not contest any of Lubbock's applications or filings that seek to divert and use the playa lake storm water flows. The City has a pending application for Water Use Permit 5921 requesting the authorization to impound and divert treated effluent discharges and storm water from the South and South Central Playa Lake Drainage Systems in Lake 7, and has a pending application for an amendment to Water Use Permit 3985 which will authorize the City to use storm water from the Northwest Playa Lake Drainage System.

10.2 Lake Alan Henry Phase 2 Strategy

The LAH Phase 2 water supply strategy includes expanding the existing LAH infrastructure capacity to transport and treat an additional 15 mgd of raw water from the lake, thus increasing the total capacity to 30 mgd. As discussed in Section 4.3, Lubbock began using LAH as a water supply during the fall of 2012 and currently utilizes about 8,000 ac-ft/yr supply from this source. The existing LAH raw water supply pipeline (Phase 1) consists of:

- Two raw water pump stations—LAH Pump Station (LAHPS) and the Post Pump Station (PPS);
- The South Water Treatment Plant (SWTP);
- A 42-inch diameter raw water transmission pipeline from the LAHPS to the PPS;
- A 48-inch diameter raw water transmission pipeline from the PPS to the SWTP; and
- Treated water transmission lines that move water into three pump stations ([PS] #8, PS #10, and PS #14) within Lubbock's water distribution system.

Expansion of the existing infrastructure is necessary to supply water to the City at a greater daily rate. The major infrastructure components of the LAH Phase 2 strategy include:

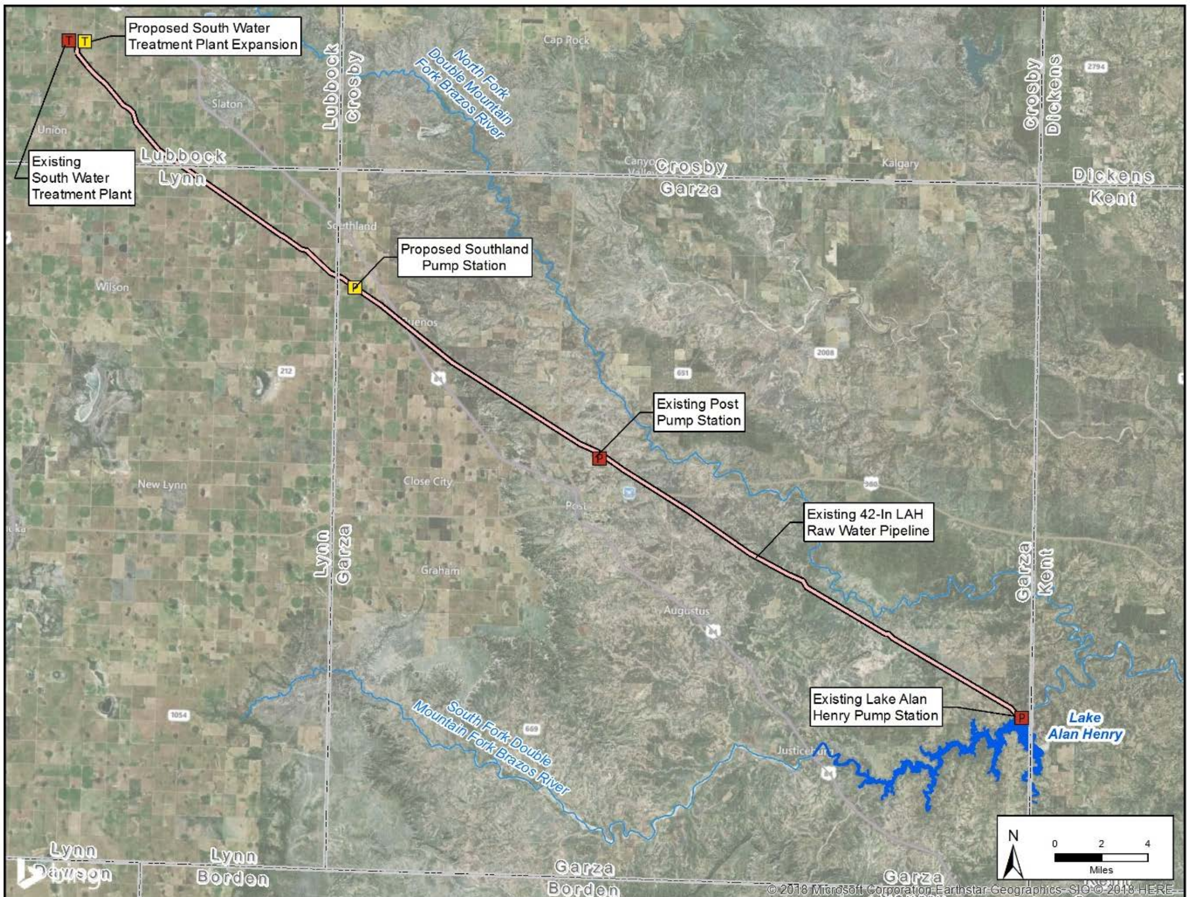
- Construction of a Southland Pump Station (SLPS);
- Capacity expansion of equipment at the LAHPS and the PPS;

[4] Interlocal Agreement between the Brazos River Authority of Texas and the City of Lubbock, Texas. Resolution No. 2009-R0187. May 14, 2009.

- A 15 mgd expansion of the SWTP, which includes expansion of the high service pump station;
- A 4.5-mile, 30-in Low Head C Transmission pipeline to allow flow from the SWTP to reach PS 16 or Bailey County groundwater to flow to PS 14 (see Figure 4.11); and
- A 15 mgd Low Head C Pump Station to transfer water from the SWTP to PS 16.

Figure 10.6 shows the additional infrastructure required for this strategy.

Figure 10.6. Lake Alan Henry Phase 2



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10.2.1 Quantity of Available Water

The City intends to operate LAH near the 2-year safe yield of 12,875 ac-ft/yr.[5] The current water supply infrastructure will only deliver 8,000 ac-ft/yr with a peaking capacity of 15 mgd. Phase 2 will be constructed to increase the total deliverable water to 16,000 ac-ft/yr from LAH, an incremental increase of 8,000 ac-ft/yr. The pump stations and the SWTP will be modified to provide a peak capacity of 30 mgd. Additional raw water transmission lines will

[5] Lake Alan Henry Current and Future Supply for 2018 Strategic Water Plan - Memo. HDR, Inc. July 12, 2017.

not be necessary since the existing pipelines were sized to handle up to 34 mgd[6] with the appropriate pumping capacity.

The additional capacity of the raw water transmission lines may be used if other water supply strategies are implemented, such as the North Fork Diversion to Lake Alan Henry Pump Station (NFD-LAHPS) (Section 7.8), the Post Reservoir (Section 10.4), or the North Fork Scalping Operation (Section 10.5).

10.2.2 Strategy Costs

Costs associated with this strategy are presented in Table 10.3. Assumptions and conditions associated with these costs include:

- Energy costs to transmit the additional water from the expansion through the LAHPS and pipeline are included. These costs are based on an average annual delivery of an additional 4.4 mgd (4,875 ac-ft/yr) through the upgraded system;
- Existing infrastructure will be used to transmit treated water from the SWTP into the City's water distribution system;
- Land for the new SLPS has already been purchased;
- Energy costs for the Low Head C Pump Station were not included in transmission pipeline costs;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

[6] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: 4-179.

Table 10.3. Lake Alan Henry Phase 2 Costs (January 2017 Prices)

Item	Estimated Cost for Facilities
Capital Costs	
LAH Pump Station Expansion (additional 15 mgd)	$6,150,000
Post Pump Station Expansion (additional 15 mgd)	$4,865,000
Southland Pump Station (30 mgd)	$9,147,000
Low Head C Transmission Pipeline	$9,393,000
Low Head C Pump Station	$12,000,000
Water Treatment Plant Expansion (additional 15 mgd)	$27,131,000
Total Capital Cost	**$68,686,000**
Engineering, Legal Costs, and Contingencies	$23,570,000
Environmental & Archaeology Studies and Mitigation	$0
Land Acquisition and Surveying (0 acres)	$0
Interest During Construction (2 years)	$6,458,000
Total Project Cost	**$98,714,000**
Annual Costs	
Debt Service (5.5%, 20 years)	$8,260,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$893,000
SWTP Expansion	$2,713,000
Pumping Energy Costs (0.09 $/kwh)	$861,000
Total Annual Cost	**$12,727,000**
Available Project Yield (ac-ft/yr)	4,875
Annual Cost of Water ($ per ac-ft)	$2,611
Annual Cost of Water ($ per 1,000 gallons)	$8.01

As shown, the total project cost is estimated to be $98,714,000. Annual debt service is $8,260,000; and, the annual operational cost, including power, is $4,467,000. This results in a total annual cost of $12,727,000. The unit cost for an additional annual supply of 4.4 mgd or 4,875 ac-ft/yr from LAH is estimated to be $2,611 per ac-ft, or $8.01 per 1,000 gallons.

10.2.3 Implementation Issues

Environmental

Environmental issues associated with this option should be minimal. The Texas Water Development Board (TWDB) approved an environmental assessment[7] for the overall Phase 1 project so the City could qualify for low interest loans administered through the TWDB. In addition, environmental assessments were performed at the locations of the proposed SLPS[8] and the SWTP[9] expansion. Therefore, no additional assessment should be necessary at these locations. The treated water transmission pipeline routes can be selected to avoid sensitive wildlife habitat and cultural resources.

Permitting

Raw water will be obtained from LAH, which is owned by the City of Lubbock. Water Use Permit No. 4146 allows for the annual diversion of 35,000 ac-ft; therefore, no additional permitting requirements are anticipated. The TCEQ will need to approve design modifications to the existing system.

Other Issues

The City owns property where the SLPS and the additional SWTP capacity will be constructed. The treated water transmission pipeline will be installed within the city limits and preferably within existing City street easements.

10.3 Jim Bertram Lake 7

The Jim Bertram Lake 7 strategy consists of a new 20,000 ac-ft reservoir immediately upstream of Buffalo Springs Lake on the North Fork. The new reservoir would impound reclaimed water, developed playa lake stormwater, and natural inflows. Diversions from the lake would be transported to the North Water Treatment Plant (NWTP) via a 12-mile, 36-in pipeline. Supplies from Lake 7 would be used to help meet annual and peak day demands and transmission facilities are sized with a 2.0 peaking factor. Figure 10.7 provides the location of the proposed Lake 7 and pipeline route to the NWTP.

This strategy includes advanced treatment to address water quality concerns. Wastewater effluent will constitute a large percentage of the volume in Lake 7 and the blended concentration of total dissolved solids (TDS) in the lake will increase as a result. Multiple treatment barriers will be required for direct potable reuse of the lake water since extended drought periods would decrease the detention time and concentrate the amount of treated wastewater in the lake.

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[7] Environmental Assessment for the City of Lubbock Lake Alan Henry Water Supply Project. Freese and Nichols, Inc.; June 2009

[8] Phase I Environmental Site Assessment, 4.82 Acre Tract, Southland, Garza County, Texas (Southland Pump Station Site), Prepared by V-Tech Environmental Services, January 8, 2008.

[9] Phase I Environmental Site Assessment, West half of Section 72, Block S, Lubbock County, Texas (South Water Treatment Plant Site), Prepared by the City of Lubbock, August 5, 2008.

The major infrastructure components of this strategy include:

- Construction of a 20,000 ac-ft, 774 acre reservoir;
- A new intake structure and pump station located at the reservoir site;
- A 12-mile, 36-in transmission pipeline to deliver water from Lake 7 to the NWTP; and
- A new 21.4 mgd advanced treatment plant adjacent to the NWTP.

10.3.1 Quantity of Available Water

According to the HDR technical memorandum dated 15 July 2015, Jim Bertram Lake 7 will supply a one-year safe yield of 11,550 ac-ft/yr of raw water without considering the Northwest Playa Lake System discharges. When this additional developed water is considered, the one-year safe yield would increase to 11,975 ac-ft/yr. The safe yield is contingent upon the availability of return flows discharged by the City and the availability of playa lake developed water. Natural inflows captured by Lake 7 were modeled subject to the instream flow requirements based on the Lyons Method. At the time of the yield analysis, environmental flow requirements pursuant to the Senate Bill 3 (SB3) process had not been adopted by the TCEQ and were not incorporated into the analysis. However, they are expected to have little effect on the yields because only State water (natural inflows) are affected by the instream flow criteria, and little State water is available to Lake 7. The individual contributions of the three sources of inflows to increase the yield of Lake 7 are presented in Table 10.4.

Figure 10.7. Jim Bertram Lake 7 Infrastructure

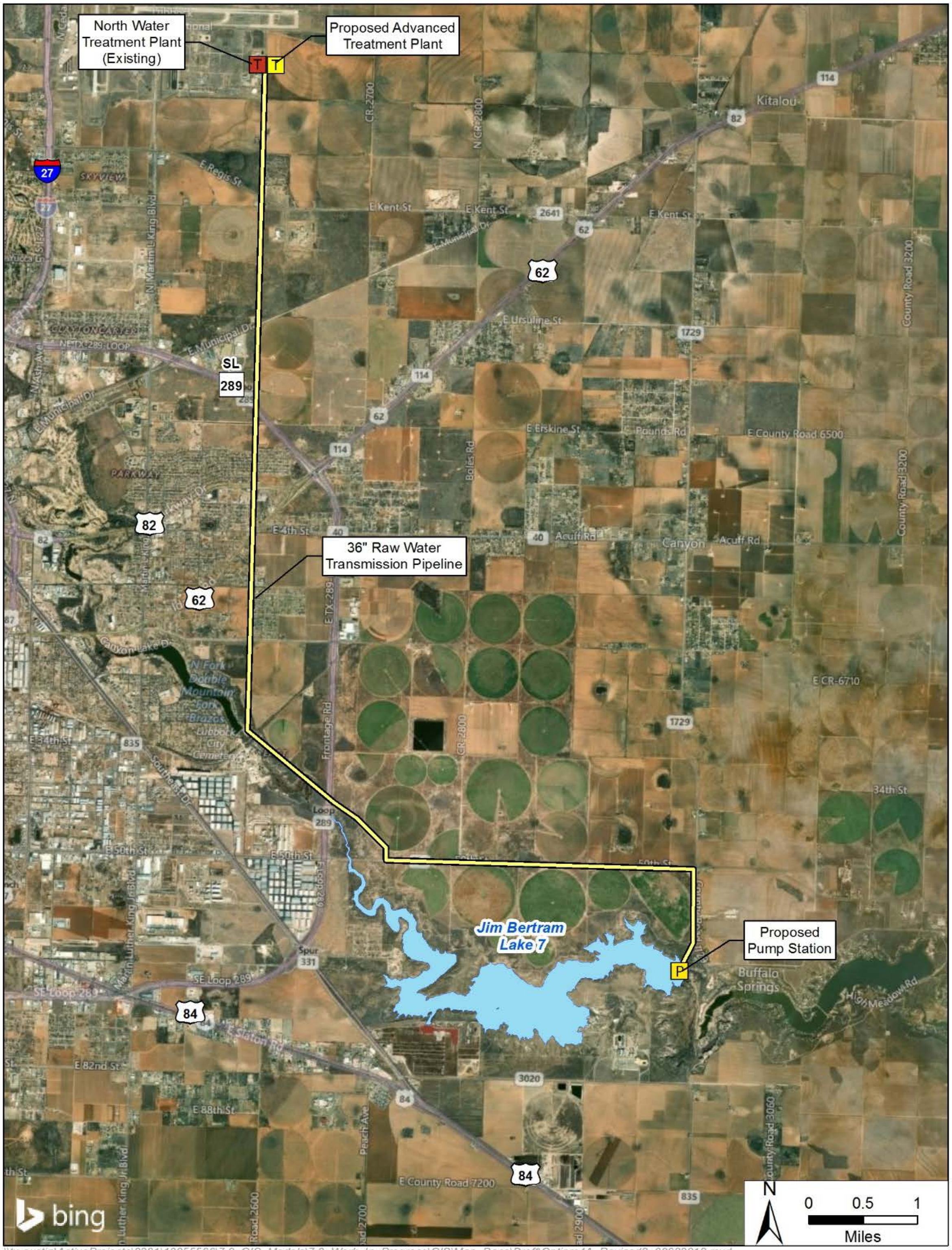

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Table 10.4. Lake 7 Yield Components

Yield Component	1-Year Safe Yield Amount (ac-ft/yr)
Reclaimed Water (8 mgd)	7,300
Playa Lake Developed Water	2,875
Natural Inflow (Unappropriated State Water)	1,800
Total	**11,975**

This safe yield amount is subject to the City obtaining sole rights to its developed water (playa lake storm water and reclaimed water).[10] Increases or decreases of the reclaimed water available will have an approximate one to one increase or decrease on the reservoir's safe yield. The reclaimed water will be discharged from Outfall 007 located near the Southeast Water Reclamation Plant (SEWRP), at Conquistador Lake (associated with the NWWRP), and at Llano Estacado Lake (associated with the Northwest Playa System outfall). The Lake 7 yield does not include any reductions attributed to potential horizontal leakage through the canyon walls. An analysis completed in 2014 projects that this leakage will be significant upon initial filling of the lake, but will rapidly diminish to a small, steady-state volume as reservoir and proximate groundwater levels balance.[11]

10.3.2 Strategy Costs

Costs associated with this strategy are presented in Table 10.5. Assumptions and conditions associated with these costs include:

- Flows used to design the intake, pump station, advanced treatment plant and transmission pipelines include an estimated 5% downtime and are sized for a 2.0 peaking factor;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period;
- The project will be financed for 20 years at a 5.5% annual interest rate; and
- Costs do not include the distribution of the potable water from the NWTP to potential customers.

[10] Feasibility of Constructing the Proposed Lake 7, HDR, Inc., September 2011, p. 7-1.

[11] Estimated Groundwater Interaction with the Proposed Lake 7, HDR, Inc., April, 2014, p. 29.

Table 10.5. Jim Bertram Lake 7 Strategy Costs (January 2017 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
Dam and Reservoir (20,000 ac-ft, 774 acres)	$28,775,000
Intake and Pump Station (21.4 mgd)	$11,577,000
Transmission Pipeline	
36 in dia., 12 miles	$19,275,000
Advanced Water Treatment Plant (21.4 mgd)	$81,290,000
Total Capital Cost	**$140,917,000**
Engineering, Legal Costs, and Contingencies	$48,357,000
Environmental & Archaeology Studies and Mitigation	$2,243,000
Land Acquisition and Surveying (803 acres)	$2,184,000
Interest During Construction (2 years)	$13,560,000
Total Project Cost	**$207,261,000**
Annual Costs	
Debt Service (5.5%, 20 years)	$13,515,000
Reservoir Debt Service (5.5%, 20 years)	$3,366,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$482,000
Dam and Reservoir	$432,000
Advanced WTP	$1,768,000
Pumping Energy Costs (0.09 $/kwh)	$781,000
Total Annual Cost	**$20,344,000**
Available Project Yield (ac-ft/yr)	11,975
Annual Cost of Water ($ per ac-ft)	$1,699
Annual Cost of Water ($ per 1,000 gallons)	$5.21

As shown the table, the total project cost is estimated to be $207,261,000. Annual debt service is $16,881,000; and, the annual operational cost, including power, is $3,463,000. This results in a total annual cost of $20,344,000. The unit cost for 11,975 ac-ft/yr supply is estimated to be $1,699 per acre-foot, or $5.21 per 1,000 gallons.

10.3.3 Implementation Issues

Environmental Issues

The primary environmental issue related to this strategy is the change in land use of 774 acres from ranchland to a reservoir site. In July 2011, the City provided an Environmental Information Document (EID) to the TCEQ which described the environment that will potentially be affected by the construction of Lake 7.[12] According to the EID, this project will have an impact on the environment, and a mitigation plan will be required to compensate for unavoidable impacts. Some of the issues identified in the EID include:

- No federal or state protected aquatic life has been found in the project reach,[13] although two listed species of minnow – the sharpnose shiner and the smalleye shiner – would potentially be impacted in the reach downstream from the reservoir;
- A baseline survey revealed that the Texas horned lizard (Texas listed threatened species) is thriving in the project vicinity. Additional evaluation and a management and mitigation plan will be necessary if the reservoir is built;[14] and
- A review of Texas Historical Commission and other records identified 17 archeological sites in or near the project area that will need to be assessed.[15]

The advanced treatment facilities would be constructed on property owned by Lubbock that is currently being used for similar purposes, and environmental issues should be minimal. The transmission line corridor that will convey the reclaimed water should be selected to avoid potentially sensitive areas.

Permitting Issues

The existing TPDES Permit No. 10353-002 authorizes the City to discharge up to 14.5 mgd (16,242 ac-ft/yr) of reclaimed water at the SEWRP into the North Fork at Outfall 007. In 2005, the City submitted Water Rights Application No. 5921 which, among other things, seeks the right to impound and divert water from the proposed Lake 7. Although the application was declared administratively complete in April 2006, the TCEQ's technical review is still on-going. The TCEQ has received eight requests for contested case hearings. It will most likely take several years before the permit may be issued to the City.

In addition, a United States Army Corps of Engineers (USACE) Section 404 permit will be required prior to commencing construction of Lake 7. This reservoir is large enough to require an individual permit. Mitigation plans for the project's environmental impacts must be developed and agreed upon by the USACE and other state and federal resource agencies.

The TCEQ is currently developing potable reuse guidance requirements to be applied to proposed projects and to be used as the basis for reviewing permit applications. Treatment

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[12] Environmental Information Document in Support of Water Use permit Application No. 5921; City of Lubbock, July 2011.

[13] Feasibility of Constructing the Proposed Lake 7, HDR, Inc., September 2011, p. 5-4.

[14] Feasibility of Constructing the Proposed Lake 7, HDR, Inc., September 2011, p. 5-5.

[15] Feasibility of Constructing the Proposed Lake 7, HDR, Inc., September 2011, p. 5-7.

requirements for any reclaimed water as a drinking water source may consider the pretreatment program, influent wastewater quality, vulnerability assessment of the collection system, results of effluent quality sampling/monitoring data, and wastewater treatment process.

Monitoring is likely to include Cryptosporidium (or a surrogate organism), other regulated contaminants, and may include contaminants on the U.S. Environmental Protection Agency (USEPA) Candidate Contaminate List (CCL), including Emerging Constituents of Concern (ECCs) and pharmaceuticals and personal care products (PPCPs).

Other

Property will need to be acquired for the lake, dam, pump station, and mitigation area. In addition, pipeline utility easements will be necessary to construct a raw water transmission line to the NWTP.

The geological formation that the dam foundation will be constructed upon appears to be somewhat pervious. Extensive cut-off wall and grout curtains will need to be installed to avoid water seeping under the dam and around the abutments. In addition, there is the potential for considerable leakage from the reservoir conservation pool to the local groundwater aquifer system. The Comanche Peak formation could also allow vertical leakage from the reservoir through the valley floor.[16] A study commissioned by the City was completed in 2014 to investigate these geologic formation issues, and determined that such leakage can be controlled[17].

Wastewater effluent will constitute a large percentage of the volume in Lake 7 and the blended concentration of TDS in the lake will increase as a result. During drought conditions, the TDS concentration may become greater than the secondary drinking water standard requiring advanced treatment which should consider:

- Multiple treatment process barriers;
- redundancy and backup power sources;
- alternate storage or discharge locations to divert reclaimed water from the potable distribution system during an acute episode; and
- real time monitoring and regular sampling to ensure process performance and avoid any acute episode of pathogens in the reclaimed water.

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[16] Feasibility of Constructing the Proposed Lake 7, HDR, Inc., September 2011, p. 7-2.

[17] Estimated Groundwater Interaction with the Proposed Lake 7, HDR, Inc., April 2014, pp. 21-25.

10.4 Post Reservoir

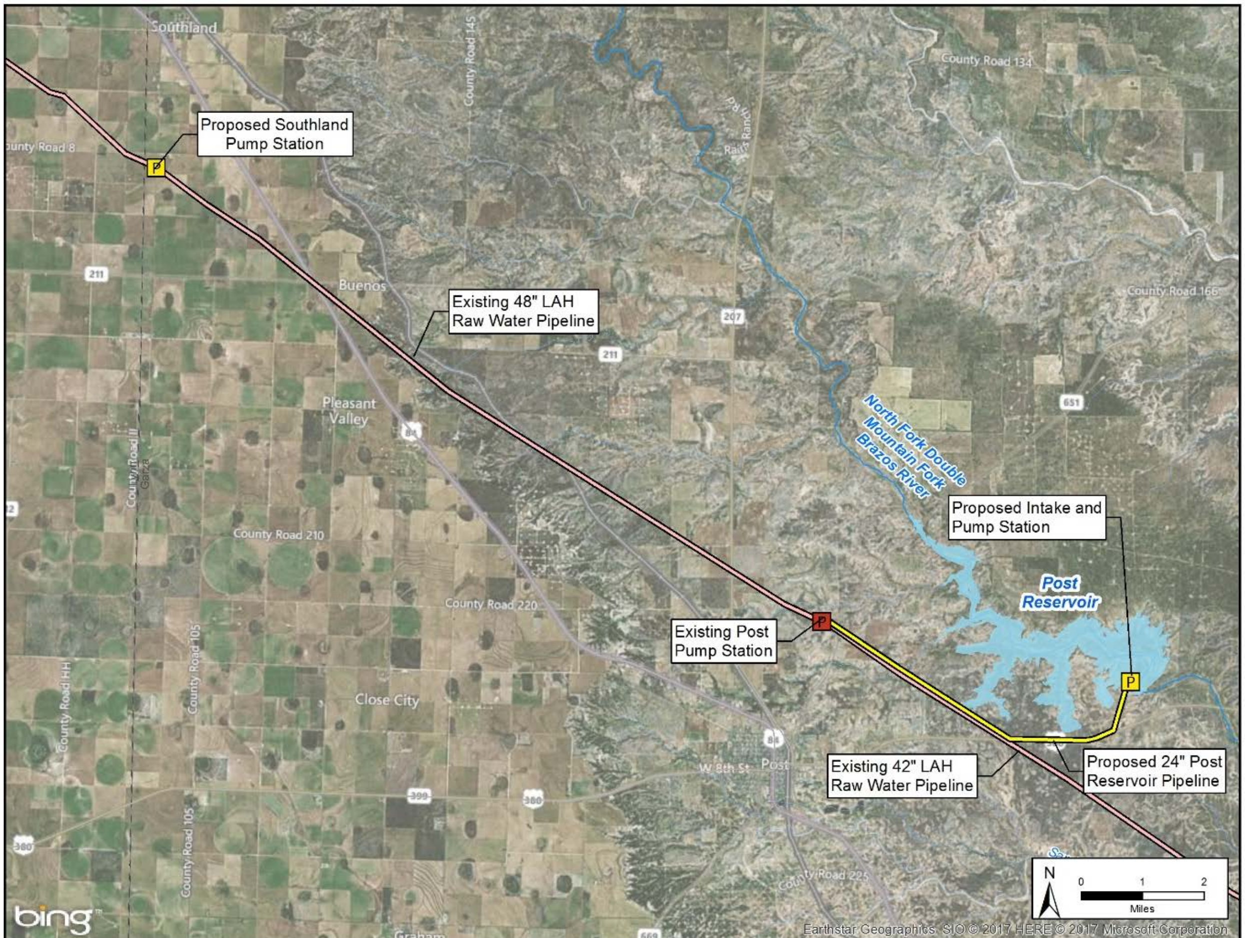
The Post Reservoir strategy consists of a new reservoir located immediately northeast of Post, Texas on the North Fork. Certificate of Adjudication No. 12-3711 authorizes the impoundment of 57,420 ac-ft of water and the diversion and use of up to 10,600 ac-ft of water per year. Under this strategy, water will be impounded and diverted from the reservoir and transported to the existing PPS that delivers water from LAH to Lubbock. The 48-inch diameter LAH raw water line is adequate to convey water from both Post Reservoir and LAH. However, an expansion of the SWTP will be necessary. Figure 10.8 provides the location of Post Reservoir and the proposed LAH pipeline connection route.

The major infrastructure components of this strategy include:

- Construction of a 57,420 ac-ft, 2,280 acre reservoir;
- A new intake structure and pump station located at the reservoir site;
- A 6-mile, 24-in transmission pipeline to deliver water from Post Reservoir to the PPS;
- Expansion of the PPS to transport raw water along the LAH pipeline system;
- The addition of the SLPS located on the LAH raw water pipeline.
- An 8 mgd expansion of the SWTP;
- A 4.5-mile, 30-in Low Head C Transmission pipeline to allow flow from the SWTP to reach PS 16 or Bailey County groundwater to flow to PS 14 (see Figure 4.11); and
- A 15 mgd Low Head C Pump Station to transfer water from the SWTP to PS 16.Quantity of Available Water.

Similar to the Lake 7 strategy, the yield of Post Reservoir relies heavily on inflows from developed playa stormwater and reclaimed water. Analyses using the TCEQ Water Availability Model (WAM) indicate a range of firm and safe yield supplies could be developed for this strategy, depending upon treatment of upstream return flows, sediment storage reserves, instream flow requirements and playa lake stormwater flows. For purposes of this analysis, it is assumed that 8,962 ac-ft/yr (8 mgd) of water is available for diversion from the Post Reservoir, assuming that Lake 7 would not be constructed upstream.

Figure 10.8. Post Reservoir Infrastructure



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10.4.1 Strategy Costs

Costs associated with this strategy are presented in Table 10.6, and are shown with and without the LAH pipeline expansion. Assumptions and conditions associated with these costs include:

- Flows used to design the intake, pump station, and transmission pipeline designs include an estimated 5% downtime;
- Expansion costs of the PPS is included;
- The construction of the SLPS is included;
- Land for the new SLPS has already been purchased;
- Energy costs to transmit water through the LAHPS and pipeline are included;
- Existing infrastructure will be used for transmission of treated water from the SWTP into the City's water distribution system;
- Energy costs related to the Low Head C Pump Station were not included in transmission pipeline costs;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

Table 10.6. Post Reservoir Strategy Costs (January 2017 Prices)

Item	Estimated Costs for Facilities	Costs Including LAH Pipeline Expansion
Capital Costs		
Dam and Reservoir (57,420 ac-ft, 2,280 acres)	$25,164,000	$25,164,000
Intake and Pump Station	$6,056,000	$6,056,000
Transmission Pipeline (24 in dia., 6 miles)	$3,611,000	$3,611,000
Low Head C Transmission Pipeline	$9,393,000	$9,393,000
Low Head C Pump Station	12,000,000	12,000,000
SWTP Expansion (8.0 mgd)	$17,096,000	$17,096,000
LAH Pipeline Expansion		
Post Pump Station Expansion (additional 15 mgd)	$0	$4,865,000
Southland Pump Station (30 mgd)	$0	$9,147,000
Total Capital Cost	**$73,320,000**	**$87,332,000**
Engineering, Legal Costs, and Contingencies	$25,012,000	$29,916,000
Permitting Fees	$5,000,000	$5,000,000
Environmental & Archaeology Studies and Mitigation	$5,978,000	$5,978,000
Land Acquisition and Surveying	$5,928,000	$5,928,000
Interest During Construction (2 years)	$8,067,000	$9,391,000
Total Project Cost	**$123,305,000**	**$143,545,000**
Annual Costs		
Debt Service (5.5%, 20 years)	$5,895,000	$7,589,000
Reservoir Debt Service (5.5%, 20 years)	$3,889,000	$3,889,000
Operation and Maintenance		
Intake, Pipeline, Pump Station	$581,000	$932,000
Dam and Reservoir	$365,000	$365,000
SWTP Expansion	$1,710,000	$1,710,000
Post Pipeline Pumping Energy Costs (0.09 $/kwh)	$323,000	$323,000
LAH Pipeline Pumping Energy Costs (0.09 $/kwh)	$530,000	$530,000
Total Annual Cost	**$13,293,000**	**$15,338,000**
Available Project Yield (ac-ft/yr)	8,962	8,962
Annual Cost of Water ($ per ac-ft)	$1,483	$1,711
Annual Cost of Water ($ per 1,000 gallons)	$4.55	$5.25

As shown, the total project cost not including the LAH pipeline expansion is estimated to be $123,305,000. Annual debt service is $9,784,000; and annual operational cost, including power, is $3,509,000, resulting in a total annual cost of $13,293,000. The unit cost for 8,962 ac-ft/yr supply is estimated to be $1,483 per ac-ft, or $4.55 per 1,000 gallons. If the LAH pipeline expansion is included, the unit cost of the project is increased to $1,711 per ac-ft, or $5.25 per 1,000 gallons.

10.4.2 Implementation Issues

Environmental

The primary environmental issue related to this strategy is the change in land use of 2,280 acres from ranchland to a reservoir site. There will be a high impact on animal habitats that must be mitigated. It is anticipated that the construction of the reservoir will have a low to moderate impact related to these concerns.[18] Studies will be necessary to determine the actual impact to cultural resources, wetlands, and threatened and endangered species, although two listed species of minnow – the sharpnose shiner and the smalleye shiner – would potentially be impacted in the reaches upstream and downstream from the reservoir, which could preclude construction of this project.

Permitting

As discussed in Section 7.0, the existing TPDES Permit No. 10353-002 authorizes the City to discharge up to 14.5 mgd (16,242 ac-ft/yr) of reclaimed water at the SEWRP into the North Fork at Outfall 007, and up to 9.0 mgd (10,089 ac-ft/yr) at FM400 at Outfall 001. The White River Municipal Water District (WRMWD) holds Certificate of Adjudication No. 12-3711, which authorizes the Post Reservoir with a priority date of January 20, 1970. This Certificate authorizes impoundment of 57,420 ac-ft in the reservoir. It also authorizes diversion of 5,600 ac-ft/yr for municipal use, 1,000 ac-ft/yr for industrial use, and 4,000 ac-ft/yr for mining purposes. The City will need to obtain ownership of the water right in order to construct the reservoir. The certificate will need to be amended so the City can obtain authorization to divert and use the full 10,600 ac-ft/yr for municipal purposes and obtain clarification regarding 19,000 ac-ft of sediment reserve identified in the special conditions of the certificate. In addition, a USACE Section 404 permit will be required prior to commencing construction of the Post Reservoir. This lake is large enough to require an individual permit. Mitigation plans for the project's environmental impacts must be developed and agreed upon by the USACE and other interested state and federal resource agencies.

Other Issues

Property will need to be acquired for the lake, dam, pump station, and habitat mitigation area. In addition, pipeline utility easements will be necessary to construct a raw water transmission line to the PPS.

[18] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: p. 4-219-221.

10.5 North Fork Scalping Operation

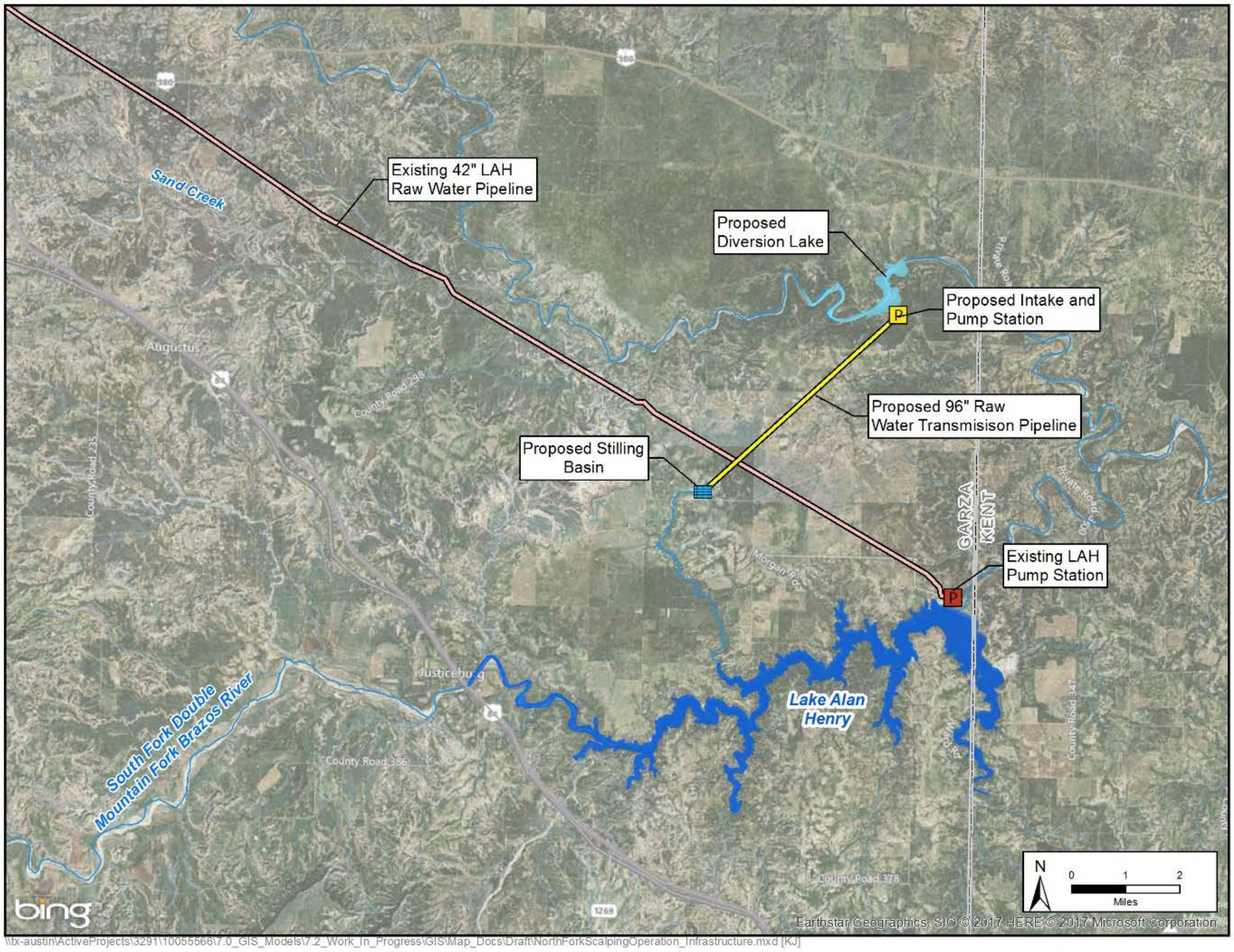
The North Fork Scalping Operation strategy is designed to increase the yield of LAH by collecting and re-directing storm water from the North Fork into the lake. To accomplish this, a diversion reservoir would need to be built on the North Fork in Garza County to capture stormwater flows and provide adequate pumping head for the intake pump station. The stormwater would be delivered to a point on Gobbler Creak upstream of LAH via a 5-mile, 96-inch pipeline. The intake, pump station, and pipeline would have a capacity of 162.4 mgd (251 cfs), making the transmission system capable of diverting large amounts of water during a short duration high flow event. A stilling basin would be necessary at the discharge location on Gobbler Creek to decrease the velocity of the scalped water and therefore reduce erosion. The water from the stilling basin would then flow through Gobbler Creek and naturally drain into LAH. Figure 10.9 provides the location of the diversion reservoir on the North Fork and transmission pipeline route to Gobbler Creek.

The major infrastructure components of this strategy include:

- A 1,000 ac-ft, 650 acre diversion reservoir on the North Fork to aid in the capture of high flows for scalping;
- A new 162 mgd intake structure and pump station at the diversion site;
- A 5-mile, 96-in transmission pipeline to deliver the scalped high flows from the North Fork to LAH;
- A stilling basin located at the discharge point located on Gobbler Creek;
- Construction of the SLPS and expansion of the LAH and PPSs;
- A 7.8 mgd expansion of the SWTP which includes expansion of the high service pump station at the SWTP;
- A 4.5-mile, 30-in Low Head C Transmission pipeline to allow flow from the SWTP to reach PS 16 or Bailey County groundwater to flow to PS 14 (see Figure 4.11); and
- A 15 mgd Low Head C Pump Station to transfer water from the SWTP to PS 16.

There is an opportunity to combine this strategy with the North Fork Diversion to LAHPS strategy (diverting reclaimed water) described in Section 7.8. By combining these strategies there is a possibility for cost savings since both strategies would share the expanded LAH infrastructure.

Figure 10.9. North Fork Scalping Operation Infrastructure



10.5.1 Quantity of Available Water

The North Fork Scalping Operation will be an intermittent and unpredictable source of water because it is dependent upon local precipitation and storm events. However, analyses by HDR estimates that the North Fork Scalping Operation could increase the firm yield of LAH by as much as 7.8 mgd or 8,725 ac-ft/yr.[19] Based on a WAM analysis of 1940 through 1997, the North Fork Scalping Operation would operate in all but three years of the simulation – the drought years of 1951, 1952 and 1956.

[19] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: 4-202.

10.5.2 Strategy Costs

Costs associated with this strategy are presented in Table 10.7 and are provided with and without the inclusion of the LAH pipeline expansion. Assumptions and conditions associated with these costs include:

- Expansion costs of the LAH and PPSs;
- Construction of the SLPS;
- Land for the new SLPS has already been purchased;
- Energy costs to transmit the additional water through the LAH pipeline are included;
- Existing infrastructure will be used to transmit treated water from the SWTP into the City's water distribution system;
- Energy costs associated with the Low Head C Transmission Pipeline were not included in transmission pipeline costs;
- Engineering, legal, and contingency costs are 30% of pipeline construction and 35% of other facilities constructed;
- Power is available at $0.09 per kwh;
- Interest during construction is estimated at 4.0%, and a 1% return on investments over a 2-year period.; and
- The project will be financed for 20 years at a 5.5% annual interest rate.

Table 10.7. North Fork Scalping Operation Costs (January 2017 Prices)

Item	Estimated Costs for Facilities	Costs Including LAH Pipeline Expansion
Capital Costs		
Dam and Reservoir (Conservation Pool 1,000 ac-ft, 650 acres)	$2,935,000	$2,935,000
Intake and Pump Station (162.4 mgd)	$28,994,000	$28,994,000
Transmission Pipeline (96 in dia., 5 miles)	$21,988,000	$21,988,000
Low Head C Transmission Pipeline	$9,393,000	$9,393,000
Low Head C Pump Station	12,000,000	12,000,000
Stilling Basin	$756,000	$756,000
SWTP Expansion (7.8 mgd)	$16,760,000	$16,760,000
LAH Pipeline Expansion		
LAH Pump Station Expansion (additional 15 mgd)	$0	$6,150,000
Post Pump Station Expansion (additional 15 mgd)	$0	$4,865,000
Southland Pump Station (30 mgd)	$0	$9,147,000
Total Capital Cost	**$92,826,000**	**$112,988,000**
Engineering, Legal Costs, and Contingencies	$30,883,000	$37,939,000
Environmental & Archaeology Studies and Mitigation	$1,883,000	$1,883,000
Land Acquisition and Surveying (687 acres)	$1,758,000	$1,758,000
Interest During Construction (2 years)	$8,916,000	$10,821,000
Total Project Cost	**$136,266,000**	**$165,389,000**
Annual Costs		
Debt Service (5.5%, 20 years)	$10,754,000	$13,191,000
Reservoir Debt Service (5.5%, 20 years)	$570,000	$570,000
Operation and Maintenance		
Intake, Pipeline, Pump Station	$1,.346,000	$1,529,000
Dam and Reservoir	$44,000	$44,000
SWTP Expansion	$1,676,000	$1,676,000
Pumping Energy Costs (0.09 $/kwh)	$313,000	$313,000
LAH Pumping Energy Costs (0.09 $/kwh)	$1,238,000	$1,238,000
Total Annual Cost	**$15,941,000**	**$18,882,000**
Available Project Yield (ac-ft/yr)	8,725	8,725
Annual Cost of Water ($ per ac-ft)	$1,827	$2,164
Annual Cost of Water ($ per 1,000 gallons)	$5.61	$6.64

As shown, the total project cost not including the LAH pipeline expansion is estimated to be $136,266,000. Annual debt service is $11,324,000; and, the annual operational cost, including power, is $4,617,000. This results in a total annual cost of $15,941,000. The unit cost for 7.8 mgd or 8,725 ac-ft/yr supply is estimated to be $1,827 per acre-foot, or $5.61 per 1,000 gallons. If the LAH pipeline expansion is included, the unit cost of the project is increased to $2,164 per ac-ft or $6.64 per 1,000 gal.

10.5.3 Implementation Issues

Environmental Issues

This project should have a low to moderate impact on the environment, including habitats, cultural resources, wetlands, and threatened or endangered species.[20] Some concern exists that discharging storm water from the North Fork into LAH could encourage golden algae growth in LAH. Golden alga is an organism that is toxic to fish under certain conditions, and has been found in lakes along the North Fork.[21] The sharpnose shiner and smalleye shiner are listed as endangered species on the federal list. These fish have been found along this reach of the North Fork and could potentially be impacted by the diversion lake, although the diversion dam could be designed to mitigate those impacts by allowing passage of the shiners during all but high flow events. Additionally, increased flows into Gobbler Creek may change the size and configuration of the channel.[22]

Permitting Issues

A new water use permit from the TCEQ will be required for the impoundment and diversion of water from the North Fork and the conveyance of the diverted water into LAH. Diversions will be subject to instream flow requirements. A USACE Section 404 permit will be required prior to commencing construction of the diversion facilities. Mitigation plans for the project's environmental impacts must be developed and agreed upon by the USACE and other interested state and federal resource agencies. The TCEQ must review and approve construction of proposed facilities.

Other Issues

Property will need to be acquired for the diversion reservoir, dam, and pump station. In addition, pipeline utility easements will be necessary to construct a raw water transmission line to Gobbler Creek.

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[20] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: p. 4-213.

[21] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: p. 4-206.

[22] 2011 Llano Estacado Regional Water Plan. Llano Estacado Regional Water Planning Group. September 2010: p. 4-208, 210.

11 Other Strategies Considered

In addition to the water supply strategies that were fully evaluated and ranked, several strategies were considered that either:

- did not consist of enough data to be fully evaluated, or
- were evaluated in the past but found undesirable for various reasons.

These strategies include Jim Bertram Lake 8, a Jim Bertram Lakes well field, a linear well field along the Canadian River Municipal Water Authority (CRMWA) Aqueduct, the addition of a second CRMWA Aqueduct often referred to as CRMWA III, the South Lubbock Well Field, and the Brackish Well Field. These strategies are discussed in this section.

11.1 Jim Bertram Lake 8

This strategy was included in the 2006 Llano Estacado (Region O) Regional Water Plan. The concept behind this strategy was to construct both Jim Bertram Lake 7 and 8 simultaneously. These lakes were both included to provide a way to use Lubbock's developed water resources. Developed resources include storm water collected into playa lakes, groundwater pumped from under the Lubbock Land Application Site (LLAS), and treated wastewater discharged into the North Fork. Figure 11.1 depicts the proposed location of Lake 8 downstream of Lake Ransom Canyon.

Lake 8 would be built to capture, store, and divert water to the South Water Treatment Plant (SWTP) and subsequently pumped into Lubbock's water distribution system. Design includes: [1]

- A reservoir with 49,900 acre-feet of storage capacity;
- A 26.7 million gallons per day (mgd) capacity pump station and intake structure;
- A 90-inch diameter raw water transmission pipeline with a 26.7 mgd capacity to transfer water 7 miles to the SWTP; and
- Expansion of the SWTP to include an additional 21 mgd treatment capacity.

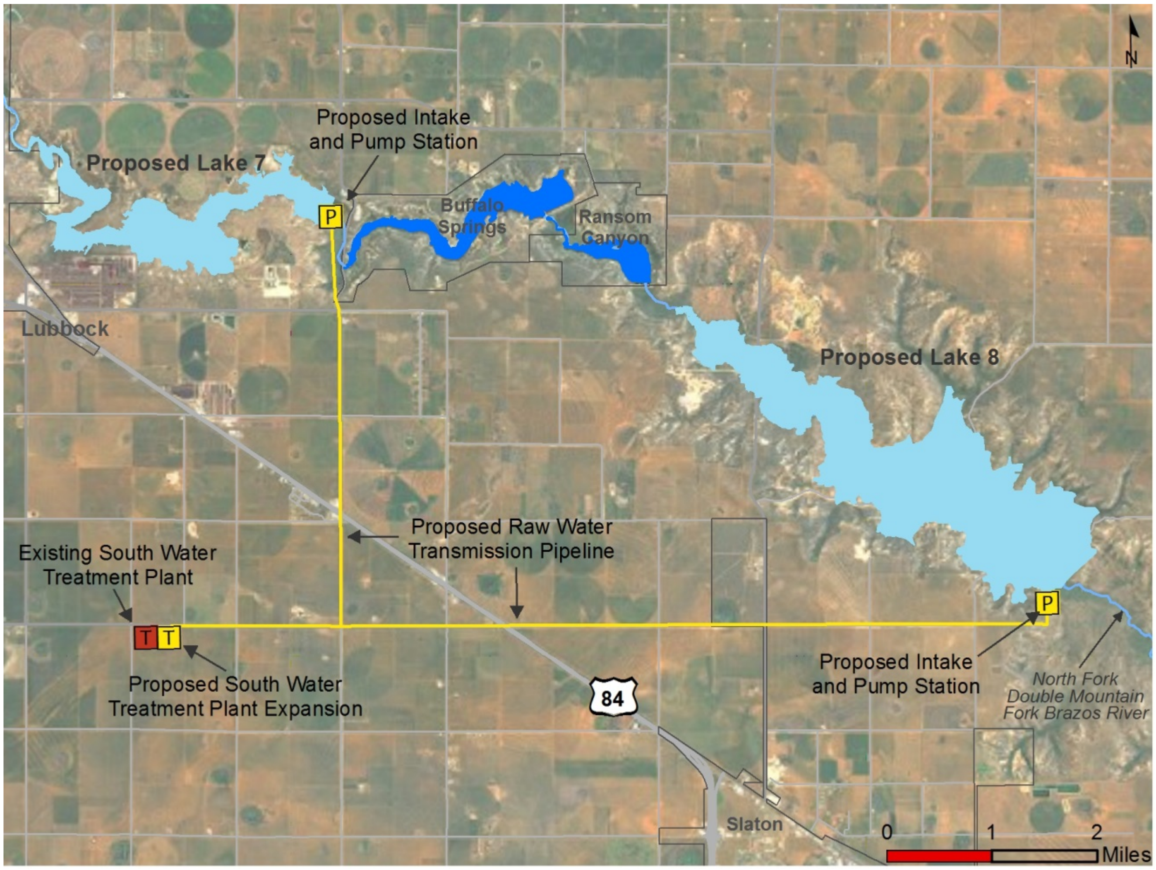
11.1.1 Quantity of Available Water

This strategy was estimated to provide an additional 17,720 acre-feet per year (ac-ft/yr) of annual water supply to Lubbock. This firm yield was determined in conjunction with a 3,500 ac-ft/yr yield for Lake 7 for a total system yield of 21,200 ac-ft/yr.[2] The yield estimate for these two lakes is based on 25,648 ac-ft/yr of available reclaimed water. Current projections indicate that by 2118 (in 100 years), 22.88 mgd (25,625 ac-ft/yr) of reclaimed water will be available for direct and/or indirect reuse (See Section 7.3).

[1] 2006 Llano Estacado Regional Water Plan, HDR, p. 4-183

[2] 2006 Llano Estacado Regional Water Plan, HDR, p. 4-185

Figure 11.1. Location of Proposed Jim Bertram Lake 8



11.1.2 Implementation Issues

In 2005, the City of Lubbock (City) submitted Water Rights Application No. 5921, which, among other things, originally sought the right to impound and divert water from both Lakes 7 and 8. Although the application was declared administratively complete in April 2006, the Texas Commission on Environmental Quality (TCEQ's) technical review is still on-going. On March 4, 2008, a request was made by Lubbock to the TCEQ to remove Lake 8 from the permit application. This was due primarily to the number of existing structures and properties that Lake 8 would inundate if constructed. Lake 8 was subsequently deleted from the 2011 Region O Water Plan.

11.2 Jim Bertram Lakes Well Field

Another potential strategy consists of installing a series of shallow wells in close proximity to the Jim Bertram Lake System (JBLS). This lake system flows through east Lubbock as depicted in Figure 11.2. Wells would be installed on either side of the Lakes 1, 2 and 3. The water would be pumped to the surface, collected, and transported through a pipeline to the North Water Treatment Plant (NWTP) for treatment and distribution.

Data needed to further evaluate this strategy includes:

- The recommended distance between the “bed and banks” of the stream to the proposed wells;
- The hydraulic characteristics of the alluvial formation;
- The depth to the groundwater table and the base of the formation;
- The recommended number of wells;
- A determination of the amount of water that these wells can produce over a sustained period;
- A determination of whether the groundwater is under the influence of surface water;
- A determination of whether the groundwater is considered to be part of the “bed and banks” of the river system;
- Water rights or water use permits that will be required;
- The allowable spacing of the proposed wells;
- Evaluation of the 1970 tornado debris that is buried along the south side of the JBLS;
- The size and length of collection and transmission pipelines that will be needed;
- The type of pumping facilities that will be needed; and,
- The level of treatment that will be required.

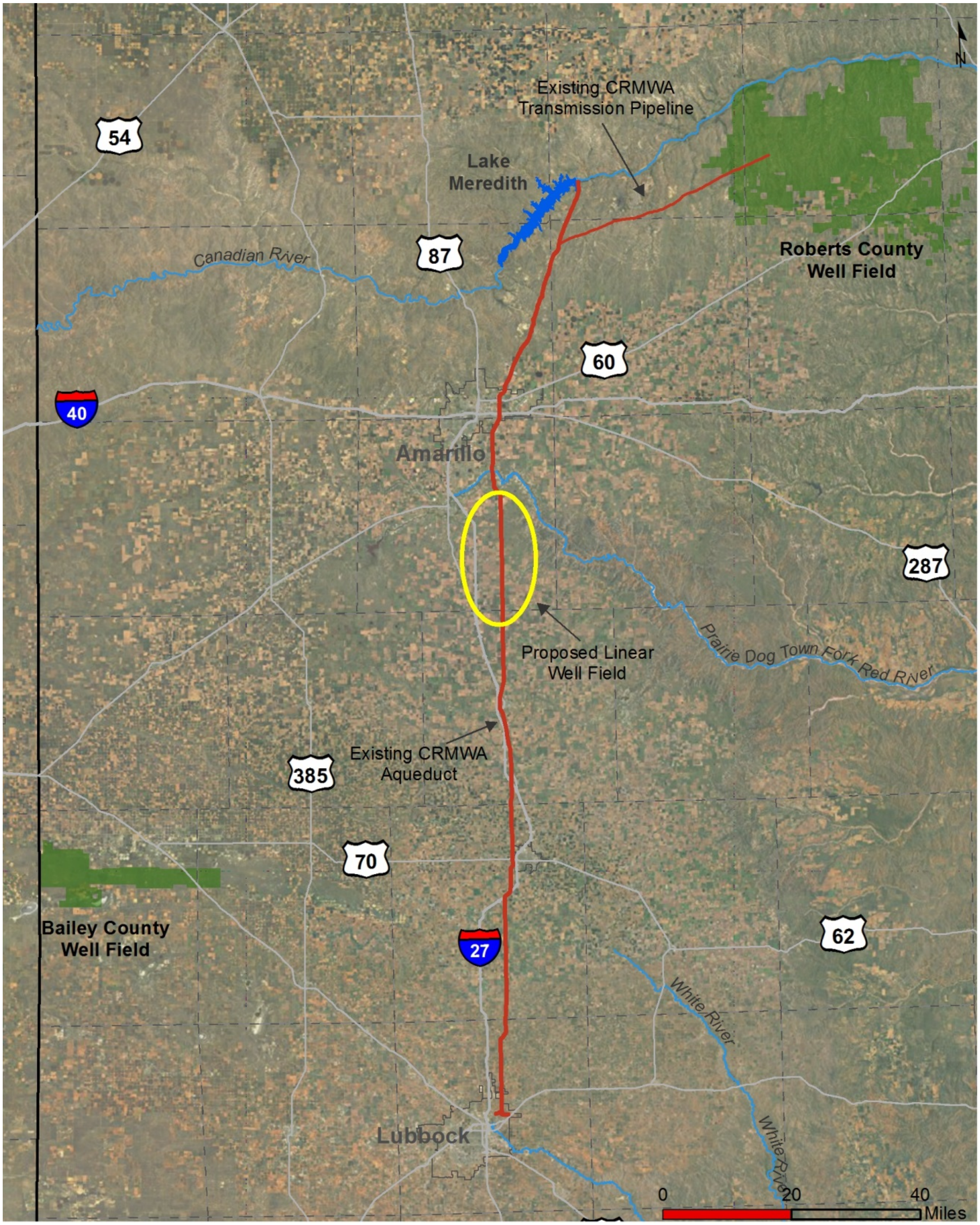
Figure 11.2. Jim Bertram Lakes Well Field

This strategy has been considered because installing a well field along the JBLS has the potential to be a sustainable supply of water since the water in the lakes is recharging into the surrounding water bearing formations. The Northwest Water Reclamation Plant (NWWRP) began discharging treated effluent into JBLS Lake 1 in April 2018. This discharge of water helps mitigate the uncertainty that most of the water found in the lake system has been supplied in the past by pumping groundwater from the LLAS and discharging it into Lake 1. This groundwater remediation project will not provide a long-term, reliable supply of water (beyond 30 years). When the remediation project is ended, the effluent from the NWWRP will be the main source of water discharged into the JBLS. Section 7.9 describes a potable reuse strategy utilizing the discharged groundwater and delivering it to an advanced treatment plant near the NWTP rather than into the JBLS.

11.3 Linear Well Field - CRMWA Aqueduct

This potential strategy consists of installing a series of wells into the Ogallala Aquifer at optimal locations near the existing CRMWA Aqueduct. The groundwater would be pumped to the surface, collected, and transported to the aqueduct for delivery to Lubbock's NWTP for treatment and distribution. This concept is depicted in Figure 11.3.

Figure 11.3. Linear Well Field – CRMWA Aqueduct



The proposed linear well field would be located in an optimal area (encircled in yellow on the figure) between Tulia and Amarillo along the CRMWA Aqueduct.

Data needed to further evaluate this strategy includes:

- Recommended areas along the aqueduct to install proposed wells;
- The hydraulic characteristics of the Ogallala formation in the areas of interest;
- The depth to the groundwater table and the base of the formation;
- The recommended number of wells;
- A determination of the amount of water the wells can produce over a sustained period;
- Water rights and/or water use permits that will be required;
- The allowable spacing of the proposed wells;
- The size and length of collection and transmission pipelines that will be needed;
- The type of pumping facilities that will be needed;
- The level of treatment that will be required.

This strategy has been considered because installing wells along the aqueduct could be a cost effective way to supplement the supply of water in the aqueduct. However, additional information is needed before the evaluation can be completed.

11.4 Additional CRMWA Aqueduct

When the Roberts County Well Field (RCWF) New Transmission Line (Section 8.5) is built, the current CRMWA Aqueduct will be near capacity delivering up to 43,728 ac-ft/yr to Lubbock. At that point, the only way to increase the allocation of water to CRMWA member cities will be to expand the capacity of the aqueduct system. This strategy proposes the construction of a new aqueduct that runs parallel to the existing CRMWA Aqueduct from an area north of Amarillo to Lubbock's NWTP. Since the long-term reliability of Lake Meredith is questionable and the two RCWF transmission lines will be at capacity, a third transmission line may be needed to convey greater quantities of water from the RCWF to the aqueducts in the future.

The existing aqueduct was originally built to transport surface water to member cities. The water must pass through two open top balancing reservoirs between the lake and Lubbock. Therefore, all of the raw water, including groundwater, is treated the same as surface water. If the second aqueduct is constructed, it could be built as a "groundwater only" pipeline and by-pass the balancing reservoirs. This would allow the groundwater to be chlorinated and by-pass Lubbock's NWTP, which is a conventional surface water treatment facility.

Data needed to further evaluate this strategy includes:

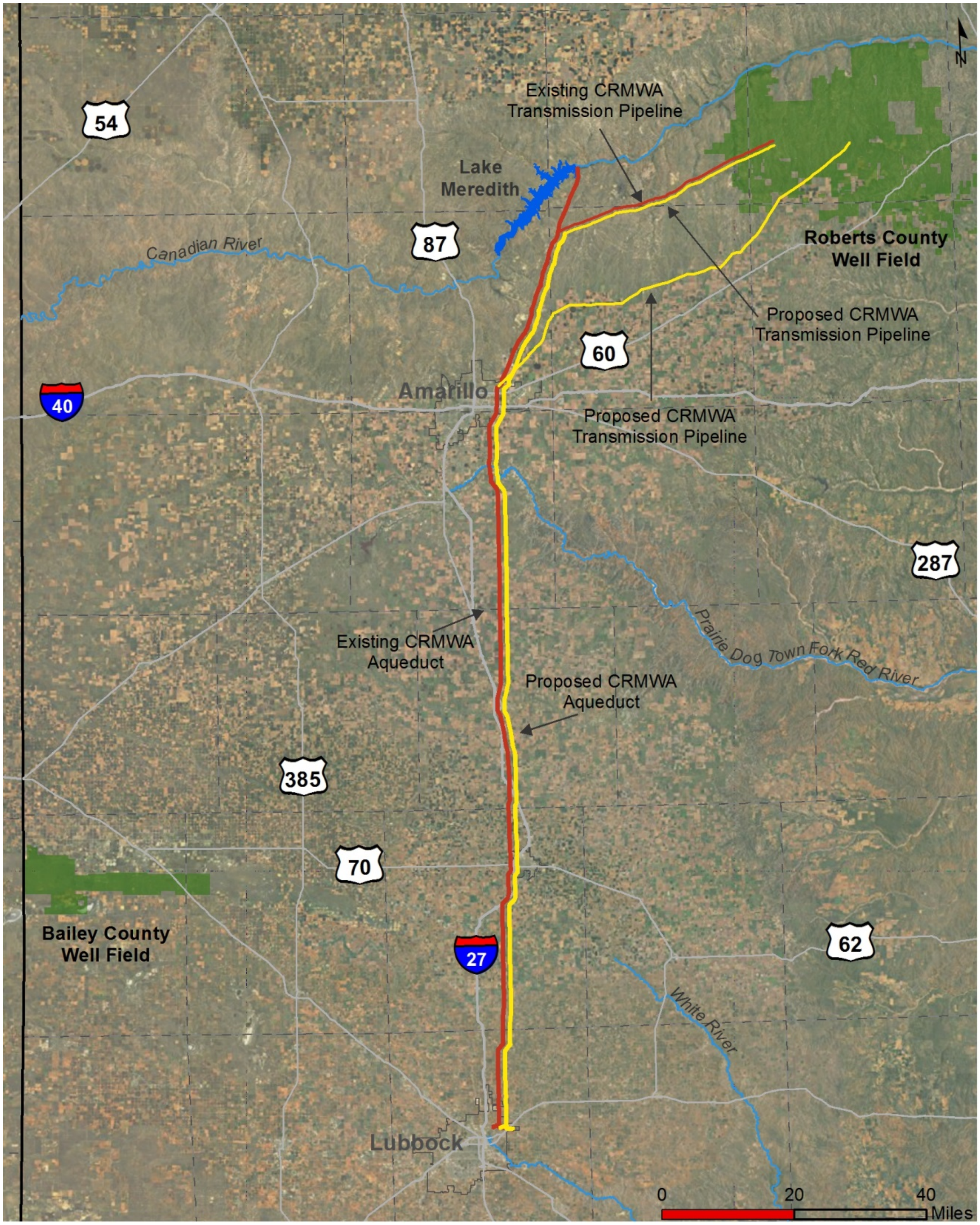
- The allowable RCWF field pumping capacity based on Panhandle Groundwater Conservation District rules;
- The optimal rate of RCWF production;
- The recommended size of the second CRMWA aqueduct;

- The recommended size of the third RCWF transmission line to the CRMWA aqueduct system;
- The length of aqueduct and transmission pipelines that will be needed; and,
- The type of pumping facilities that will be needed.

Figure 11.4 shows a schematic of the necessary infrastructure for the CRMWA Aqueduct Expansion.

This strategy has been considered because installing additional aqueduct and transmission lines in the CRMWA system could quadruple the amount of water allocated to Lubbock from the current CRMWA allocation of 24,088 ac-ft/yr to an allocation of approximately 90,000 ac-ft/yr. However, this means that the RCWF would be depleted at least four times faster than current depletion rates. Additional modeling of the RCWF would be necessary to determine its long-term viability at a much higher production rate. In addition, the cost of such a large and long aqueduct may not be as cost effective as other water supply strategies.

Figure 11.4. Additional CRMWA Aqueduct



11.5 South Lubbock Well Field Strategy

Although the City used over 60 Ogallala Aquifer wells located within the city limits from 1911 to 1970 for potable water supply, the wells and water collection systems have been decommissioned and abandoned. However, in 2006, the City initiated a study to evaluate the feasibility of creating a new well field in the southern part of the City where groundwater levels are relatively high and the saturated thickness is relatively large. The results of the evaluation are documented in the City's *Groundwater Treatment Plant Engineering Report* delivered by Parkhill, Smith & Cooper and Black & Veatch in May 2006[3] and the *Groundwater Utilization Study* delivered by Daniel B. Stephens & Associates (DBS&A) in March 2007.[4] The information in these reports was utilized to evaluate this strategy.

The South Lubbock Well Field Strategy includes the installation of wells on existing City-owned properties. Groundwater would be transported to a new water treatment plant at Pump Station #10, near the intersection of Memphis Avenue and 82nd Street. The raw groundwater will require advanced water treatment to overcome relatively high salinity and the possibility of the groundwater being influenced by hydraulic connection to surface water. The treated water will be discharged into the ground storage tank at Pump Station 10 for blending and distribution. However, there is not sufficient capacity in Pump Station 10 to accommodate this new water supply, and some of the water at Pump Station 10 would need to be diverted to Pump Station 14 for distribution to customers.

The major design features of this strategy include:

- Installation of 17 water supply wells (2 are standby wells);
- All wells are installed on City property and located to meet TCEQ's sanitary control easement requirements (The well locations are based on previous work by DBS&A.);
- Approximately 7 miles of 6- to18-inch diameter raw water collection pipeline;
- Well pumps will be sized to deliver the raw water directly to the new water treatment plant at Pump Station 10;
- A new water treatment plant will be constructed near Pump Station #10. The new treatment plant will provide microfiltration and reverse osmosis (RO) for desalination. The new treatment plant will produce finished water with salinity near the concentration of current potable water supplies;
- Treated water will be delivered to the existing ground storage tank at Pump Station #10 for blending and distribution;
- Since Pump Station 10 is at its designed capacity, some or all of the new water supply would be diverted to Pump Station 14 in order to accommodate the new supply at Pump Station 10;
- A 4-mile, 42-in Low Head C Transmission pipeline to allow flow from the SWTP to reach PS 16 or Bailey County groundwater to flow to PS 14 (see Figure 4.11);

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[3] Engineering Report: Groundwater Treatment Plant- Lubbock, Texas. Parkhill, Smith & Cooper, Inc. May 2006.

[4] City of Lubbock Groundwater Utilization Study. Daniel B. Stephens & Associates Inc. March 23, 2007.

- Desalination concentrate will be disposed of by injecting the concentrate into the Dockum Aquifer;
- The new treatment plant will be designed to produce desalination concentrate with a total dissolved solids (TDS) concentration that is less than or equal to the salinity of water in the Dockum Aquifer; and
- The concentrate disposal well will be located near the new treatment plant.

Figure 11.5 depicts the relative locations of the well field and associated infrastructure needed.

Figure 11.5. South Lubbock Well Field Infrastructure

11.5.1 Quantity of Available Water

This strategy is estimated to produce 7.2 mgd during the summer months (June - September) each year to assist the City in meeting its peak demand. The *Groundwater Utilization Study* report delivered by DBS&A in March 2007 state that this pumping schedule would contribute 2,613 ac-ft/yr to Lubbock's overall water supply.[5] Part of this 2007 study included analyzing a Pump Station #10 strategy with approximately the same yield and well locations as the strategy described here. Their modeling analysis showed 50-year

[5] City of Lubbock Groundwater Utilization Study. Daniel B. Stephens & Associates, Inc. March 23, 2007: ES-3.

groundwater declines of about 20 to 40 ft in the new well field, which results in a minimum saturated thickness of about 40 ft.

11.5.2 Strategy Costs

Costs associated with this strategy are presented in Table 11.1. Assumptions and conditions associated with these costs include:

- A high-capacity Ogallala Aquifer production well can produce 325 gallons per minute (gpm) (0.47 mgd);
- The depth to the base of the Ogallala is averages approximately 135 feet;
- Sparse and relatively old data suggest TDS concentrations range from approximately 570 to over 1,600 milligrams per liter (mg/L). Assuming that the raw groundwater has TDS concentration of 1,250 mg/L, and 50% of the raw water goes to desalination, the resulting TDS concentration is about 625 mg/L;
- This part of the Ogallala Aquifer receives rather rapid and direct recharge from rainfall and possibly urban runoff and irrigation. Considering the likelihood of the water being slightly brackish and possibly influenced by surface water, advanced water treatment is planned. Advanced treatment will include microfiltration and RO;
- Based on a 2003 Texas Water Development Board (TWDB) report,[6] the depth to the base of the best Dockum sandstone is about 1,900 feet;
- Groundwater in the Dockum Aquifer at this location has an estimated TDS concentration of about 25,000 mg/L;
- Brine concentrate will be discharged into a new Dockum disposal well;
- For an operational capacity of 7.2 mgd of potable water, 7.6 mgd of raw water is required. The balance of 0.4 mgd becomes concentrate (50% bypass and 90% efficiency);
- Engineering, legal, and contingency costs is 35% for facilities required by this strategy;
- Power is available at $0.09 per kilowatt-hour (kwh);
- Interest during construction is 4.0%, and a 1.0% return on investments; and
- The project will be financed for 20-years at a 5.5 % interest rate.

As shown, the total project cost is estimated to be $41,888,000. Cost estimates include adjustment for construction in an urban setting. Annual debt service is $3,535,000 and, annual operational cost, including power, is $2,471,000. This results in a total annual cost of $6,006,000. The unit cost for a 2,613 ac-ft/yr supply is estimated to be $2,299 per ac-ft, or $7.05 per 1,000 gallons.

[6] Bradley, R.G., and S. Kalaswad. December 2003. The groundwater resources of the Dockum Aquifer in Texas: TWDB Report 359.

Table 11.1. South Lubbock Well Field Costs (January 2017 Prices)

Item	Estimated Costs for Facilities
CAPITAL COST	
Low Head C Transmission Pipeline	$9,393,000
Low Head C Pump Station	$12,000,000
Well Fields (17 Wells with Pumps, and 6.5 mi of Collector Piping)	$9,579,000
Brackish Water Treatment Plant (4.0 mgd) with 1 Deep Disposal Well	$13,103,000
Integration, Relocations, & Other	$50,000
TOTAL COST OF FACILITIES	**$44,125,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$14,987,000
Environmental & Archaeology Studies and Mitigation	$293,000
Interest During Construction (4% for 1 year with a 1% ROI)	$2,092,000
TOTAL COST OF PROJECT	**$61,497,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$5,176,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$201,000
Water Treatment Plant	$2,235,000
Pumping Energy Costs (622,712 kwh @ 0.09 $/kwh)	$56,000
TOTAL ANNUAL COST	**$7,668,000**
Available Project Yield (ac-ft/yr)	2,613
Annual Cost of Water ($ per ac-ft)	$2,935
Annual Cost of Water ($ per 1,000 gallons)	$9.00

11.5.3 Implementation Issues

Environmental Issues

Environmental issues should be minimal since the new infrastructure would be installed in an urban area.

Permitting Issues

Water well permits from the High Plains Underground Water Conservation District No. 1 will be necessary. Design and construction of public water supply wells and water treatment facilities must be approved by the TCEQ. Authorization to construct and operate an injection well for concentrate disposal will also be required by the TCEQ.

Other

Wells will be placed on City owned properties. In addition, pipelines will be placed in City utility easements. However, pipeline construction under City streets is costly due to the surface infrastructure restoration necessary. Consideration will need to be made regarding a proximate landfill (Old Kingsgate Landfill) located east of Quaker and north of 78th Street. Depletion of groundwater may have a negative effect on existing private wells in the area.

11.6 Brackish Well Field Strategy

This strategy consists of installing wells in the Santa Rosa Formation of the Dockum Aquifer. Brackish water would be pumped to the surface and treated before being used for drinking water. The well system would be constructed on the City's existing 320-acre SWTP site. Desalination facilities will be required for proper treatment, and a concentrate disposal well discharging into the Permian formation will be necessary to dispose of the concentrate produced during treatment.

A recent test drilling study completed HDR for the City and summarized in the March 2017 *Brackish Groundwater Water Supply Evaluation* report provides documentation on local hydrogeologic conditions and updates previous estimates of potential well depths and yields, depth to water, and salinity.[7.]

The major design features of this strategy include:

- The installation of four Dockum production wells in the corners of the SWTP property. Because of the availability of other water sources, no contingency or standby wells are planned.
- The installation of one Permian Formation injection well. As with the supply wells, no contingency well is planned. Storage facilities will be located on the east side of the property;
- Approximately 10,400 feet of 6-inch diameter raw water collection pipeline;
- Approximately 1,000 feet of 6-inch diameter concentrate disposal pipeline;

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[7] HDR Engineering, 2017. Brackish Groundwater Water Supply Evaluation, Engineering Report for City of Lubbock.

- Pumps will deliver the raw water directly to the desalination water treatment plant;
- The desalination water treatment plant will use RO technology. It is assumed to have an efficiency of 85% and will require 98% of the raw water to be treated. The product water will have a TDS concentration of about 840 mg/L and the concentrate will have a TDS concentration of about 280,000 mg/L;
- Concentrate will be delivered to a ground storage tank near the desalination water treatment plant, which is sized to hold the amount of concentrate that is produced in a day;
- From the ground storage tank, concentrate will flow by gravity to the disposal well. No pump station is needed because the static water level in the Permian Formation is expected to be about 500 ft below land surface;
- For an operational capacity of 0.18 mgd of potable water, 0.21 mgd of raw water is required. The balance becomes concentrate; and
- Treated water will be delivered to the SWTP for final blending and distribution.

Figure 11.6 depicts the relative locations of the Brackish Well Field and associated infrastructure needed.

11.6.1 Quantity of Available Water

This strategy is designed for a dependable treated supply of 200 ac-ft/yr or 0.18 mgd. The required raw water supply will be about 235 ac-ft/yr or 0.21 mgd and will generate approximately 34 ac-ft/yr or 0.03 mgd of concentrate. Because the water supply will come from a deep aquifer, it is considered to be independent of drought conditions.

11.6.2 Strategy Costs

Costs associated with this strategy are presented in Table 11.2. Assumptions and conditions associated with these costs include:

- Based on information included in the March 2017 HDR report, a high-capacity Dockum Aquifer production well at this location is expected to produce about 60 gpm (0.09 mgd);
- Based on the March 2017 HDR report, the depth to the base of the best Dockum sandstone is about 1,420 feet;
- Data show that the water has an estimated TDS concentration of about 42,000 mg/L;
- A Permian injection well to a depth of about 5,000 feet provides for disposal of the brine concentrate;
- Engineering, legal, and contingency costs are 35% for the facilities required by this project;
- Power is available at $0.09 per kwh;
- Interest during construction is 4.0%, and a 1.0% return on investments; and
- The project will be financed for 20-years at a 5.5% interest rate.

Figure 11.6. Brackish Well Field Infrastructure

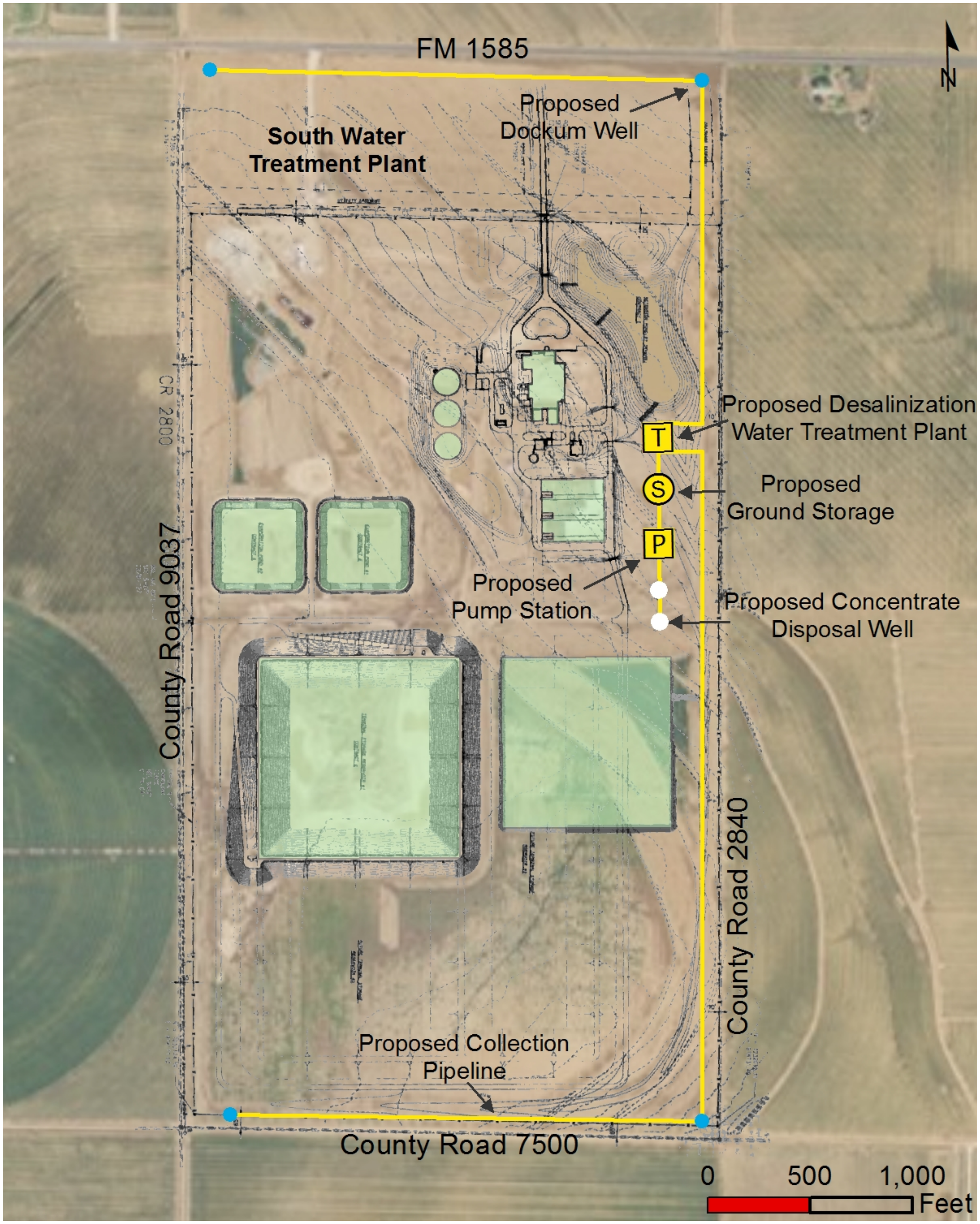

Table 11.2. Brackish Well Field Costs (January 2017 Prices)

Item	Estimated Costs for Facilities
CAPITAL COST	
Concentrate Storage Tank	$106,000
Production Well Field (4 Wells, Pumps, and Collector Piping)	$1,938,000
Disposal Well Field (1 Well and Piping)	$2,019,000
Water Treatment Plant (0.2 mgd)	$4,052,000
TOTAL COST OF FACILITIES	**$8,115,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$2,840,000
Environmental & Archaeology Studies and Mitigation	$54,000
Land Acquisition and Surveying (5 acres)	$0
Interest During Construction (4% for 1 years with a 1% ROI)	$386,000
TOTAL COST OF PROJECT	**$11,395,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$953,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$41,000
Water Treatment Plant	$391,000
Pumping Energy Costs (235,218 kwh @ 0.09 $/kwh)	$21,000
TOTAL ANNUAL COST	**$1,406,000**
Available Project Yield (ac-ft/yr)	200
Annual Cost of Water ($ per ac-ft)	$7,030
Annual Cost of Water ($ per 1,000 gallons)	$21.57

As shown, the total project cost is estimated to be $11,395,000. Annual debt service is $953,000; and, annual operational cost, including power, is $453,000. The total annual cost is $1,406,000. The unit cost for a 200 ac-ft/yr supply is estimated to be $7,030 per ac-ft, or $21.57 per 1,000 gallons.

11.6.3 Implementation Issues

Environmental Issues

Environmental issues should be minimal since the new infrastructure would be installed on existing City properties. No known wildlife habitat or cultural resources would be affected. An environmental assessment for the SWTP approved by the TWDB was prepared as part of the Lake Alan Henry (LAH) Phase 1 infrastructure project. In addition, environmental assessments were performed as part of the City's due diligence in purchasing the property for the SWTP.

Permitting Issues

Water well permits from the High Plains Underground Water Conservation District No. 1 will be necessary. Design and construction of public water supply wells and water treatment facilities must be approved by the TCEQ. Authorization to construct and operate an injection well for concentrate disposal will also be required by the TCEQ.

Other

Wells and collection pipelines will be placed on City-owned properties.

The target zone for brine disposal from oil and gas production in the area is about 5,000 feet deep in the Permian Formation. No other information is readily available to estimate its suitability for a concentrate disposal well. As a result, there is considerable uncertainty in the capacity of the Permian Formation to accept the required injection rate for an extended period of time.

Review of Feasibility for Locating Well Field to a More Favorable Area

A review of the potential yield for this strategy shows that a brackish groundwater supply from the Dockum Aquifer at the SWTP is not feasible because of very high unit cost, which is attributed to deep well depths, low well yields, and high salinity.

A cursory review the potential for more favorable locations in Lubbock County and in neighboring counties was undertaken by studying maps on the Santa Rosa Formation, including: (1) sand thickness, (2) formation thickness, (3) aquifer hydraulic conductivity, (4) total dissolved solids, and (5) depth to base of water bearing zone. Within Lubbock County, these maps show that the most favorable area is the extreme northeast part of the county. The improvement in aquifer properties over the SWTP site is mostly based on considerably lower concentrations of total dissolved solids. In this area, the estimated total dissolved solids concentration is expected to range between less than 1,000 to 5,000 mg/L instead of greater than 40,000 mg/L. In neighboring counties, the aquifer properties in Floyd County appears to be considerable better than those at the SWTP site and the northeast part of Lubbock County. This improvement is based on shallower wells, greater aquifer hydraulic conductivity, thicker sands, and much lower total dissolved solid concentrations. The aquifer properties in Crosby County are also much better than the SWTP site, but not quite as favorable as those in Floyd County.

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12 Supply Strategy Scoring

The potential water supply strategies developed and discussed in Sections 6, 7, 8, 9 and 10 are evaluated and ranked in this section. The objective of the evaluation is to determine which strategies appear to be the most feasible for the City of Lubbock (City) to implement. The scores do not factor in the volume of water produced by each strategy. Neither do the scores incorporate how long it will take for a project to be ready for implementation. These two factors are independently considered in the development of the water supply packages discussed in Section 13.

12.1 Strategy Scoring Criteria

All strategies were evaluated and scored based on a common set of eight criteria. The first three criteria – confidence, reliability/vulnerability, and sustainability consist of some level of subjectivity. Confidence was determined based on the total score of permitting ease, technical feasibility, political feasibility, dependence on others, and staff opinion. The last five criteria – quality, unit cost after debt service, project cost, energy efficiency and operational complexity – are objective. Strategies were assigned a ranking for each criterion on a scale from 1 to 5. The raw scores were then weighted based on the relative importance of each criterion as determined by City staff. The evaluation method provides a relatively objective framework for comparing the relative merits of these strategies. Descriptions of these criteria and associated weightings are presented in Table 12-1.

12.2 Individual Strategy Scoring

Detailed tables providing the rationale for the scoring of each strategy with respect to each criterion are shown in Tables 12.2 through 12.20. Strategy rankings are based on the current known political, regulatory, technological, and other conditions. Many supply strategies are interchangeable. The attractiveness of each strategy may change over time based on a variety of unforeseen circumstances. Rankings can be updated periodically as evaluation factors change in the future.

Table 12.1. Evaluation Criteria

Category	Weight	1 Low / Poor	2	3 Medium	4	5 High / Excellent
Confidence	2.0	The likely success of the potential project based on several factors (permitting, technical and political challenges; dependence on others; and overall staff opinion).				
Reliability/ Vulnerability	1.0	The likelihood that the water source is available 100% of the time. The likelihood that the water source is not at risk of being interrupted (pipeline breaks, contamination, drought susceptibility, etc.) 1: High risk of interrupted supply 5: Low risk of interrupted supply				
Sustainability	1.0	The likelihood that the supply will be available for a longer period than other strategies. 1: less than or equal to (≤) 20 yrs; 2: ≤ 40 yrs; 3: ≤ 60 yrs; 4: ≤ 80 years 5: greater than (>) 80 years				
Quality	0.5	The relative level of water treatment required for each strategy. 1: Advanced Treatment: RO + Other Techniques; 2: Advanced Treatment: RO only; 3: Conventional Treatment; 4: Filtration; 5: Chlorination Only				
Unit Cost after Debt Service (cost /1,000 gal)	1.5	The relative unit costs compared to other strategies after debt service is retired. 1: greater than (>) $3.07; 2: less than or equal to (≤) $3.07; 3: ≤ $2.00; 4: ≤ $1.38; 5: ≤ $0.62				
Project Cost ($ in millions)	1.0	The relative total project cost compared to other strategies. 1. greater than (>) $125 M;2: less than or equal to (≤) $125 M; 3: ≤ $100 M; 4: ≤ $60 M; 5: ≤ $15 M				
Operational Complexity	0.5	The relative operational complexity compared to other strategies. 1: High complexity to operate 5: Low complexity to operate				
Energy Efficiency	1.5	The relative energy intensity compared to other strategies. 1: greater than (>) 5500 kwh/MG; 2: less than or equal to (≤) 5500 kWh/MG; 3: ≤ 4500 kWh/MG; 4: ≤ 3000 kWh/MG; 5: ≤ 1250 kWh/MG				

12.2.1 Conservation Strategies

Table 12.2. All Conservation Strategies Scored Together – Strategy Evaluation

Category	Score	Reason for Ranking
Confidence	5	Past experience has shown that the conservation savings can be achieved.
Reliability/ Vulnerability	5	Water saved is not subject to outside influences.
Sustainability	5	Most water savings can be continued indefinitely.
Quality	5	No change in water quality from existing sources.
Unit Cost after Debt Service (cost /1,000 gal)	4	Cost is reasonable for the water savings achieved.
Project Cost ($ in millions)	5	Cost is reasonable for the water savings achieved.
Operational Complexity	3.4	Requires a variety of programs be implemented and maintained over time.
Energy Efficiency	5	Requires virtually no energy to implement.

12.2.2 Reclaimed Water Strategies

Table 12.3. North Fork at CR 7300 – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	3	This supply strategy is within 15 miles of Lubbock. The City holds permits to discharge, transport, and divert the reclaimed water at CR 7300 on the North Fork. Sufficient reclaimed water will be needed to implement this strategy. Landowner opposition may be an issue at CR 7300. The City holds a permit to discharge up to 10,089 ac-ft/yr (9 mgd) of treated effluent at Outfall 001 into the North Fork. In addition, the impoundment and diversion permit at CR 7300 was issued in 2012. However, the City must still acquire the land for the diversion facility, easements for the pipelines, and authorization by the TCEQ to construct facilities.
Reliability/ Vulnerability	5	This strategy uses 100% reclaimed water. Reclaimed water availability is dependent on commitments to other users and operational decisions. The water supplied is interruptible.
Sustainability	5	Since water used for this strategy is 100% reclaimed water, it should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Quality	1	This strategy consists of treated effluent that is discharged into the North Fork and transported downstream 2.7 miles where it will be diverted. Before entering the distribution system, this water will need to undergo advanced treatment that includes membrane barriers.
Unit Cost after Debt Service	3	The unit cost of water for this strategy after debt service is $1.62/1,000 gal.
Project Cost	1	The project cost for this strategy is $161,186,000.
Operational Complexity	1	This project required advanced treatment.
Energy Efficiency	3	The energy efficiency for this strategy is 3,567 kWh/MG produced.

Raw Score	22
Weighted Score	27

Table 12.4. Direct Potable Reuse to NWTP – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	3.4	Public perception of direct potable reuse in Texas has improved some. Improvements in technology and drought conditions have stimulated increased desire in many communities to implement this type of strategy. Standards, rules, and regulations are still being developed. The TCEQ is currently developing potable reuse guidance requirements to be applied to proposed projects and to be used as the basis for reviewing permit applications. Future permits must comply with these "undeveloped" regulations
Reliability/ Vulnerability	5	This strategy uses 100% reclaimed water. Reclaimed water availability is dependent on commitments to other users and operational decisions. The water supplied is interruptible.
Sustainability	5	The water used by this strategy will be 100% reclaimed water. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Quality	1	The water used by this strategy must be treated using RO plus other barriers during advanced treatment since it includes direct reuse of wastewater effluent.
Unit Cost after Debt Service	4	The unit cost of water for this strategy is $0.85/1,000 gal.
Project Cost	2	The project cost for this strategy is $117,104,000.
Operational Complexity	1	This project requires advanced treatment.
Energy Efficiency	4	The energy intensity for this strategy is 2,861 kWh/MG produced.

Raw Score	25.4
Weighted Score	31.8

Table 12.5. Direct Potable Reuse to SWTP – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	3.2	Public perception of direct potable reuse in Texas has improved some. Improvements in technology and drought conditions have stimulated increased desire of many communities to implement this type of strategy. Standards, rules, and regulations are still being developed.
Reliability/ Vulnerability	5	This strategy uses 100% reclaimed water. Reclaimed water availability is dependent on commitments to other users and operational decisions. The water supplied is interruptible.
Sustainability	5	The water used by this strategy will be 100% reclaimed water. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Quality	1	The water used by this strategy must be treated using RO plus other barriers during advanced treatment since it includes direct reuse of wastewater effluent.
Unit Cost after Debt Service	3	The unit cost of water for this strategy is $1.39/1,000 gal after debt service.
Project Cost	1	The project cost for this strategy is $147,519,000.
Operational Complexity	1	This project requires advanced treatment.
Energy Efficiency	4	The energy efficiency for this strategy is 2,422 kWh/MG produced.

Raw Score	23.2
Weighted Score	28.9

Table 12.6. South Fork Discharge to LAH Supplement – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	3.0	Public concern exists about discharging reclaimed water into the South Fork that will be mixed with LAH water. Furthermore, high carriage losses (19%) make this strategy less attractive. The City's existing discharge permit (TPDES Permit WQ0010353002) will need to be amended to include an additional outfall on the South Fork. Also, although the City's current Water Right Permit No. 4146 for LAH authorizes a maximum annual withdrawal of 35,000 ac-ft/yr, the City needs to ensure that the return flow discharges on the South Fork can be diverted and used.
Reliability/ Vulnerability	4	This strategy uses 100% reclaimed water. The water supplied could be considered interruptible during dry times due to distance from City and interception by intervening users.
Sustainability	5	The water used by this strategy will be 100% reclaimed water. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Quality	3	This water consists of treated effluent that is discharged, transported 36 miles down the South Fork, and impounded in LAH. The water will be blended into the lake water. Treatment will be advanced treatment with membranes.
Unit Cost after Debt Service	4	The unit cost of water for this strategy is $0.84/1,000 gal after debt service.
Project Cost	2	The project cost for this strategy is $82,852,000.
Operational Complexity	3	This project requires continued discharges and maintenance of facilities into a tributary of the South Fork that drains into LAH.
Energy Efficiency	2	The energy efficiency for this strategy is 4,703 kWh/MG produced.

Raw Score	26
Weighted Score	29

Table 12.7. North Fork Diversion to LAH Pump Station – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	3.6	The diversion point for this strategy is over 50 miles from Lubbock. The City holds a permit to discharge the reclaimed water, but does not hold permits to transport, impound, and divert the reclaimed water at this location. Existing water rights holders and landowners may oppose an application for a permit. Sufficient reclaimed water will be needed to implement this strategy. Carriage losses are high. Water blended with the LAH raw water at the LAHPS could present treatment issues.
Reliability/ Vulnerability	3	This strategy uses 100% reclaimed water. The water supplied could be considered interruptible during dry times due to distance from City and interception by intervening users.
Sustainability	5	The water used by this strategy will be 100% reclaimed water. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Quality	3	This water consists of treated effluent that is discharged into the North Fork and transported downstream 67 miles where it will be diverted. Before entering the distribution system, this water will need to undergo advanced treatment that includes membrane barriers.
Unit Cost after Debt Service	4	The unit cost of water for this strategy is $0.89/1,000 gal after debt service.
Project Cost	3	The project cost for this strategy is $75,480,000.
Operational Complexity	3	This project requires continued discharge of return flows into the North Fork, and monitoring to assure they reach the diversion location. Potential water quality differences between the North Fork and LAH supplies may increase operational complexity.
Energy Efficiency	4	The energy efficiency for this strategy is 2,934 kWh/MG produced.

Raw Score	28.6
Weighted Score	33.2

Table 12.8. DPR NWWRP to NWTP (Option 7B) – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	3.6	Public perception of direct potable reuse in Texas has improved some. Improvements in technology and drought conditions have stimulated increased desire of many communities to implement this type of strategy. Standards, rules, and regulations are still being developed.
Reliability/ Vulnerability	5	This strategy uses 100% reclaimed water. Reclaimed water availability is dependent on commitments to other users and operational decisions. The water supplied is interruptible.
Sustainability	5	The water used by this strategy will be 100% reclaimed water. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Quality	1	The water used by this strategy must be treated using RO plus other barriers during advanced treatment since it includes direct reuse of wastewater effluent.
Unit Cost after Debt Service	4	The unit cost of water for this strategy is $1.16/1,000 gal after debt service.
Project Cost	3	The project cost for this strategy is $74,886,000.
Operational Complexity	1	This project requires advanced treatment.
Energy Efficiency	3	The energy efficiency for this strategy is 3,679 kWh/MG produced.

Raw Score	25.6
Weighted Score	31.7

Table 12.9. DPR NWWRP to PS9 (Option 8) – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	2.4	Public perception of direct potable reuse in Texas has improved some. Improvements in technology and drought conditions have stimulated increased desire of many communities to implement this type of strategy. Standards, rules, and regulations are still being developed.
Reliability/ Vulnerability	5	This strategy uses 100% reclaimed water. Reclaimed water availability is dependent on commitments to other users and operational decisions. The water supplied is interruptible.
Sustainability	5	The water used by this strategy will be 100% reclaimed water. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Quality	1	The water used by this strategy must be treated using RO plus other barriers during advanced treatment since it includes direct reuse of wastewater effluent.
Unit Cost after Debt Service	3	The unit cost of water for this strategy is $1.29/1,000 gal after debt service.
Project Cost	3	The project cost for this strategy is $81,728,000.
Operational Complexity	1	This project requires advanced treatment.
Energy Efficiency	3	The energy efficiency for this strategy is 3,679 kWh/MG produced.

Raw Score	23.4
Weighted Score	27.8

Table 12.10. LLAS Groundwater Potable Reuse – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	3.8	Public perception of direct potable reuse in Texas has improved some. Improvements in technology and drought conditions have stimulated increased desire of many communities to implement this type of strategy. Standards, rules, and regulations are still being developed.
Reliability/ Vulnerability	5	This strategy uses 100% reclaimed water. Reclaimed water availability is dependent on commitments to other users and operational decisions. The water supplied is interruptible.
Sustainability	3	The water used by this strategy will be 100% reclaimed water. This supply should be available for less than 60 years assuming that the City is depleting the mounded groundwater under the LLAS.
Quality	1	The water used by this strategy must be treated using RO plus other barriers during advanced treatment since it includes direct reuse of wastewater effluent.
Unit Cost after Debt Service	4	The unit cost of water for this strategy is $0.65/1,000 gal after debt service.
Project Cost	4	The project cost for this strategy is $15,116,000.
Operational Complexity	1	This project requires advanced treatment.
Energy Efficiency	5	The energy efficiency for this strategy is 615 kWh/MG produced.

Raw Score	26.8
Weighted Score	34.1

12.2.3 Groundwater Strategies

Table 12.11. RCWF Capacity Maintenance – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	4.0	The likely success of this project is high since it maintains the capacity of an already existing water supply. All financial decisions for this strategy must be approved and implemented by the CRMWA board. Panhandle Groundwater Conservation District rules may change production strategies from the RCWF. Water well permits from the Panhandle Groundwater Conservation District will be necessary. Design and construction of public water supply wells and water transmission facilities must be approved by the TCEQ.
Reliability/ Vulnerability	5	This strategy relies on groundwater that should be available as needed.
Sustainability	3	Estimates vary as to the amount of available groundwater in the Ogallala Aquifer in Roberts County. Further data collection is needed to determine the exact saturated thickness. This water supply should last at least 60 years.
Quality	3	The groundwater from Roberts County is high quality. The only treatment typically required is chlorination. However, Lubbock must treat the groundwater like surface water since the groundwater must pass through two open topped balancing reservoirs before it reaches Lubbock.
Unit Cost after Debt Service	5	The unit cost of water for this strategy is $0.16/1,000 gal.
Project Cost	5	The project cost for this strategy is $8,747,000.
Operational Complexity	5	This project involves continued operation and expansion of existing facilities already well understood.
Energy Efficiency	4	The energy efficiency for this strategy is 1,566 kWh/MG produced.

Raw Score	34
Weighted Score	38.5

Table 12.12. BCWF Capacity Maintenance – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	4.2	The likely success of this project is high since it includes maintaining the capacity of an already existing water supply. This strategy has minimal legal/permitting issues, a relatively low unit/project/annual cost, and can be implemented quickly. Water well permits from the High Plains Underground Water Conservation District No. 1 will be necessary. Design and construction of public water supply wells and water transmission facilities must be approved by the TCEQ.
Reliability	3	This strategy relies on groundwater that should be available as needed.
Sustainability	1	With the estimated annual use of 5,000 ac-ft/yr, current modeling suggests that the BCWF should be sustainable for at least 40 years.
Quality	4	The groundwater from Bailey County is high quality. The only treatment required is chlorination.
Unit Cost	5	The unit cost of water for this strategy is $4.30/1,000 gal.
Project Cost	5	The project cost for this strategy is $4,328,000.
Operational Complexity	5	This project involves continued operation and expansion of existing facilities already well understood.
Energy Efficiency	5	The energy efficiency for this strategy is 1,225 kWh/MG produced.

Raw Score	32.2
Weighted Score	36.9

Table 12.13. RCWF New Transmission Line to Aqueduct – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	3.8	Any decision regarding the RCWF requires the consent of all CRMWA member cities. Many of the cities have expressed interest in this project as the large incremental increase in water supply will assist with the cities' growing water demands. Water well permits from the Panhandle Groundwater Conservation District will be necessary. Design and construction of public water supply wells and water transmission facilities must be approved by the TCEQ. Furthermore, CRMWA must acquire easements for the new transmission line.
Reliability/ Vulnerability	5	This strategy relies on groundwater that should be available as needed.
Sustainability	3	Estimates vary as to the amount of water contained in the Ogallala Aquifer in Roberts County. Further data collection and aquifer modeling is needed to estimate saturated thickness and well field decline patterns.
Quality	3	The groundwater from Roberts County is high quality. The only treatment typically required is chlorination. However, Lubbock must treat the groundwater like surface water since the groundwater must pass through two open topped balancing reservoirs before it reaches Lubbock.
Unit Cost after Debt Service	4	The unit cost of water for this strategy is $1.06/1,000 gal.
Project Cost	2	Lubbock's portion of the project cost for this strategy is $122,811,000.
Operational Complexity	5	This project involves operation of a facility very similar to existing facilities by a party other than the City, i.e., CRMWA.
Energy Efficiency	1	The energy efficiency for this strategy is 7,048 kWh/MG produced.

Raw Score	26.8
Weighted Score	29.1

12.2.4 Surface Water Strategies

Table 12.14. Lake Alan Henry Phase 2 – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	5.0	Phase 1 of the LAH water supply is already complete. Phase 2 expands the treatment and pumping capacity. Staff is confident that Phase 2 can be implemented successfully. The permitting issues associated with this project were addressed in Phase 1. No additional permitting requirements are anticipated with Phase 2. Design and construction of public water supply and treatment facilities must be approved by the TCEQ.
Reliability/ Vulnerability	4	The water used for this strategy will be 100% surface water. Water from this strategy should be available at all times and useful for peaking capacity also.
Sustainability	5	If precipitation patterns, land use trends, and the City's usage from the lake do not change in the coming decades, LAH should be sustainable for more than 80 years.
Quality	3	Advanced treatment using membrane barriers was installed during Phase 1. Phase 2 will include the same type of treatment facilities.
Unit Cost after Debt Service	2	The unit cost of water for this strategy is $2.61/1,000 gal.
Project Cost	3	The project cost for this strategy is $77,907,000.
Operational Complexity	5	This project involves operation and expansion of an existing system
Energy Efficiency	2	The energy efficiency for this strategy is 5,470 kWh/MG produced.

Raw Score	29
Weighted Score	32

Table 12.15. Jim Bertram Lake 7 – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	3.4	There is mixed public interest in this project. Some downstream water rights holders are opposed to the lake while others are in favor. Due to complex permitting issues, high project costs, and length of time required to plan and construct a reservoir, confidence levels are low. Water Rights Application No. 5921 associated with Lake 7 is under technical review by the TCEQ. In addition, the TCEQ has received several requests for a contested case hearing. It will take several more years before the permit can be issued. A USACE Section 404 permit will be required prior to commencing construction of Lake 7. Mitigation plans for the project's environmental impacts must be developed and agreed upon by the USACE and other state and federal agencies. The City must also acquire the property for the lake, dam, pump station, wildlife mitigation area, and pipeline easements.
Reliability/ Vulnerability	5	This strategy uses a combination of reclaimed water, state water/natural inflows, and playa lake developed water. Reclaimed water availability is dependent on City water usage and operational decisions at the wastewater treatment plant. State water/natural inflows and playa lake developed water are dependent upon precipitation.
Sustainability	5	This strategy relies heavily on City's reclaimed water to be viable. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Quality	2	This strategy uses reclaimed water, state water/natural inflows, and playa lake developed water. Sufficient blending and detention time is available most years. However, advanced treatment may be necessary during extended drought periods. Costs include advanced treatment.
Unit Cost after Debt Service	4	The unit cost of water for this strategy is $0.89/1,000 gal.
Project Cost	1	The project cost for this strategy is $207,261,000.
Operational Complexity	2	This project will require advanced treatment due to the large proportion of reclaimed water that will be stored in the reservoir.
Energy Efficiency	4	The energy efficiency for this strategy is 2,224 kWh/MG produced.

Raw Score	26.4
Weighted Score	31.8

Table 12.16. Post Reservoir – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	1.8	There is mixed public interest for this project. Some existing water rights holders may be opposed to the lake while some elected officials may be interested in economic development in Garza County. Moreover, due to complex permitting issues, high project costs, and length of time required to plan and construct a reservoir, confidence levels are low. The City would need to obtain ownership of the TCEQ Certificate of Adjudication No. 3711 from the White River Municipal Water District in order to construct the reservoir. The permit will need to be amended so the City can divert sufficient water to make this strategy viable. In addition, a USACE Section 404 permit will be required prior to commencing construction of the Post Reservoir. The project would bifurcate existing habitat for the smalleye and sharpnose shiners, two minnow species recently added to the Endangered Species List. Mitigation plans for the project's environmental impacts must be developed and agreed upon by the USACE and other state and resource agencies. The City must also acquire the property for the lake, dam, pump station, wildlife mitigation area, and pipeline easements.
Reliability/ Vulnerability	3	This strategy uses a combination of reclaimed water, state water/natural inflows, and playa lake developed water. Reclaimed water availability is dependent on City water usage and operational decisions at the wastewater treatment plant. State water/natural inflows and playa lake developed water are dependent upon precipitation. Yield data requires additional studies to increase reliability score.
Sustainability	5	This strategy relies heavily on City's reclaimed water to be viable. This supply should be available for at least 80 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Quality	3	This strategy uses reclaimed water, state water/natural inflows, and playa lake developed water. Advanced treatment with membrane barriers is necessary.
Unit Cost after Debt Service	3	The unit cost of water for this strategy is $0.78/1,000 gal.
Project Cost	1	The project cost for this strategy is $122,643,000.
Operational Complexity	3	This project would require coordinated operation with the existing LAH pipeline facilities, and differences in water quality may make also increase the project's operational complexity.
Energy Efficiency	4	The energy efficiency for this strategy is 2,102 kWh/MG produced.

Raw Score	23.8
Weighted Score	26.1

Table 12.17. North Fork Scalping Operation – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	3.2	This strategy requires the City to file a new water rights permit application with the TCEQ. It is uncertain whether the TCEQ will grant any more permits on the North Fork. The water availability may be over allocated already. It is uncertain whether existing water rights holders would protest the application. A water use permit authorized by the TCEQ will be required for the impoundment and diversion of storm water. A USACE Section 404 permit will also be required. The City will need to acquire property for the diversion facilities and pump station. In addition, pipeline utility easements will be necessary to construct a raw water transmission line to Gobbler Creek.
Reliability	3	The water used for this strategy is storm water and is, therefore, dependent upon precipitation events. Consequently, this is not the most reliable source of water. It will help "firm up" LAH's yield.
Sustainability	5	If precipitation patterns, land use, and senior water rights usage trends do not change in the coming decades, this project should be sustainable for more than 80 years.
Quality	3	This strategy is comprised of storm water flows that flow into LAH. Advanced treatment with membrane barriers is necessary.
Unit Cost after Debt Service	3	The unit cost of water for this strategy is $1.08/1,000 gal.
Project Cost	1	The project cost for this strategy is $144,564,000.
Operational Complexity	3	This project requires intermittent operation of large facilities.
Energy Efficiency	3	The energy efficiency for this strategy is 3,889 kWh/MG produced.

Raw Score	24.2
Weighted Score	27.4

12.2.5 Aquifer Storage and Recovery Strategies

Table 12.18. Reclaimed Water ASR to NWTP– Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	3.2	ASR has not been attempted in the Lubbock area of the Ogallala Aquifer. Due to the many uncertainties in reliability, sustainability, and water losses during storage, confidence in this strategy is low. Public perception of potable reuse in Texas has improved some. Improvements in technology and drought conditions have stimulated increased desire in many communities to implement this type of strategy. Standards, rules, and regulations are still being developed. The TCEQ is currently developing potable reuse guidance requirements to be applied to proposed projects and to be used as the basis for reviewing permit applications. Future permits must comply with these "undeveloped" regulations. Permits will also be needed from the Groundwater Conservation District for injection and extraction of groundwater.
Reliability/ Vulnerability	5	This strategy uses 100% reclaimed water. Reclaimed water availability is dependent on commitments to other users and operational decisions. The water supplied is interruptible. Also, some water is lost between injection into the aquifer and recovery from the aquifer.
Sustainability	5	The water used by this strategy will be 100% reclaimed water. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Quality	2	The water used by this strategy must be treated using RO plus other barriers during advanced treatment since it includes direct reuse of wastewater effluent.
Unit Cost after Debt Service	3	The unit cost of water for this strategy is $1.59/1,000 gal after debt service
Project Cost	4	The project cost for this strategy is $54,806,000.
Operational Complexity	1	This project requires advanced treatment and operation of ASR facilities for which little experience is available.
Energy Efficiency	3	The energy efficiency for this strategy is 4,375 kWh/MG produced.

Raw Score	26.2
Weighted Score	30.9

Table 12.19. Reclaimed Water ASR to SWTP– Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	3.4	ASR has not been attempted in the Lubbock area of the Ogallala Aquifer. Due to the many uncertainties in reliability, sustainability, and water losses during storage, confidence in this strategy is low. Public perception of potable reuse in Texas has improved some. Improvements in technology and drought conditions have stimulated increased desire in many communities to implement this type of strategy. Standards, rules, and regulations are still being developed. The TCEQ is currently developing potable reuse guidance requirements to be applied to proposed projects and to be used as the basis for reviewing permit applications. Future permits must comply with these "undeveloped" regulations. Permits will also be needed from the Groundwater Conservation District for injection and extraction of groundwater.
Reliability/ Vulnerability	5	This strategy uses 100% reclaimed water. Reclaimed water availability is dependent on commitments to other users and operational decisions. The water supplied is interruptible. Also, some water is lost between injection into the aquifer and recovery from the aquifer.
Sustainability	5	The water used by this strategy will be 100% reclaimed water. This supply should be available for at least 60 years unless the City seeks to use the reclaimed water for another beneficial purpose.
Quality	2	The water used by this strategy must be treated using RO plus other barriers during advanced treatment since it includes direct reuse of wastewater effluent.
Unit Cost after Debt Service	2	The unit cost of water for this strategy is $1.93/1,000 gal after debt service
Project Cost	1	The project cost for this strategy is $133,592,000.
Operational Complexity	1	This project requires advanced treatment and operation of ASR facilities for which little experience is available.
Energy Efficiency	1	The energy efficiency for this strategy is 5,850 kWh/MG produced.

Raw Score	19.5
Weighted Score	23.3

Table 12.20. CRMWA to Aquifer Storage & Recovery – Strategy Evaluation

Category	Raw Score	Reason for Score
Confidence	3.6	ASR has not been attempted in the Lubbock area of the Ogallala Aquifer. Due to the many uncertainties in reliability, sustainability, and water losses during storage, confidence in this strategy is low. It is uncertain when excess water will be available in the CRMWA Aqueduct to use for ASR. Both injection and recovery wells will need to be permitted by the High Plains Underground Water Conservation District No. 1. Design and construction of the public water supply transmission facilities must be approved by the TCEQ.
Reliability/ Vulnerability	3	This strategy seeks to store CRMWA water during the winter months so it can be used in the summer to meet peak demands. The amount of water available for storage is dependent upon the amount of excess capacity in the CRMWA Aqueduct.
Sustainability	4	Long-term sustainability of this strategy is dependent upon how CRMWA uses the capacity of the existing or future aqueducts that supply Lubbock with water. Important factors include member city allocations which are set annually and Lubbock's water demand/usage. These factors will likely change in future years creating some uncertainty.
Quality	3	Groundwater recovered from the Ogallala Aquifer is high quality. It should only require chlorination for treatment.
Unit Cost	5	The unit cost of water for this strategy is $0.43/1,000 gal.
Project Cost	3	The project cost for this strategy is $97,870,000.
Operational Complexity	1	This project requires operation of ASR facilities for which little experience is available.
Energy Efficiency	4	The energy efficiency for this strategy is 1,242 kWh/MG produced.

Raw Score	26.6
Weighted Score	32.7

12.3 Strategy Scoring

Based on the aggregate score for each strategy, the strategies were compared and ranked. Scores ranged from 27 to 38.5. The results of the scoring by type of water supply (reclaimed water, surface water, and groundwater) are presented in Table 12.21. From this table the following general observations can be made:

- The highest scoring reclaimed water strategy is the Lubbock Land Application Site (LLAS) Potable Reuse;
- The highest scoring groundwater strategy is the Roberts County Well Field (RCWF) Capacity Maintenance;
- The highest scoring surface water strategy is Lake Alan Henry (LAH) Phase 2;
- Strategies involving Ogallala groundwater generally have the highest scores of all categories; and

- Reclaimed water strategies demonstrated a wider range in scores than the other types of strategies.

Table 12.22 provides a list of the strategies sorted by their respective scores (highest to lowest). From this table the following general observations can be made:

- The two top ranked strategies – RCWF Capacity Maintenance and the Bailey County Well Field (BCWF) Capacity Maintenance are associated with existing Ogallala water supplies;
- The RCWF New Transmission Line provides the most incremental increase in water supply at 21,583 ac-ft/yr;
- The BCWF Capacity Maintenance provides the least incremental increase in water supply at 286 ac-ft/yr; and
- Four strategies have essentially the same score – Lake Alan Henry Phase 2, Jim Bertram Lake 7, Direct Potable Reuse (DPR) to North Water Treatment Plant (NWTP) from Southeast Water Reclamation Plant (SEWRP), and DPR Option 7B (Northwest Water Reclamation Plant [NWWRP] to NWTP).

Figure 12.1 provides a graphical representation of the ranking of the strategies and the amount of additional water each strategy will provide. This information is used to prepare the strategic supply packages presented in Section 13.

Table 12.21. Water Supply Strategy Scores by Supply Type

Lubbock Water Supply Strategies	2016 Region O Plan[3]	Additional Studies since 2013 SWSP	Incremental Capacity Increase (ac-ft/yr)	Reliability/ Vulnerabilty	Sustainability	Quality	Unit Cost after debt	Project Cost	Operational Complexity	Energy Efficiency	Confidence	Raw Score	Total Weight Score
Weight				1.0	1.0	0.5	1.5	1.0	0.5	1.5	2.0		
Reclaimed Water													
LLAS Groundwater Potable Reuse		yes	2,240	5	3	1	4	4	1	5	3.8	26.8	34.1
North Fork Diversion to LAH Pump Station	Alt	no	12,385	3	5	3	4	3	3	4	3.6	28.6	33.2
DPR to NWTP from SEWRP	Alt	yes	9,274	5	5	1	4	2	1	4	3.4	25.4	31.8
DPR Option 7B (NWWRP to NWTP)		yes	5,376	5	5	1	4	3	1	3	3.6	25.6	31.7
South Fork Discharge - LAH Supplement	Alt	no	13,058	4	5	3	4	2	3	2	3.0	26	29
DPR to SWTP from SEWRP	Alt	no	9,274	5	5	1	3	1	1	4	3.2	23.2	28.9
DPR Option 8 (NWWRP to PS9)		yes	5,376	5	5	1	3	3	1	3	2.4	23.4	27.8
North Fork Diversion - County Road 7300	Alt	yes	10,089	5	5	1	3	1	1	3	3	22	27
Groundwater													
RCWF - Capacity Maintenance		no	11,630	5	3	3	5	5	5	4	4	34	38.5
BCWF Capacity Maintenance	Rec	yes	286	3	1	4	5	5	5	5	4.2	32.2	36.9
RCWF - New Transmission Line[1]	Rec	no	21,583	5	3	3	4	2	5	1	3.8	26.8	29.1
Surface Water													
LAH - Phase 2	Rec	no	4,875	4	5	3	2	3	5	2	5	29	32
Jim Bertram Lake 7	Rec	yes	11,975	5	5	2	4	1	2	4	3.4	26.4	31.8
North Fork Scalping Operation	Rec	no	13,600	3	5	3	3	1	3	3	3.2	24.2	27.4
Post Reservoir	Alt	no	13,837	3	5	3	3	1	3	4	1.8	23.8	26.1
ASR Water													
CRMWA ASR[2]	Rec	yes	10,920	3	4	3	5	3	1	4	3.6	26.6	32.7
Reclaimed ASR to NWTP	Alt	yes	5,600	5	5	2	3	4	1	3	3.2	26.2	30.9
Reclaimed ASR to SWTP		yes	5,600	5	5	1	2	1	1	1	3.4	19.4	23.3

1 - Strategy is dependent on another for the full yield or full operation.

2 - Strategy would be activated if CRMWA Lake Meredith supplies are unavailable due to drought or water quality.

3 - "Alt" and "Rec" indicate alternative or recommended strategy in the 2016 Region O Plan.

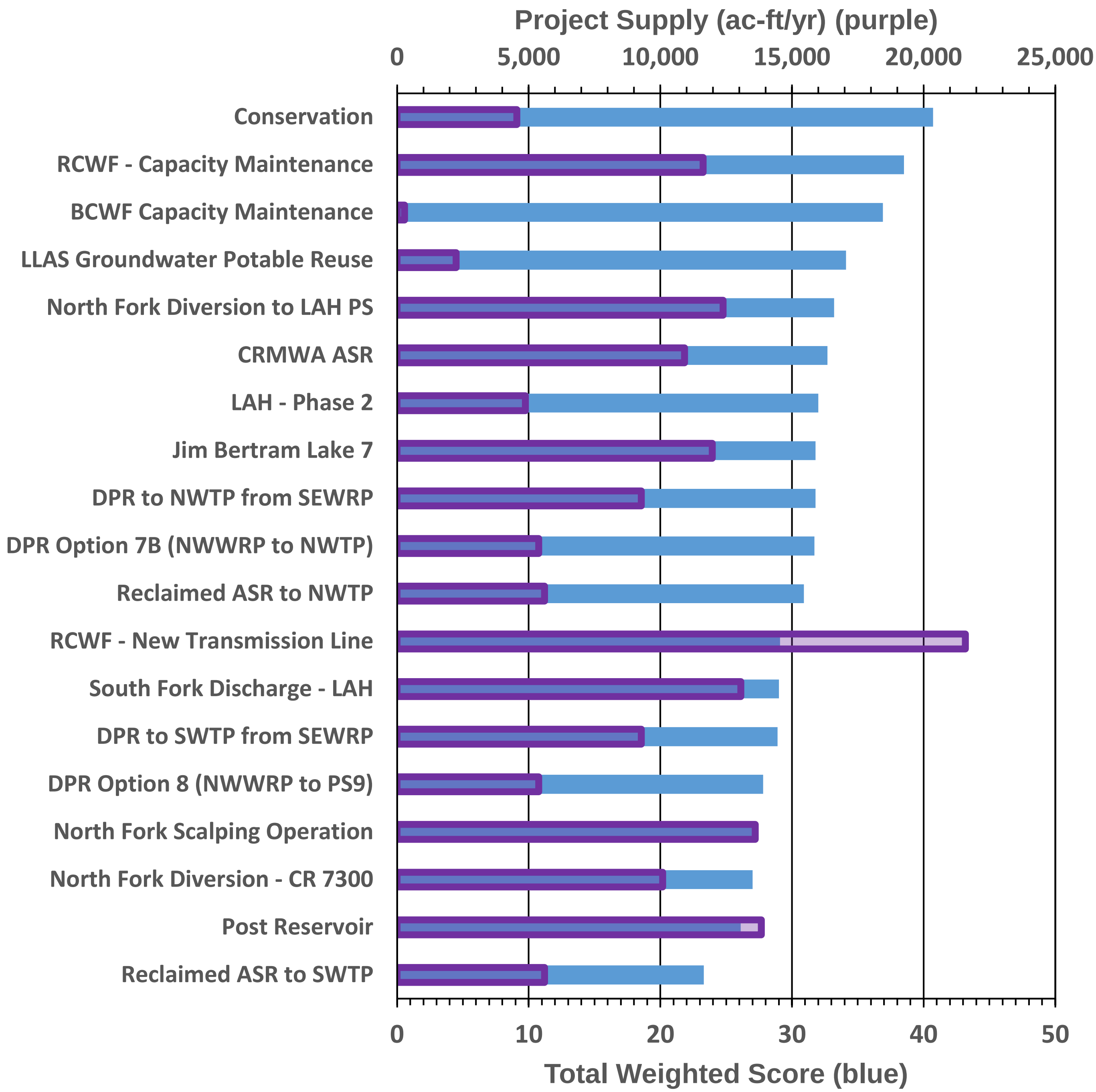
Table 12.22. Water Supply Strategy Scores from Highest to Lowest

Lubbock Water Supply Strategies	2016 Region O Plan	Additional Studies since 2013 SWSP	Incremental Capacity Increase (ac-ft/yr)	Reliability/ Vulnerability	Sustainability	Quality	Unit Cost after debt	Project Cost	Operational Complexity	Energy Efficiency	Confidence	Raw Score	Total Weight Score
Weight				1.0	1.0	0.5	1.5	1.0	0.5	1.5	2.0		
RCWF - Capacity Maintenance		no	11,630	5	3	3	5	5	5	4	4	34	38.5
BCWF Capacity Maintenance	Rec	yes	286	3	1	4	5	5	5	5	4.2	32.2	36.9
LLAS Groundwater Potable Reuse		yes	2,240	5	3	1	4	4	1	5	3.8	26.8	34.1
North Fork Diversion to LAH Pump Station	Alt	no	12,385	3	5	3	4	3	3	4	3.6	28.6	33.2
CRMWA ASR2	Rec	yes	10,920	3	4	3	5	3	1	4	3.6	26.6	32.7
LAH - Phase 2	Rec	no	4,875	4	5	3	2	3	5	2	5	29	32
DPR to NWTP from SEWRP	Alt	yes	9,274	5	5	1	4	2	1	4	3.4	25.4	31.8
Jim Bertram Lake 7	Rec	yes	11,975	5	5	2	4	1	2	4	3.4	26.4	31.8
DPR Option 7B (NWWRP to NWTP)		yes	5,376	5	5	1	4	3	1	3	3.6	25.6	31.7
Reclaimed ASR to NWTP	Alt	yes	5,600	5	5	2	3	4	1	3	3.2	26.2	30.9
RCWF - New Transmission Line1	Rec	no	21,583	5	3	3	4	2	5	1	3.8	26.8	29.1
South Fork Discharge - LAH Supplement	Alt	no	13,058	4	5	3	4	2	3	2	3	26	29
DPR to SWTP from SEWRP	Alt	no	9,274	5	5	1	3	1	1	4	3.2	23.2	28.9
DPR Option 8 (NWWRP to PS9)		yes	5,376	5	5	1	3	3	1	3	2.4	23.4	27.8
North Fork Scalping Operation	Rec	no	13,600	3	5	3	3	1	3	3	3.2	24.2	27.4
North Fork Diversion - County Road 7300	Alt	yes	10,089	5	5	1	3	1	1	3	3	22	27
Post Reservoir	Alt	no	13,837	3	5	3	3	1	3	4	1.8	23.8	26.1
Reclaimed ASR to SWTP		yes	5,600	5	5	1	2	1	1	1	3.4	19.4	23.3

1 - Strategy is dependent on another for the full yield or full operation.

2 - Strategy would be activated if CRMWA Lake Meredith supplies are unavailable due to drought or water quality.

Figure 12.1. Supply Strategy Scoring and Available Water



13 Water Supply Packages

In this section, various potential water supply strategies are combined with existing water supplies to create water supply package designed to meet the City of Lubbock (City's) projected water demand over the next 100 years. The supply packages were developed by:

- Meeting projected water demands for the 100 year planning period (through 2118);
- Incorporating existing water supplies discussed in Section 4;
- Basing the need for a new strategy on either the Annual Water Demand (AWD) projection or the Peak Day Demand (PDD) projection, whichever intersects with the projected supply line (associated with the demand) first. (Note that the peak day supply capacity is often the critical factor when deciding on when to implement strategies later in the planning timeline); and
- Providing a diverse set of supply packages for meeting the City's future demands.

Five different supply packages are presented and discussed in this section that depict a wide range of strategies that can be used to meet the Expected Drought, Conservation and/or Accelerated Growth Demands presented in Section 2.

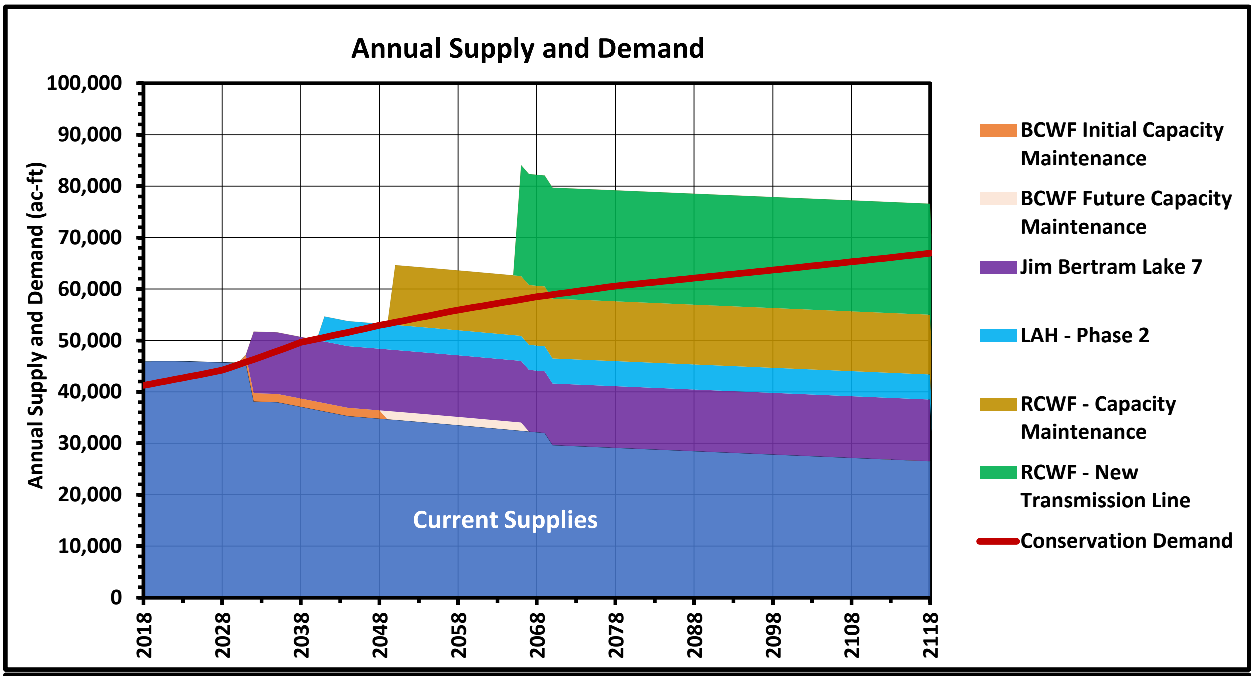
13.1 Supply Package 1 – Early Diversification

The Early Diversification supply package is intended to continue diversifying the City's water supplies so that the City is not overly dependent on a single source of supply. The City enjoys a diverse set of water supplies relying on two separate groundwater sources and two separate surface water sources. The City's current sources of supply all originate and are transported from a relatively long distance from the City and are individually vulnerable to interruption due to a variety of factors including power outages, structural failures such as pipeline breaks, water quality contamination, natural phenomena such as extended drought and wildfires, and criminal activities. Just as it is wise financially to maintain diverse investment portfolios, it is wise for the City to continue to maintain the diversity of its water supply portfolio to meet its future water supply needs.

The Early Diversification supply package meets water demands under the Conservation demand scenario by maintaining and/or increasing supplies from the existing Roberts County and Bailey County Well Fields (RCWF and BCWF) and Lake Alan Henry (LAH), and also develops a new source of supply at a fairly early stage, Jim Bertram Lake 7. Because Lake 7 will utilize the City's reclaimed effluent as the primary portion of its yield, supply from Lake 7 will be relatively drought proof. Its proximate location to the City renders it somewhat less vulnerable to extended interruption than the City's existing supplies that are located much further away from Lubbock.

Figure 13.1compares the City's annual and PDDs with the supplies developed by the strategies in the package. Figure 13.2 presents a timeline for when the various strategies would be implemented.

Figure 13.1. Early Diversification Supply Package



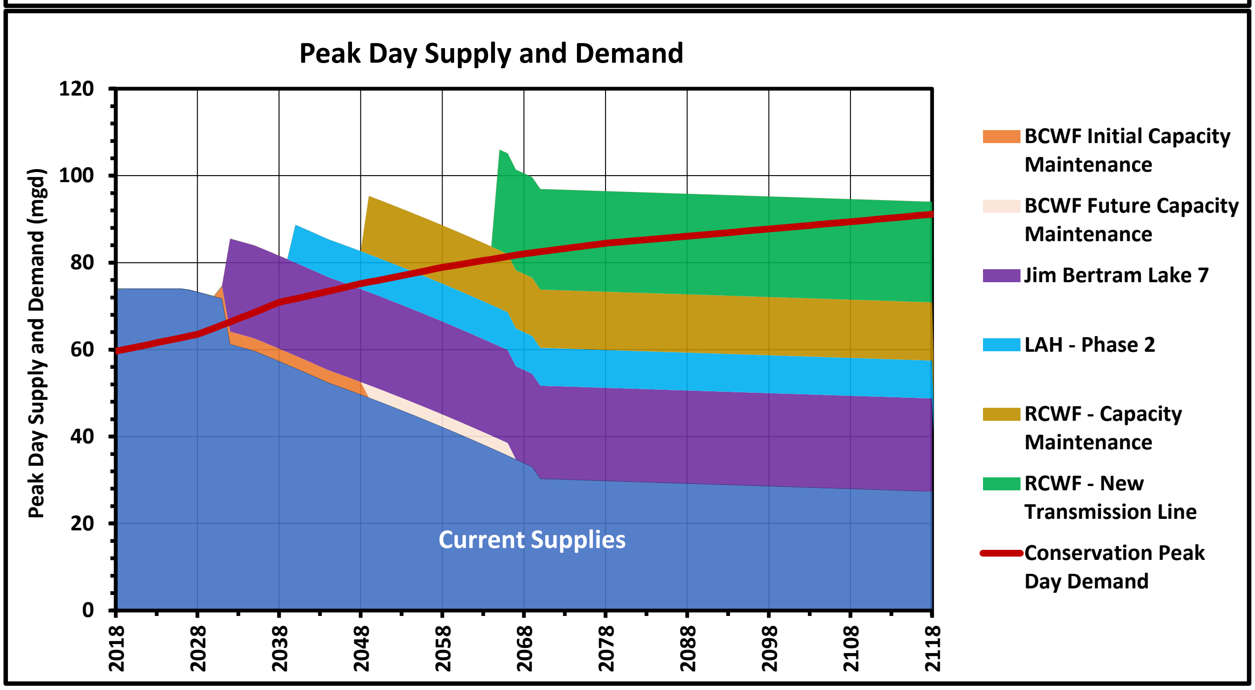
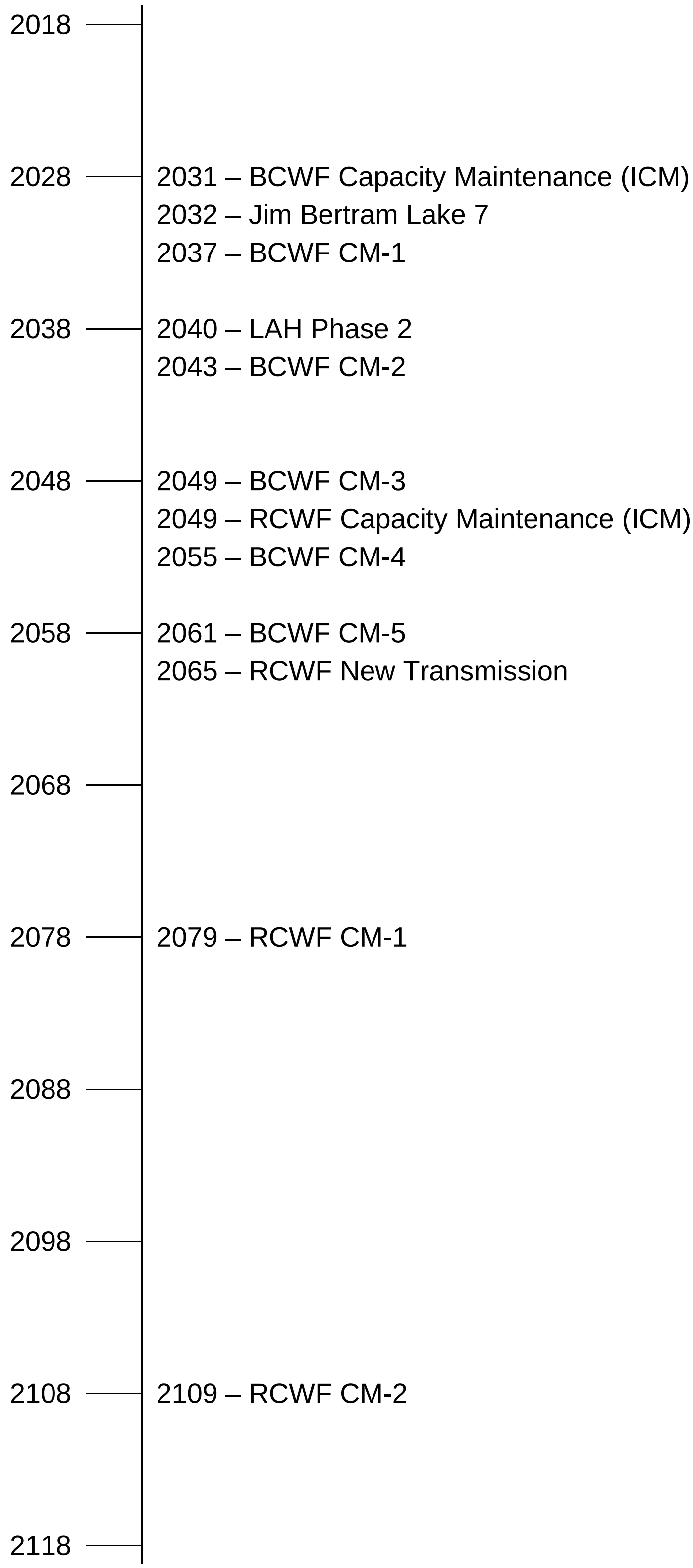


Figure 13.2. Timeline for Early Diversification Supply Package

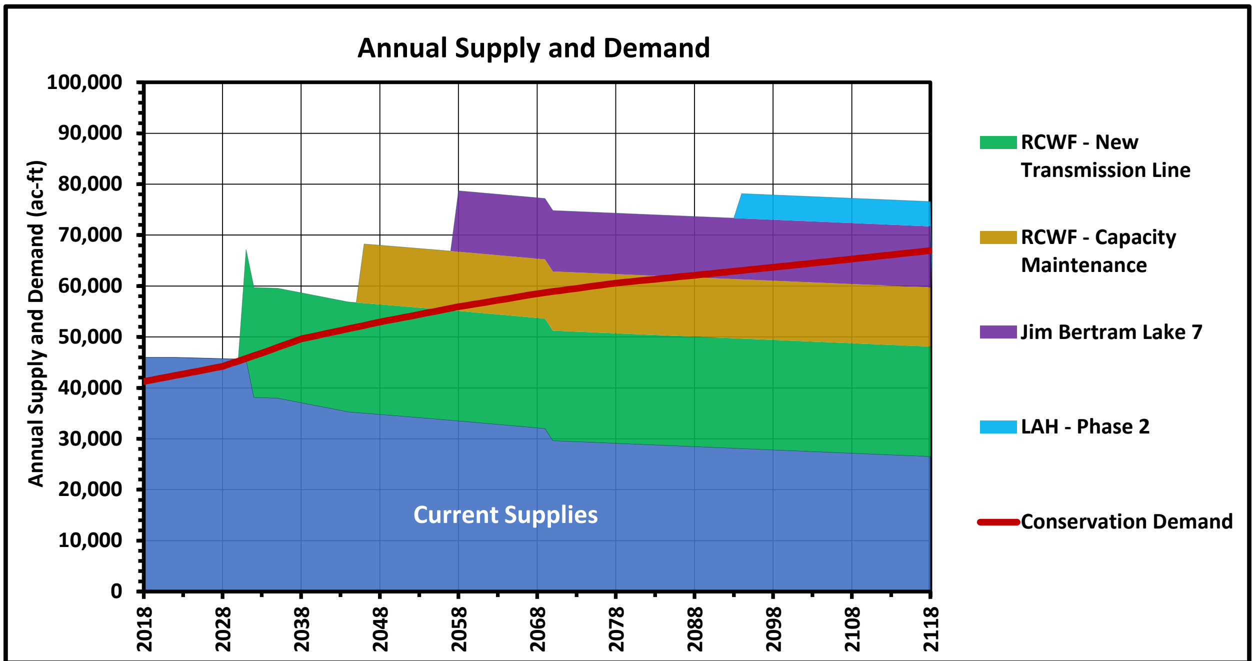


13.2 Supply Package 2 – Maximize RCWF

The Maximize RCWF supply package is intended to, as much as possible, increase reliance on supplies from the RCWF. The RCWF is a drought proof, dependable supply that is easily maintained and expanded and requires minimal water treatment. This supply package capitalizes on those characteristics early in the timeline. Expansion of surface water supplies (Lake 7 and LAH Phase 2) is delayed, and the BCWF is not maintained beyond its current configuration. Implementation of Lake 7 is needed by 2058 in order to meet PDDs, but could be delayed until almost 2088 if annual supplies were the only consideration.

Figure 13.3 compares the City's AWD and PDD with the supplies developed by the strategies in the package. Figure 13.4 presents a timeline for when the various strategies would be implemented.

Figure 13.3. Maximize RCWF Supply Package



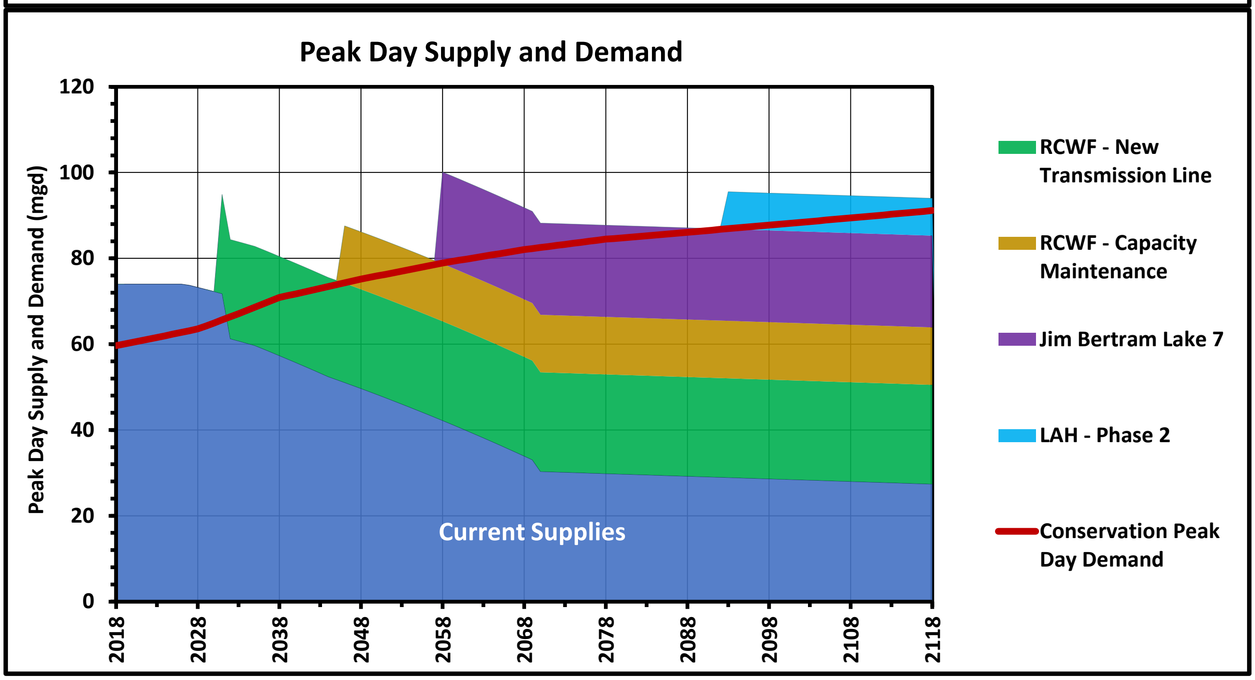
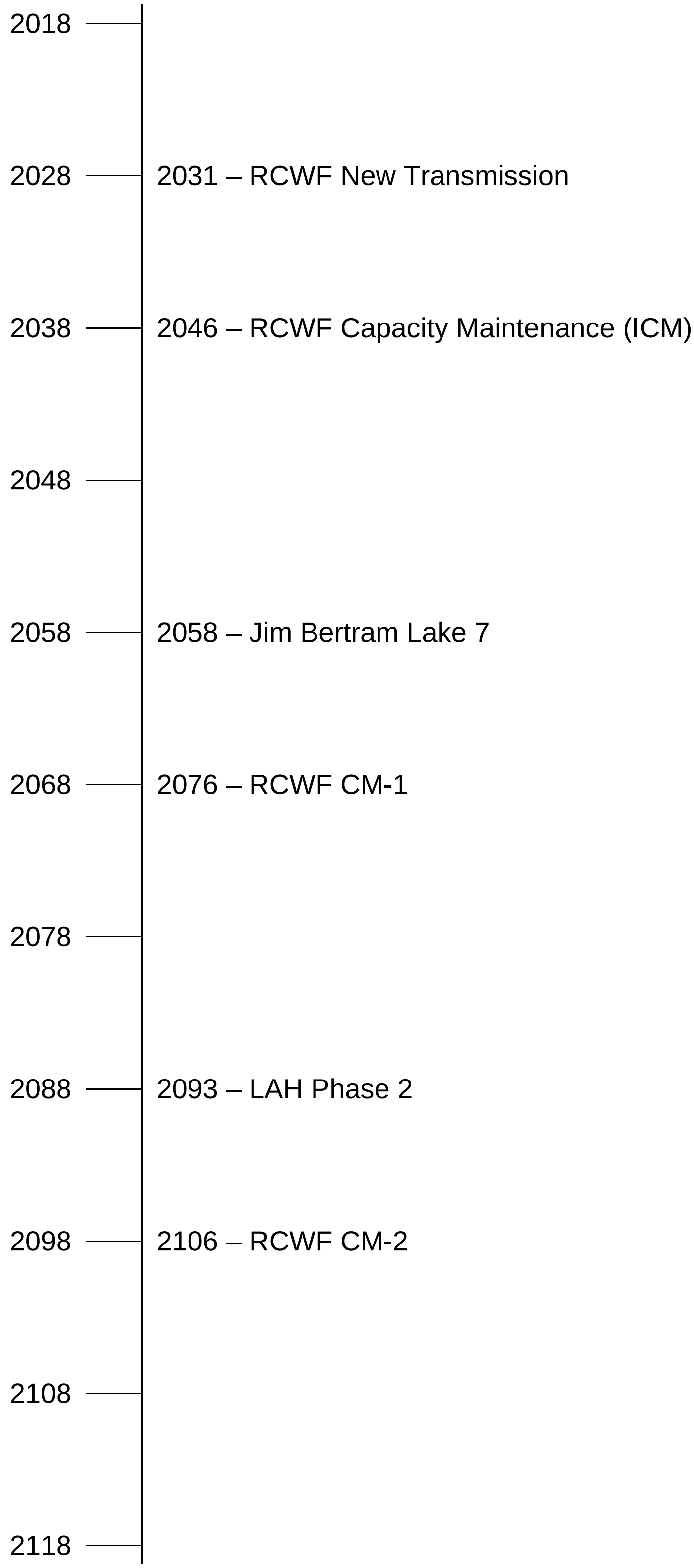


Figure 13.4. Timeline for Maximize RCWF Supply Package



13.3 Supply Package 3 – Maximize Groundwater

The Maximize Groundwater supply package is similar to the Maximize RCWF package, except that the BCWF continues to be expanded and maintained in order to retain its current 30 million gallons per day (mgd) peak day supply capacity, and the order in which the surface water supply projects (LAH Phase 2 and Lake 7) are implemented is reversed. This package delays the implementation of the RCWF strategies by one to three years. However, in order to meet PDDs in the 2060's, the Jim Bertram Lake 7 would need to be implemented soon after implementing LAH Phase 2.

Figure 13.5 compares the City's AWD and PDD with the supplies developed by the strategies in the package. Figure 13.6 presents a timeline for when the various strategies would be implemented.

Figure 13.5. Maximize Groundwater Supply Package

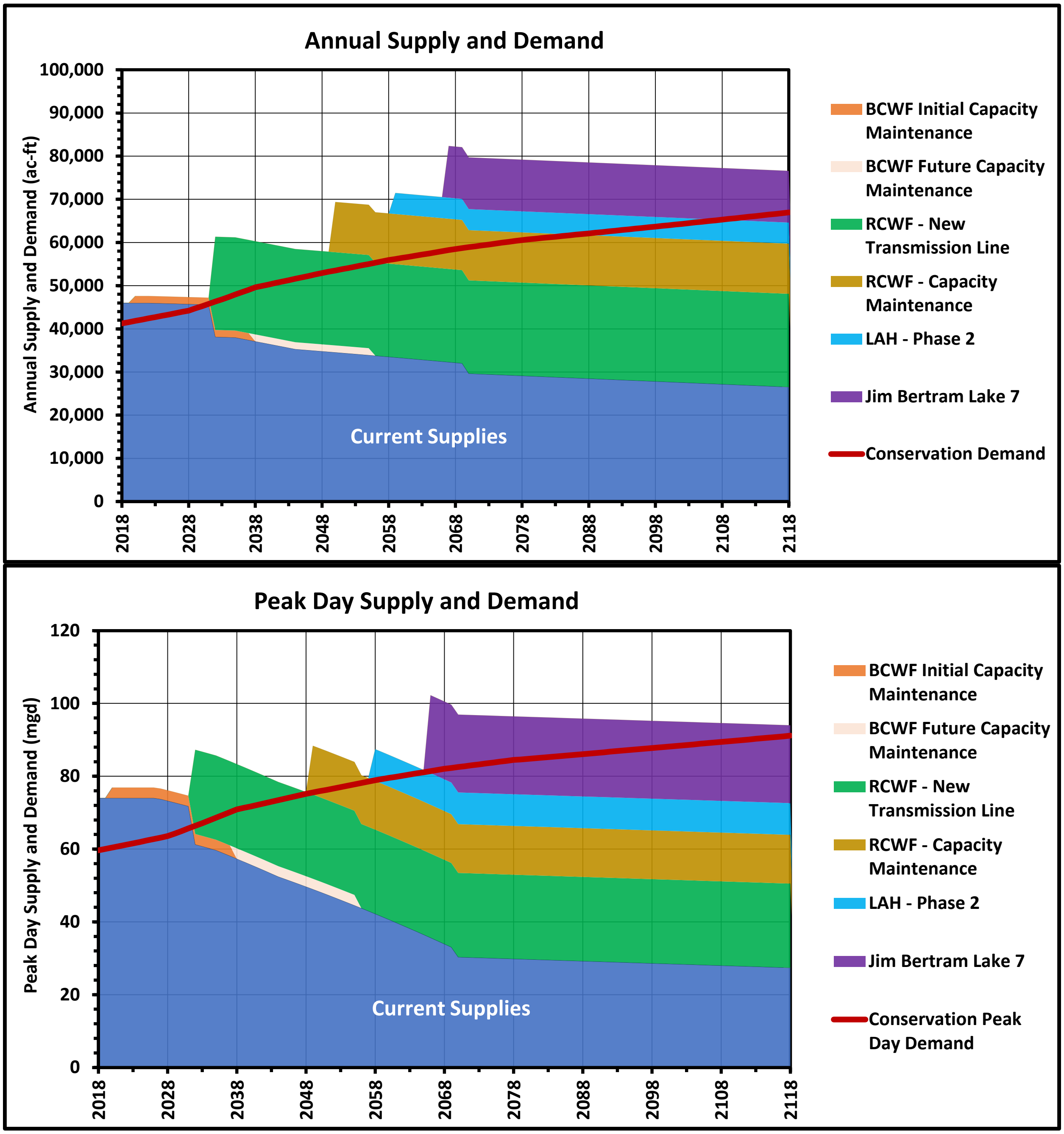


Figure 13.6. Timeline for Maximize Groundwater Supply Package

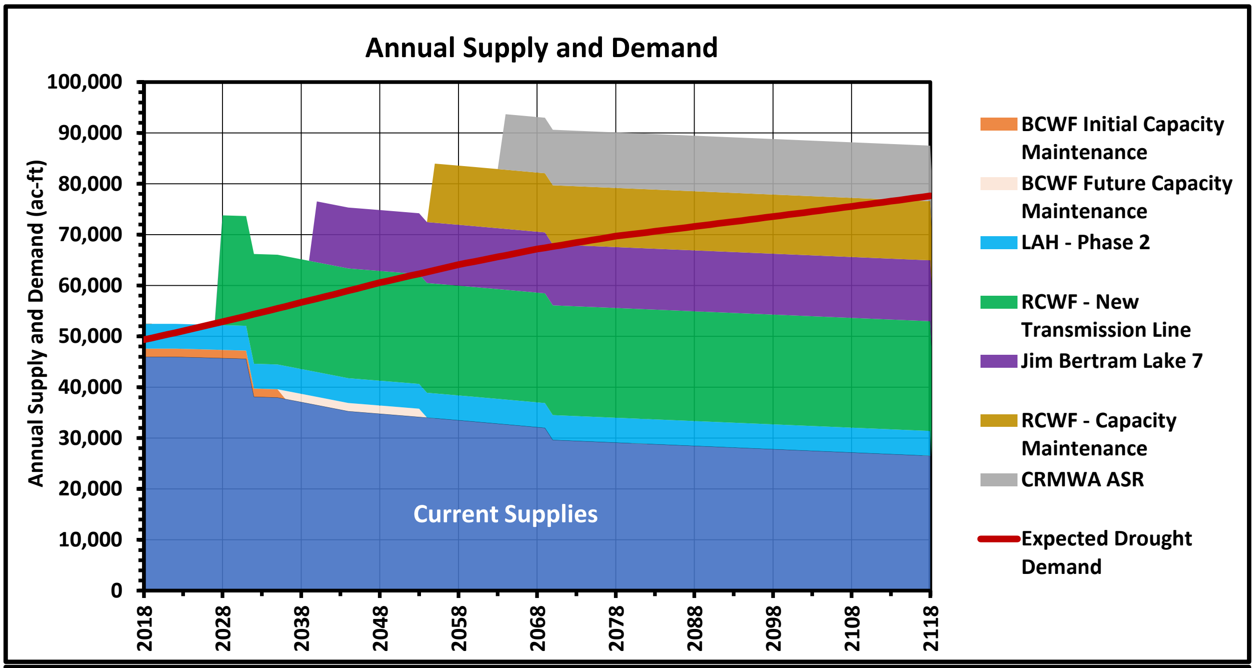
2018	2020 – BCWF Capacity Maintenance (ICM) 2026 – BCWF CM-1
2028	2032 – RCWF New Transmission 2032 – BCWF CM-2
2038	2038 – BCWF CM-3 2044 – BCWF CM-4
2048	2049 – RCWF Capacity Maintenance (ICM) 2050 – BCWF CM-5
2058	2058 – LAH Phase 2 2066 – Jim Bertram Lake 7
2068	
2078	2079 – RCWF CM-1
2088	
2098	
2108	2109 – RCWF CM-2
2118	

13.4 Supply Package 4 – Drought Demands

The Drought Demands supply package is intended to meet the larger demands under the Expected Demands scenario. Under the Expected Demands scenario, population growth follows the Expected progression, but water demands are not mitigated by successful conservation efforts and might be what would be expected under severe drought conditions. The Drought Demands supply package initiates water supply strategies sooner than the previous packages, and requires the implementation of the Canadian River Municipal Water Authority (CRMWA) Aquifer Storage and Recovery (ASR) strategy primarily to meet PDDs projected to occur by the 2060's. If these PDDs can be mitigated, then the CRMWA ASR project can be delayed or phased in more slowly over time. This supply package demonstrates the intensive water supply development that would be required if anticipated conservation savings cannot be realized.

Figure 13.7compares the City's AWD and PDD with the supplies developed by the strategies in the package. Figure 13.8 presents a timeline for when the various strategies would be implemented.

Figure 13.7. Drought Demands Supply Package



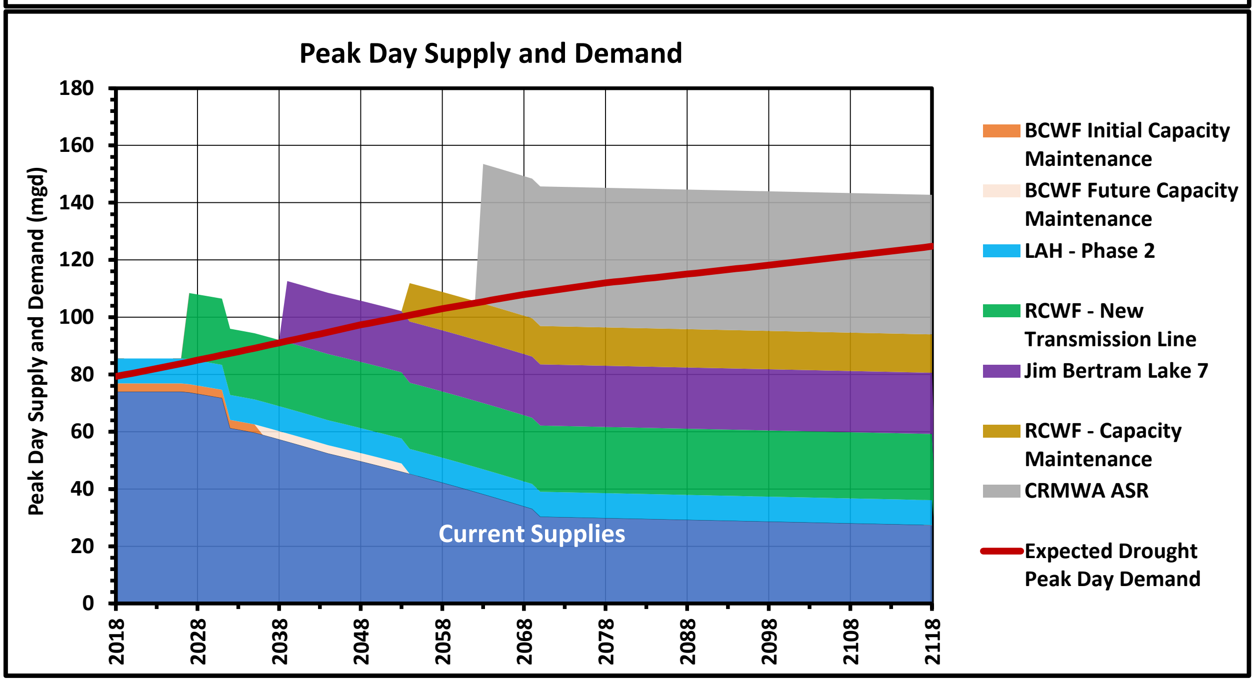


Figure 13.8. Timeline for Drought Demands Supply Package

2018	2018 – BCWF Capacity Maintenance (ICM) 2018 – LAH Phase 2 2024 – BCWF CM-1
2028	2027 – RCWF New Transmission 2030 – BCWF CM-2
2038	2036 – BCWF CM-3 2039 – Jim Bertram Lake 7 2042 – BCWF CM-4
2048	2048 – BCWF CM-5 2054 – RCWF Capacity Maintenance (ICM)
2058	2063 – CRMWA ASR
2068	
2078	2084 – RCWF CM-1
2088	
2098	
2108	2114 – RCWF CM-2
2118	

13.5 Supply Package 5 – Accelerated Population Growth

The Accelerated Population Growth supply package is designed to meet water demands under a combination of faster than expected population growth, but with annual water demands mitigated by conservation savings. Under the Accelerated Population Growth scenario, annual water demands are actually smaller than the Expected water demands met by the Drought Demands water supply package in early years of the timeline because it is assumed that the accelerated population growth would necessitate more immediate water conservation savings. However, this scenario assumes that peak day reduction efforts are not as effective, and the timing of most of this package is driven by the need to meet future PDDs.

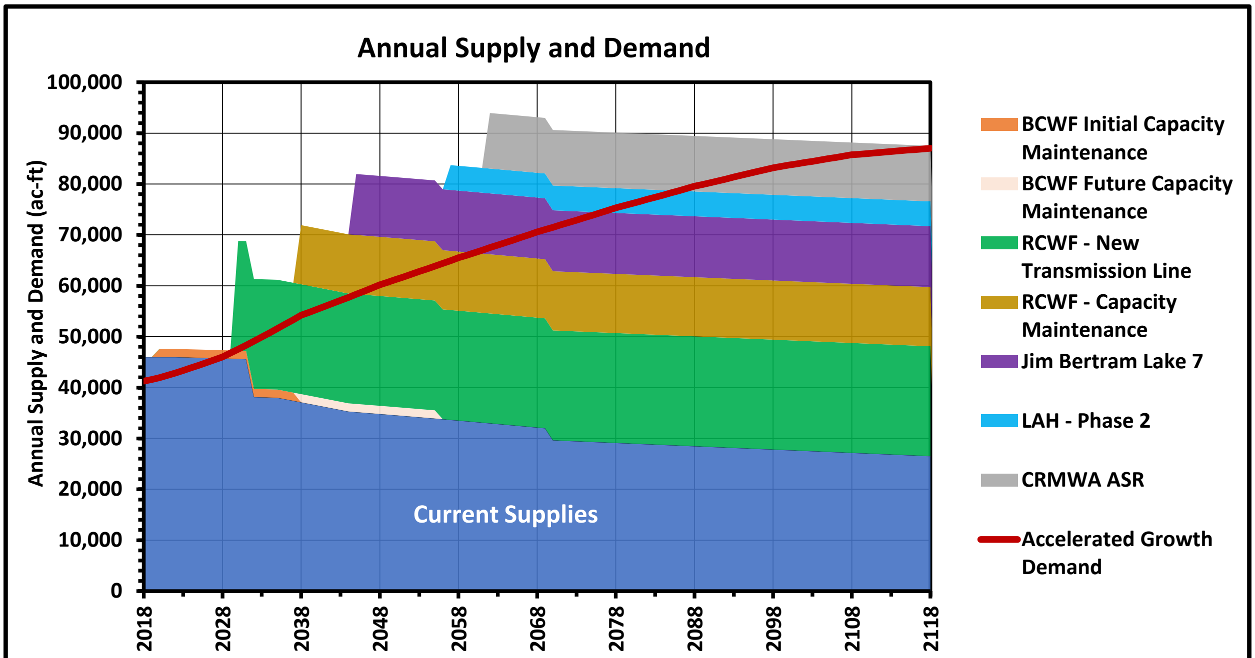
Figure 13.9 compares the City's AWD and PDD with the supplies developed by the strategies in the package. Figure 13.10 presents a timeline for when the various strategies would be implemented.

13.6 Comparison of Supply Package Schedules

Table 13.1 provides a comparison of the five supply packages discussed in this section. General observations concerning this comparison include:

- Many supply strategies are interchangeable, and various combinations of strategies can be implemented to meet the future AWD and PDD. The attractiveness of each strategy may change over time. Implementation schedules may change based on a variety of unpredictable variables including climate conditions, population, per capita consumption, industry need, changes in regulatory environments, etc.
- Direct potable reuse strategies typically will not provide the peaking capacity needed because of the cost of oversizing the advanced treatment facilities and are not included in any of the packages;
- Continued conservation efforts will delay the need for many of the strategies identified;
- If accelerated growth occurs, several additional strategies will need to be implemented to meet the projected AWD and PDD in 2118.

Figure 13.9. Accelerated Population Growth Supply Package



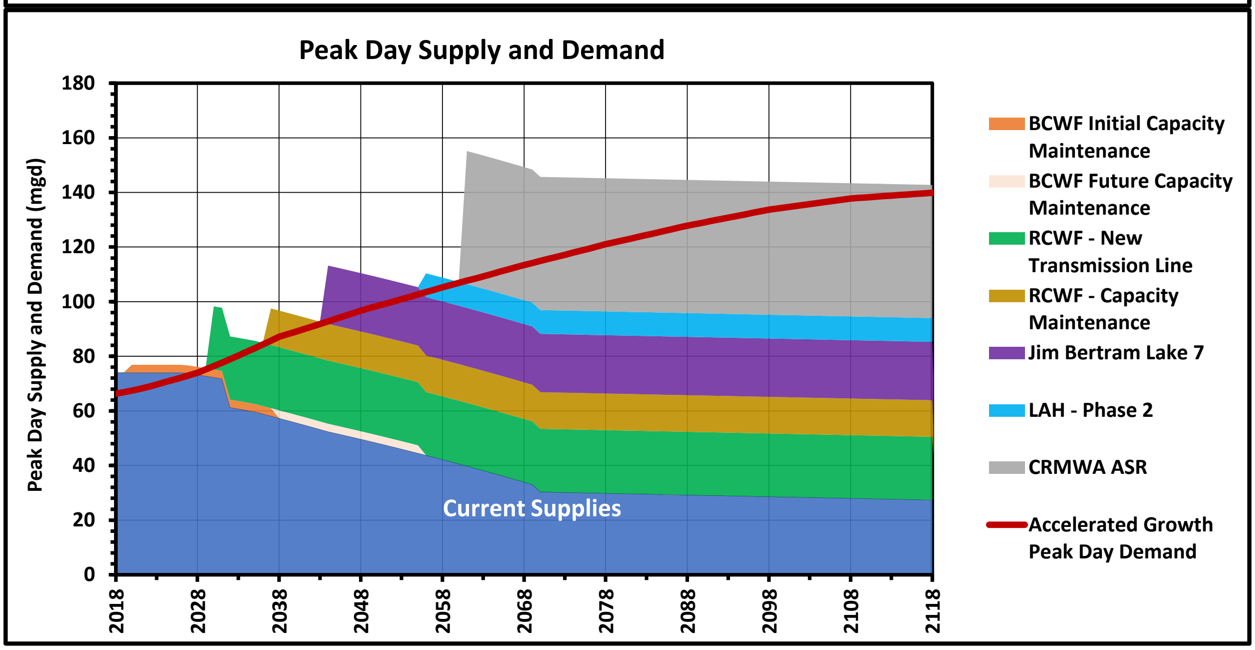


Figure 13.10. Timeline for Accelerated Population Growth Supply Package

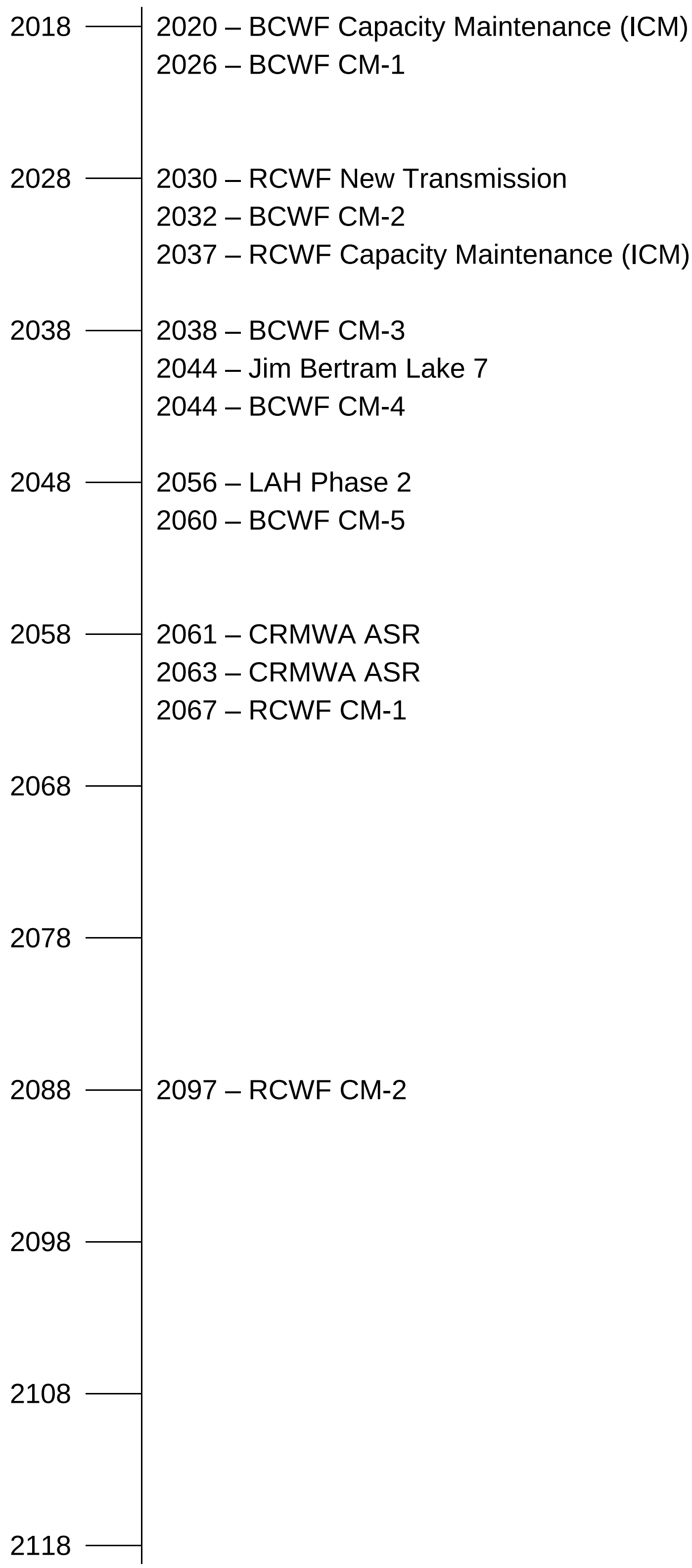


Table 13.1. Comparison of Supply Package Schedules

Supply Package 1 Early Diversification	Supply Package 2 Maximize RCWF	Supply Package 3 Maximize Groundwater	Supply Package 4 Drought Demands	Supply Package 5 Accelerated Population Growth
2018				
		2020: BCWF ICM 2026: BCWF CM-1	2018: BCWF ICM 2018: LAH Phase 2 2024: BCWF CM-1	2020: BCWF ICM 2026: BCWF CM-1
2028				
2031: BCWF ICM 2032: Jim Bertram Lake 7 2037: BCWF CM-1	2031: RCWF New Transmission	2032: RCWF New Transmission 2032: BCWF CM-2	2027: RCWF New Transmission 2030: BCWF CM-2	2032: BCWF CM-2 2030: RCWF New Transmission
2038				
2040: LAH Phase 2 2043: BCWF CM-2	2046: RCWF ICM	2038: BCWF CM-3 2044: BCWF CM-4	2036: BCWF CM-3 2039: Jim Bertram Lake 7 2042: BCWF CM-4	2037: RCWF ICM 2038: BCWF CM-3 2044: BCWF CM-4 2044: Jim Bertram Lake 7
2048				
2049: BCWF CM-3 2049: RCWF ICM 2055: BCWF CM-4		2049: RCWF ICM 2050: BCWF CM-5	2048: BCWF CM-5 2054: RCWF ICM	2050: BCWF CM-5 2056: LAH Phase 2
2058				
2061: BCWF CM-5 2065: RCWF New Transmission	2058: Jim Bertram Lake 7	2058: LAH Phase 2 2066: Jim Bertram Lake 7	2063: CRMWA ASR	2061: CRMWA ASR 2067: RCWF CM-1
2068				
	2076: RCWF CM-1			
2078				
2079: RCWF CM-1		2079: RCWF CM-1	2084: RCWF CM-1	
2088				
	2093: LAH Phase 2			2097: RCWF CM-2
2098				
	2106: RCWF CM-2			
2108				
2109: RCWF CM-2		2109: RCWF CM-2	2114: RCWF CM-2	
2118				

Note: ICM = Initial Capacity Maintenance, CM-1 = Capacity Maintenance-1, CM-2 = Capacity Maintenance-2, etc.

13.7 Financial Impact of the Water Supply Packages

The projects presented in each of the five water supply packages represent substantial capital investment by the City. The financial impact of each package will depend upon the actual timing of when specific projects are implemented. The net present value of each supply package was determined, in addition to a future debt service schedule, based upon the implementation schedule proposed for each package. The proposed implementation schedules can be adjusted to meet the City's needs, and the actual order in which projects are implemented can change based upon changes in the City's priorities, future water demands, and regulatory and other considerations.

A net present value (NPV) analysis was performed on each of the five water supply packages. As part of this analysis, assumptions were made regarding inflation rate, power cost inflation rate, discount rate, and the bond interest rate. These rates are summarizing in Table 13.2.

Table 13.2. Net Present Value Analysis – Assumed Rates Used in Calculations

Time Period	Inflation Rate	Power Cost Inflation Rate	Discount Rate	Bond Rate
2018 – 2042	3.2%	2.8%	2.0%	4.5%
2043 – 2067	3.5%	3.8%	2.1%	4.5%
2068 – 2092	3.8%	4.8%	2.2%	4.5%
2093 – 2117	4.1%	5.8%	2.3%	4.5%

13.7.1 Inflated Project Costs

Inflated project costs for each of the five water supply packages are shown in Table 13.3. These inflated costs account for estimated rates of inflation affecting future prices, using the rates shown in Table 13.2. Projects implemented later in the Plan have higher inflated costs than those implemented earlier. Table 13.3 lists the cost of projects if constructed today (Original Project Cost) and compares the inflated costs of those projects based upon their implementation date.

Table 13.3. Inflated Project Cost Comparison

		Package 1 Early Diversification		Package 2 Maximize RCWF		Package 3 Maximize Groundwater		Package 4 Drought Demands		Package 5 Accel. Population Growth	
Project Name	Original Project Cost (millions)	Year Financed	Inflated Project Cost (millions)	Year Financed	Inflated Project Cost (millions)	Year Financed	Inflated Project Cost (millions)	Year Financed	Inflated Project Cost (millions)	Year Financed	Inflated Project Cost (millions)
RCWF – CM (1)	$8.7	2047	$22.8	2044	$20.6	2047	$22.8	2052	$27.1	2035	$15.4
RCWF – CM (2)	$8.7	2077	$66.0	2074	$59.0	2077	$66.0	2082	$79.5	2065	$42.4
RCWF – CM (3)	$8.7	2107	$211.0	2104	$187.0	2107	$211.0	2112	$257.9	2095	$130.2
BCWF – CM (1)	$4.3	2029	$6.3			2018	$4.5	2018	$4.5	2018	$4.5
BCWF – CM (2)	$4.3	2035	$7.6			2024	$5.4	2022	$5.1	2024	$5.4
BCWF – CM (3)	$4.3	2041	$9.2			2030	$6.5	2028	$6.1	2030	$6.5
BCWF – CM (4)	$4.3	2047	$11.3			2036	$7.9	2034	$7.4	2036	$7.9
BCWF – CM (5)	$4.3	2053	$13.9			2042	$9.5	2040	$9.0	2042	$9.5
BCWF – CM (6)	$4.3	2059	$17.2			2048	$11.7	2046	$11.0	2048	$11.7
RCWF – New Transmission Line	$122.8	2063	$555.9	2029	$179.2	2030	$185.0	2025	$158.0	2028	$173.7
LAH – Phase 2	$98.7	2038	$191.3	2091	$1,255.2	2056	$351.2	2018	$101.9	2054	$327.8
Jim Bertram Lake 7	$207.3	2030	$312.1	2056	$737.4	2064	$971.0	2037	$389.1	2042	$455.5
CRMWA ASR	$97.9							2061	$413.6	2059	$386.1

Note: CM-1 = Capacity Maintenance-1, CM-2 Capacity Maintenance-2, etc.

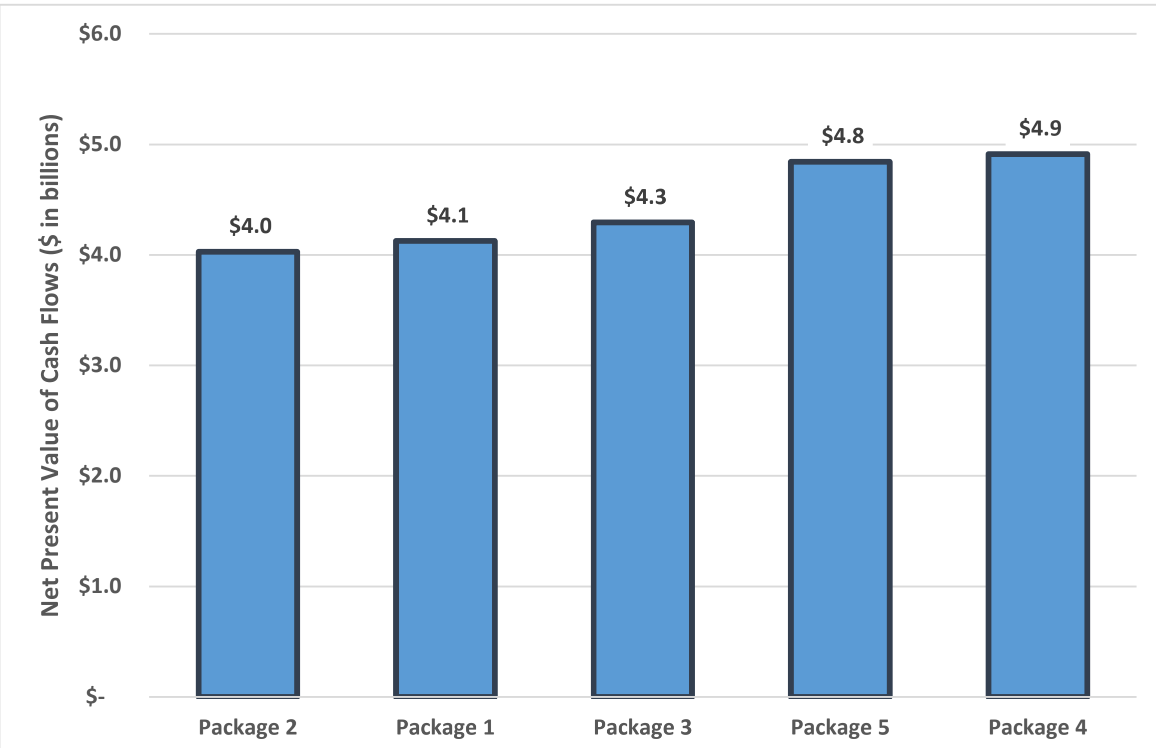
13.7.2 Net Present Value

A summary of the NPV Analysis is shown in Table 13.4 and Figure 13.11. Based on this analysis, the NPV of all five supply packages falls between $3.9 billion and $4.9 billion over the 100-year planning period.

Table 13.4. Net Present Value Analysis Summary (million dollars)

Package	Total Package Cost (Current Dollars)	Total Package Cost (Inflated Dollars)	Total Cash Flow (Inflated Dollars)	Net PV of Cash Flow
Package 1	$481	$1,424	$18,977	$4,127
Package 2	$455	$2,438	$19,522	$4,031
Package 3	$481	$1,852	$19,750	$4,294
Package 4	$579	$1,470	$20,955	$4,911
Package 5	$579	$1,577	$21,450	$4,844

Figure 13.11. Net Present Value Comparison of Supply Packages



As expected, Supply Package 2 is the least expensive alternative since it relies heavily on additional groundwater development (a less expensive alternative than surface water development). Similarly, Supply Package 4 is the most expensive alternative since it requires the implementation of more water supply strategies in order to meet the Drought Demand projections.

13.7.3 Future Debt Service

Figures 13.12 – 13.16 illustrate the timing of projected total debt to be financed for each water supply package, and the estimated debt payments, based upon the inflated project costs developed for the Net Present Value Analyses. The debt service for each project is based on a 20-year payout schedule. The cumulative debt and debt payments are superimposed on the graphs illustrating the timing of the various strategies included in each water supply package. Increases in cumulative debt or debt payments correspond with financing and implementation of each new water management strategy in a water supply package.

Figure 13.12. Debt Schedule for the Early Diversification Supply Package

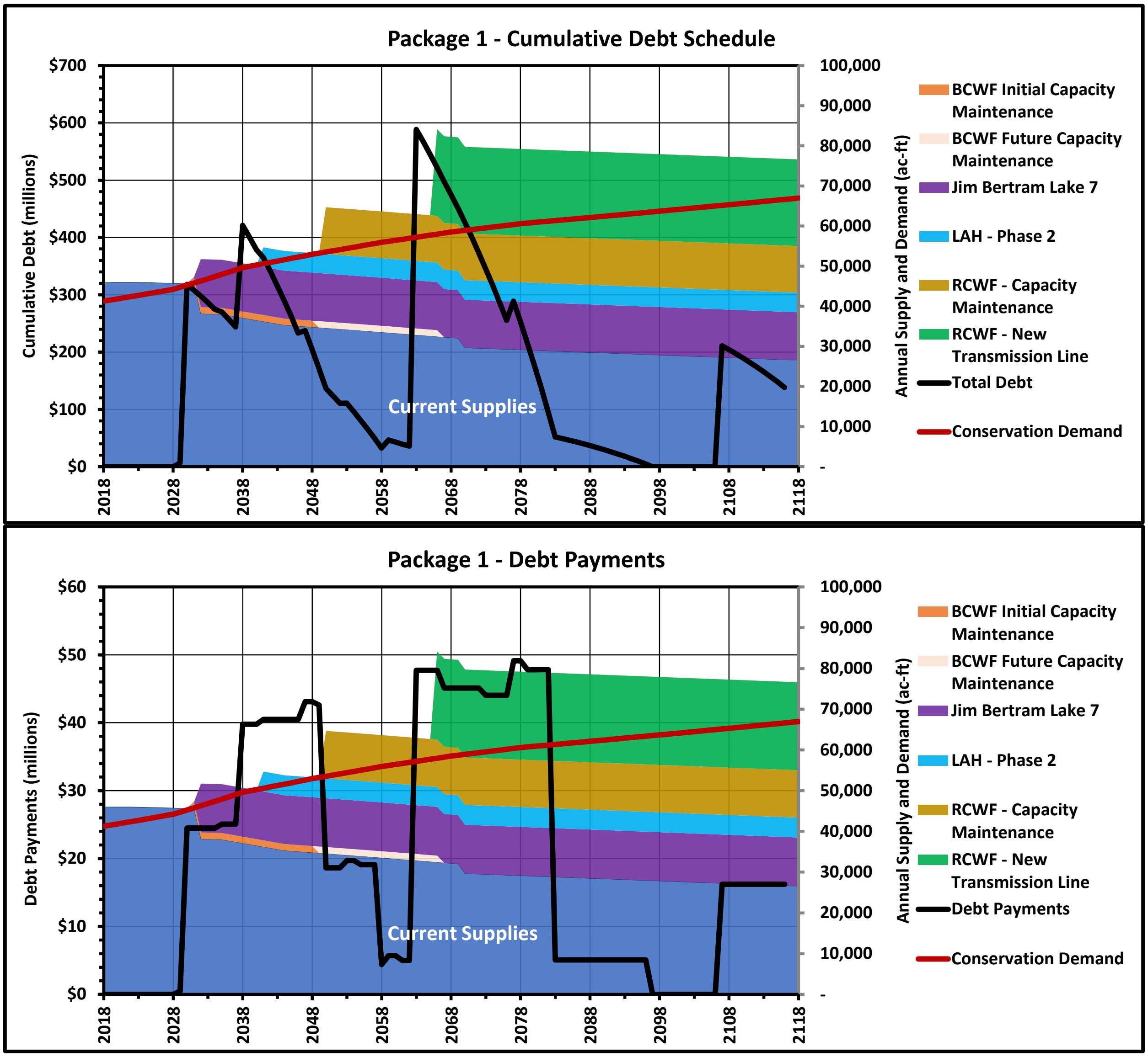
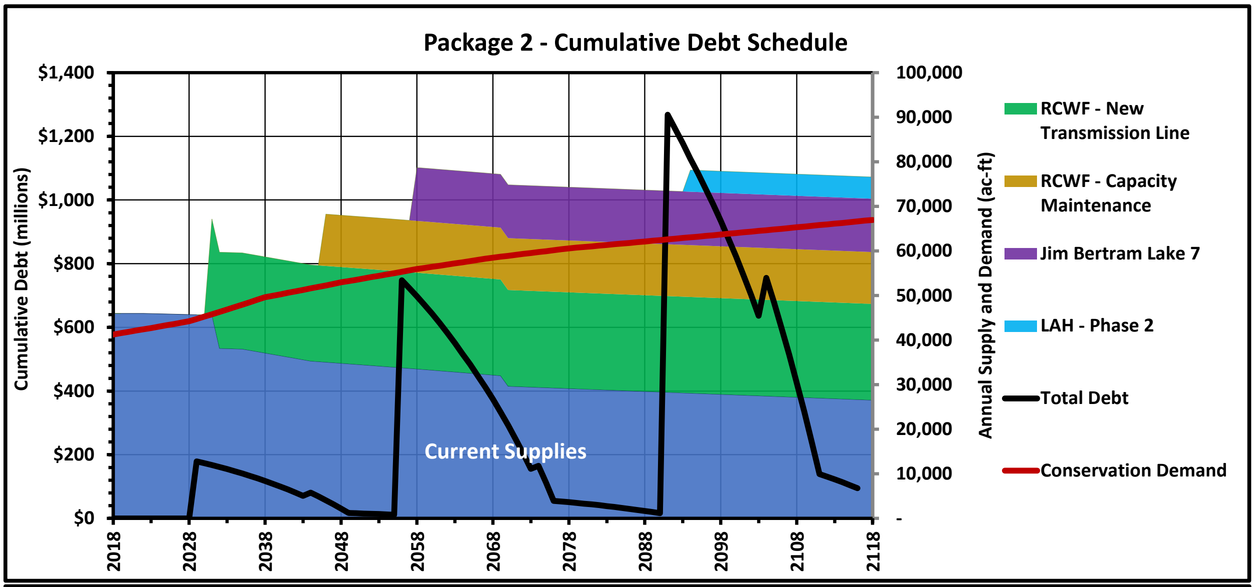


Figure 13.13. Debt Schedule for the Maximize RCWF Supply Package



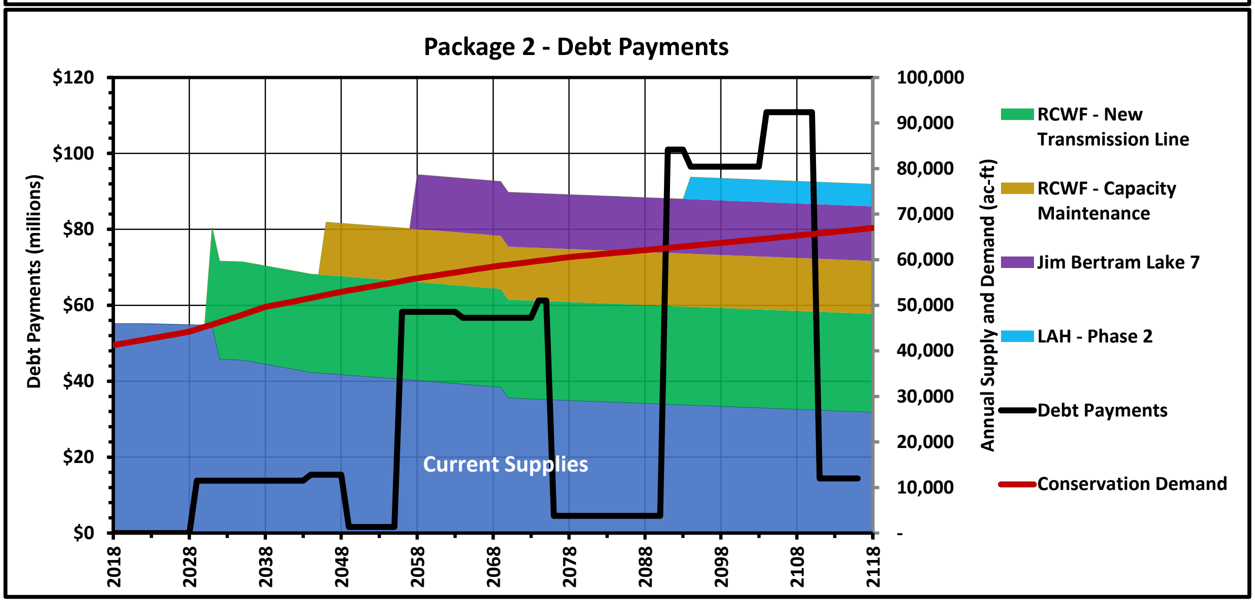
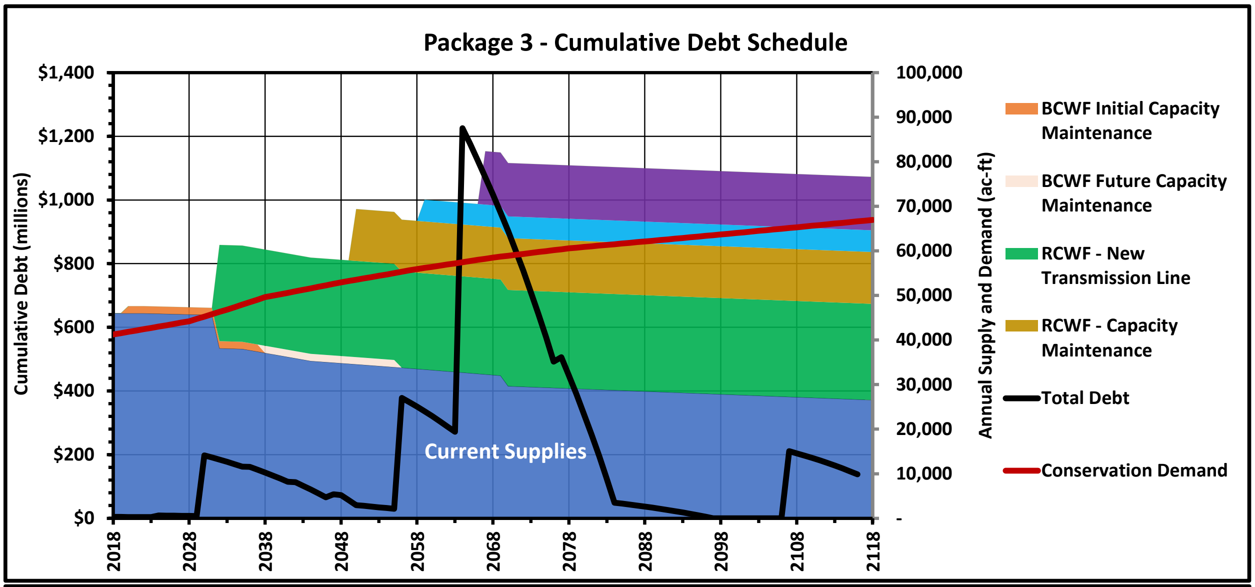


Figure 13.14. Debt Schedule for the Maximize Groundwater Supply Package



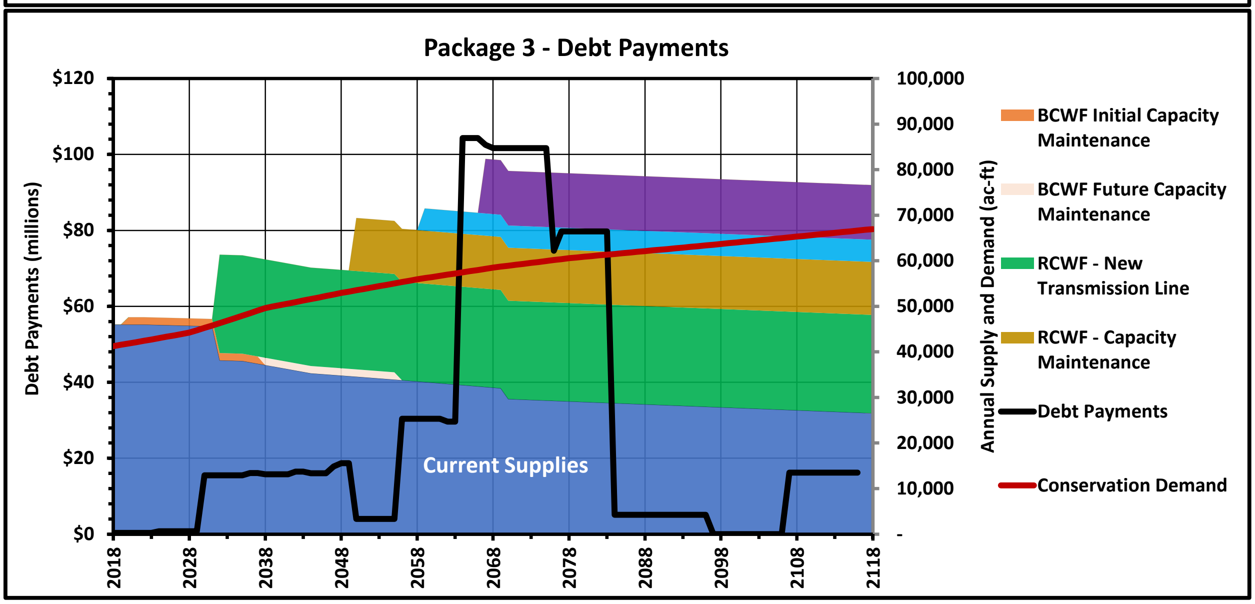


Figure 13.15. Debt Schedule for the Drought Demands Supply Package

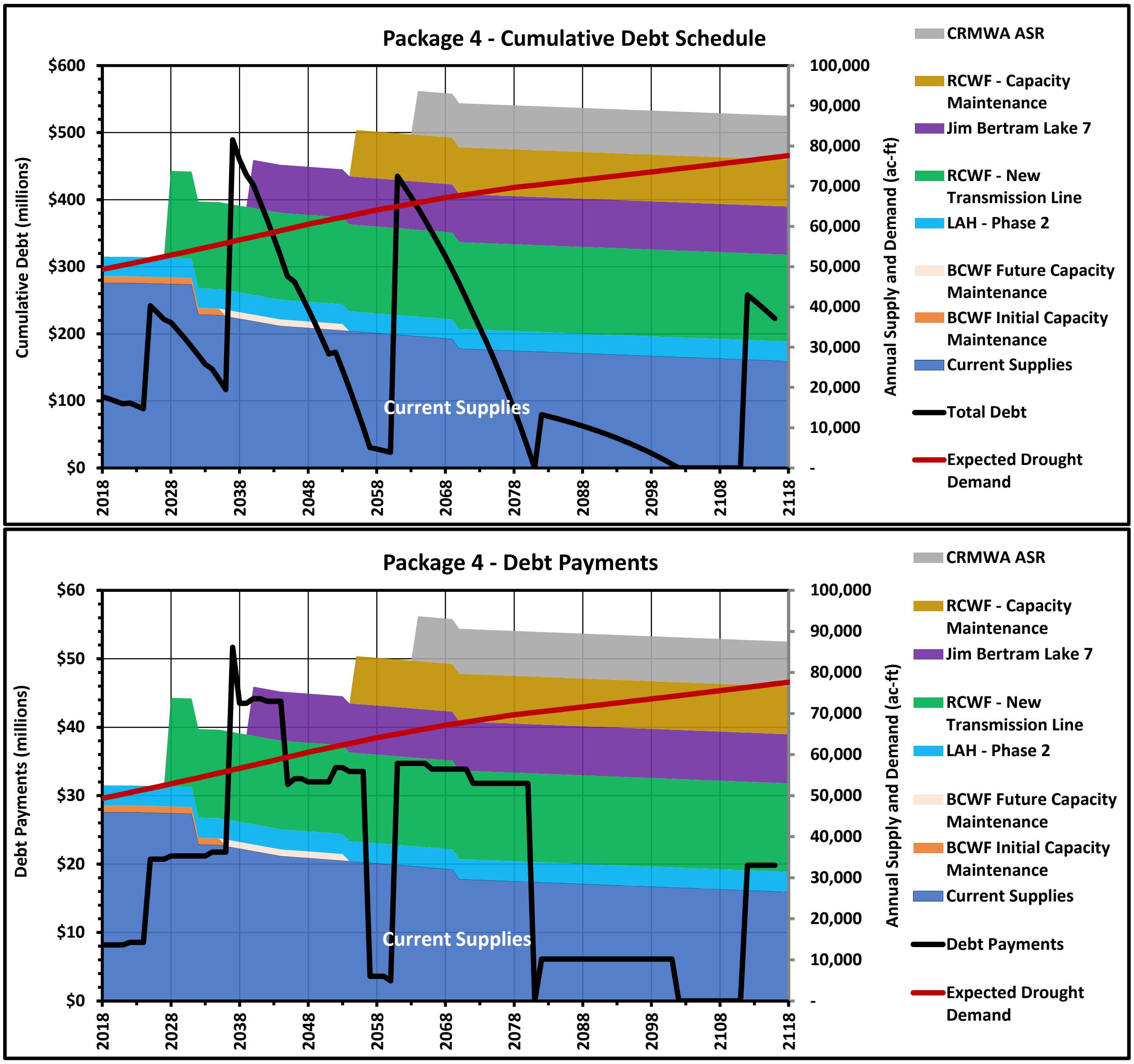
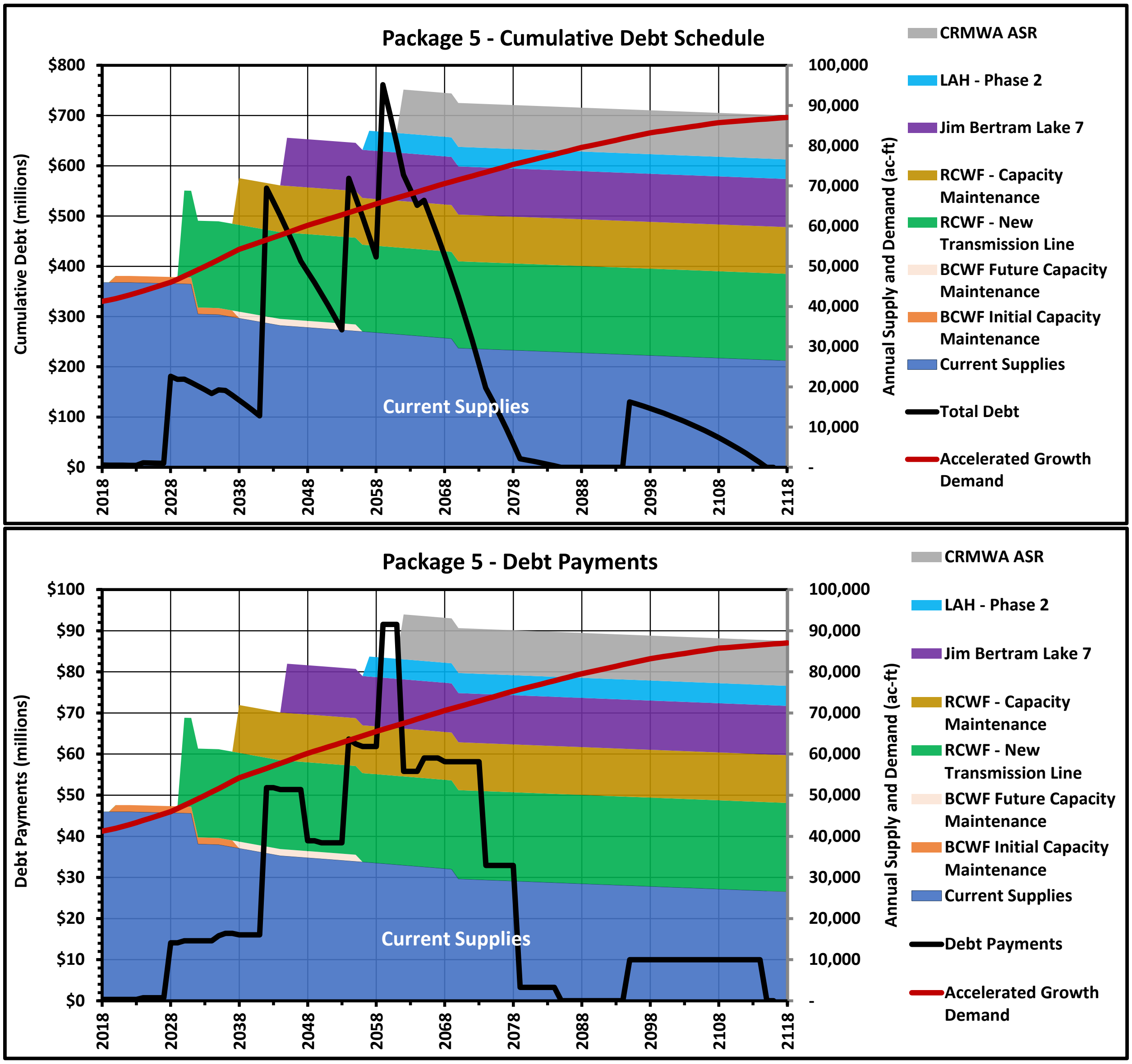


Figure 13.16. Debt Schedule for the Accelerated Population Growth Supply Package



A

Historic and Projected Water Demands

Appendix A.1

Historic Data for the City of Lubbock

Year	Population (Cenus Data)	Growth Rate (Percent)	Gallons per Capita per Day (gpcd)	Water Demand (ac-ft/yr)	Peak Day Demand (mgd)	Average Annual Day (mg)	Peaking Factor
Data by Decade							
1910	1,938	n/a	.	.	.	.	.
1920	4,051	109.03	.	.	.	.	.
1930	20,520	406.54	91	2,092	.	1.87	.
1940	31,853	55.23	135	4,820	.	4.30	.
1950	71,747	125.25	130	10,424	.	9.31	.
1960	128,691	79.37	142	20,486	.	18.29	.
1970	149,101	15.86	187	31,200	.	27.85	.
1980	173,979	16.69	206	40,205	70.85	35.89	1.97
1990	186,206	7.03	192	40,086	79.00	35.79	2.21
2000	199,564	7.17	199	44,375	67.82	39.62	1.71
2010	229,573	15.04	141	36,275	50.40	32.38	1.56

Year	Population (Cenus Data)	Growth Rate (Percent)	Gallons per Capita per Day (gpcd)	Water Demand (ac-ft/yr)	Peak Day Demand (mgd)	Average Annual Day (mg)	Peaking Factor
Data by Year							
1910	1,938	8.54	.	.	.	.	.
1911	2,104	4.02	.	.	.	.	.
1912	2,188	4.35	.	.	.	.	.
1913	2,283	8.54	.	.	.	.	.
1914	2,478	8.54	.	.	.	.	.
1915	2,690	8.54	.	.	.	.	.
1916	2,920	8.54	.	.	.	.	.
1917	3,169	8.54	.	.	.	.	.
1918	3,440	8.54	.	.	.	.	.
1919	3,733	8.51	.	.	.	.	.
1920	4,051	17.62	.	.	.	.	.
1921	4,765	17.62	.	.	.	.	.
1922	5,604	17.62	.	.	.	.	.
1923	6,591	17.62	.	.	.	.	.
1924	7,753	17.62	.	.	.	.	.
1925	9,118	17.62	.	.	.	.	.
1926	10,725	17.62	.	.	.	.	.
1927	12,614	17.62	.	.	.	.	.
1928	14,836	17.62	.	.	.	.	.
1929	17,450	17.59	.	.	.	.	.
1930	20,520	4.50	91	2,092	.	1.87	.
1931	21,443	4.50	93	2,242	.	2.00	.
1932	22,407	4.50	95	2,391	.	2.13	.
1933	23,414	4.50	97	2,541	.	2.27	.
1934	24,467	4.50	98	2,690	.	2.40	.
1935	25,567	4.50	99	2,840	.	2.54	.
1936	26,716	4.50	100	2,989	.	2.67	.
1937	27,917	4.50	100	3,139	.	2.80	.
1938	29,173	4.50	113	3,699	.	3.30	.
1939	30,484	4.49	125	4,259	.	3.80	.
1940	31,853	8.46	135	4,820	.	4.30	.
1941	34,547	8.46	139	5,380	.	4.80	.
1942	37,470	8.46	142	5,941	.	5.30	.
1943	40,639	8.46	143	6,501	.	5.80	.
1944	44,077	8.46	143	7,062	.	6.30	.
1945	47,806	8.46	142	7,622	.	6.80	.
1946	51,849	8.46	141	8,183	.	7.31	.
1947	56,235	8.46	139	8,743	.	7.81	.
1948	60,992	8.46	136	9,304	.	8.31	.
1949	66,152	8.46	133	9,864	.	8.81	.
1950	71,747	6.02	130	10,424	.	9.31	.
1951	76,064	6.02	136	11,576	.	10.33	.
1952	80,641	6.02	141	12,727	.	11.36	.
1953	85,493	6.02	145	13,879	.	12.39	.
1954	90,638	6.02	148	15,031	.	13.42	.
1955	96,091	6.02	150	16,182	.	14.45	.
1956	101,873	6.02	168	19,145	.	17.09	.
1957	108,003	6.02	135	16,374	.	14.62	.
1958	114,501	6.02	143	18,278	.	16.32	.
1959	121,391	6.01	144	19,618	.	17.51	.
1960	128,691	1.48	142	20,486	.	18.29	.
1961	130,599	1.48	137	20,020	.	17.87	.

Appendix A.1

Historic Data for the City of Lubbock

Year	Population (Cenus Data)	Growth Rate (Percent)	Gallons per Capita per Day (gpcd)	Water Demand (ac-ft/yr)	Peak Day Demand (mgd)	Average Annual Day (mg)	Peaking Factor
1962	132,536	1.48	155	22,955	.	20.49	.
1963	134,502	1.48	171	25,744	.	22.98	.
1964	136,496	1.48	181	27,674	.	24.71	.
1965	138,521	1.48	184	28,528	.	25.47	.
1966	140,575	1.48	173	27,243	.	24.32	.
1967	142,660	1.48	158	25,322	.	22.61	.
1968	144,775	1.48	161	26,187	.	23.38	.
1969	146,922	1.48	185	30,365	.	27.11	.
1970	149,101	1.55	187	31,200	.	27.85	.
1971	151,420	1.55	180	30,460	.	27.19	.
1972	153,774	1.55	187	32,242	.	28.78	.
1973	156,165	1.55	181	31,588	.	28.20	.
1974	158,593	1.55	194	34,428	.	30.74	.
1975	161,059	1.55	174	31,318	.	27.96	.
1976	163,564	1.55	181	33,098	.	29.55	.
1977	166,107	1.55	193	35,928	.	32.07	.
1978	168,690	1.55	222	42,027	.	37.52	.
1979	171,313	1.56	197	37,862	.	33.80	.
1980	173,979	0.30	206	40,205	70.85	35.89	1.97
1981	174,508	0.30	184	35,928	68.48	32.07	2.13
1982	175,038	0.30	178	34,841	58.69	31.10	1.89
1983	175,569	0.30	208	40,835	n/a	36.46	n/a
1984	176,103	2.19	195	38,385	n/a	34.27	n/a
1985	179,953	0.34	180	36,305	65.18	32.41	2.01
1986	180,561	0.23	170	34,395	65.71	30.71	2.14
1987	180,973	0.70	168	34,057	57.01	30.40	1.87
1988	182,243	0.73	183	37,417	60.40	33.40	1.81
1989	183,573	1.43	196	40,233	69.12	35.92	1.92
1990	186,206	0.50	192	40,086	79.00	35.79	2.21
1991	187,137	0.19	176	36,930	67.38	32.97	2.04
1992	187,493	0.26	167	34,971	55.50	31.22	1.78
1993	187,981	1.09	181	38,096	58.35	34.01	1.72
1994	190,038	0.52	197	41,929	74.98	37.43	2.00
1995	191,020	1.07	213	45,491	79.54	40.61	1.96
1996	193,064	1.19	204	44,178	66.71	39.44	1.69
1997	195,367	0.67	185	40,408	63.37	36.07	1.76
1998	196,679	0.22	224	49,299	84.17	44.01	1.91
1999	197,117	1.24	188	41,429	68.93	36.99	1.86
2000	199,564	0.83	199	44,375	67.82	39.62	1.71
2001	201,217	0.39	191	43,078	73.09	38.46	1.90
2002	202,000	1.35	182	41,080	63.91	36.67	1.74
2003	204,737	0.76	190	43,626	73.61	38.95	1.89
2004	206,290	1.37	161	37,121	59.94	33.14	1.81
2005	209,120	0.99	168	39,302	62.54	35.09	1.78
2006	211,187	0.56	177	41,874	68.77	37.38	1.84
2007	212,365	1.17	136	32,456	47.30	28.97	1.63
2008	214,847	1.62	148	35,671	53.66	31.85	1.69
2009	218,327	5.15	145	35,434	54.23	31.63	1.71
2010	229,573	1.03	141	36,275	50.40	32.38	1.56
2011	231,937	0.74	178	46,205	64.12	41.25	1.55
2012	233,651	1.16	152	39,869	58.07	35.59	1.63
2013	236,362	0.99	154	40,892	57.96	36.51	1.59
2014	238,706	1.10	141	37,811	50.04	33.76	1.48
2015	241,322	4.63	131	35,298	49.56	31.51	1.57
2016	252,506	0.82	132	37,286	58.37	33.29	1.75
2017	254,565		127	36,108	49.94	32.24	1.55

Appendix A.2

Population and Growth Rate Projections

Year	Population					Growth Rate (Percent)				
	Expected Growth	Accelerated Growth	2021 Region O Plan	2013 SWSP Probable	2013 SWSP Accelerated	Expected Growth	Accelerated Growth	2021 Region O Plan	2013 SWSP Probable	2013 SWSP Accelerated
Data by Decade										
2018	257,620	257,620	249,900	255,349	259,155	1.20	1.30	1.07	1.20	1.70
2028	290,258	301,934	277,688	287,700	306,739	1.20	1.70	1.06	1.20	1.70
2038	327,031	357,373	306,134	317,793	354,223	1.20	1.70	0.96	0.80	1.20
2048	354,156	402,649	336,078	342,448	395,172	0.80	1.20	0.93	0.70	1.00
2058	379,743	444,775	365,364	365,369	434,359	0.70	1.00	0.80	0.60	0.90
2068	403,152	486,466	393,998	385,969	472,724	0.60	0.90	0.74	0.50	0.80
2078	423,770	526,814	n/a	403,693	509,398	0.50	0.80	n/a	0.40	0.70
2088	441,029	564,875	n/a	420,134	543,494	0.40	0.70	n/a	0.40	0.60
2098	458,991	599,697	n/a	437,246	572,709	0.40	0.60	n/a	0.40	0.45
2108	477,685	627,237	n/a	455,054	594,550	0.40	0.45	n/a	0.40	0.30
2118	497,140	646,310	n/a	n/a	n/a	0.40	0.30	n/a	n/a	n/a

Data by Year										
2018	257,620	257,620	249,900	255,349	259,155	1.20	1.30	1.07	1.20	1.70
2019	260,711	260,969	252,564	258,413	263,561	1.20	1.40	1.07	1.20	1.70
2020	263,840	264,622	255,257	261,514	268,041	1.20	1.50	1.06	1.20	1.70
2021	267,006	268,592	257,959	264,652	272,598	1.20	1.60	1.06	1.20	1.70
2022	270,210	272,889	260,689	267,828	277,232	1.20	1.70	1.06	1.20	1.70
2023	273,452	277,528	263,448	271,042	281,945	1.20	1.70	1.06	1.20	1.70
2024	276,734	282,246	266,236	274,295	286,738	1.20	1.70	1.06	1.20	1.70
2025	280,055	287,044	269,054	277,586	291,613	1.20	1.70	1.06	1.20	1.70
2026	283,415	291,924	271,902	280,917	296,570	1.20	1.70	1.06	1.20	1.70
2027	286,816	296,887	274,779	284,288	301,612	1.20	1.70	1.06	1.20	1.70
2028	290,258	301,934	277,688	287,700	306,739	1.20	1.70	1.06	1.20	1.70
2029	293,741	307,067	280,627	291,152	311,954	1.20	1.70	1.06	1.20	1.70
2030	297,266	312,287	283,597	294,646	317,257	1.20	1.70	0.96	1.20	1.70
2031	300,833	317,596	286,321	298,182	322,650	1.20	1.70	0.96	1.20	1.70
2032	304,443	322,995	289,071	301,760	328,136	1.20	1.70	0.96	1.20	1.70
2033	308,097	328,486	291,847	305,381	333,714	1.20	1.70	0.96	1.20	1.70
2034	311,794	334,070	294,650	307,824	337,718	1.20	1.70	0.96	0.80	1.20
2035	315,535	339,749	297,480	310,287	341,771	1.20	1.70	0.96	0.80	1.20
2036	319,322	345,525	300,337	312,769	345,872	1.20	1.70	0.96	0.80	1.20
2037	323,154	351,399	303,222	315,271	350,023	1.20	1.70	0.96	0.80	1.20
2038	327,031	357,373	306,134	317,793	354,223	1.20	1.70	0.96	0.80	1.20
2039	329,648	361,661	309,074	320,336	358,474	0.80	1.20	0.96	0.80	1.20
2040	332,285	366,001	312,043	322,898	362,775	0.80	1.20	0.93	0.80	1.20
2041	334,943	370,393	314,951	325,482	367,129	0.80	1.20	0.93	0.80	1.20
2042	337,623	374,838	317,886	328,085	371,534	0.80	1.20	0.93	0.80	1.20
2043	340,324	379,336	320,848	330,710	375,993	0.80	1.20	0.93	0.80	1.20
2044	343,046	383,888	323,838	333,025	379,753	0.80	1.20	0.93	0.70	1.00
2045	345,791	388,495	326,855	335,356	383,550	0.80	1.20	0.93	0.70	1.00
2046	348,557	393,157	329,901	337,704	387,386	0.80	1.20	0.93	0.70	1.00
2047	351,345	397,875	332,976	340,068	391,259	0.80	1.20	0.93	0.70	1.00
2048	354,156	402,649	336,078	342,448	395,172	0.80	1.20	0.93	0.70	1.00
2049	356,635	406,676	339,210	344,845	399,124	0.70	1.00	0.93	0.70	1.00
2050	359,132	410,742	342,371	347,259	403,115	0.70	1.00	0.93	0.70	1.00
2051	361,646	414,850	345,562	349,690	407,146	0.70	1.00	0.80	0.70	1.00
2052	364,177	418,998	348,323	352,138	411,218	0.70	1.00	0.80	0.70	1.00
2053	366,726	423,188	351,107	354,603	415,330	0.70	1.00	0.80	0.70	1.00
2054	369,293	427,420	353,913	356,730	419,068	0.70	1.00	0.80	0.60	0.90
2055	371,878	431,694	356,742	358,871	422,839	0.70	1.00	0.80	0.60	0.90
2056	374,482	436,011	359,593	361,024	426,645	0.70	1.00	0.80	0.60	0.90
2057	377,103	440,371	362,467	363,190	430,485	0.70	1.00	0.80	0.60	0.90
2058	379,743	444,775	365,364	365,369	434,359	0.70	1.00	0.80	0.60	0.90
2059	382,021	448,778	368,284	367,561	438,268	0.60	0.90	0.80	0.60	0.90
2060	384,313	452,817	371,227	369,767	442,213	0.60	0.90	0.80	0.60	0.90
2061	386,619	456,892	374,194	371,985	446,193	0.60	0.90	0.74	0.60	0.90
2062	388,939	461,004	376,961	374,217	450,208	0.60	0.90	0.74	0.60	0.90
2063	391,273	465,154	379,748	376,463	454,260	0.60	0.90	0.74	0.60	0.90
2064	393,620	469,340	382,556	378,345	457,894	0.60	0.90	0.74	0.50	0.80
2065	395,982	473,564	385,385	380,237	461,558	0.60	0.90	0.74	0.50	0.80
2066	398,358	477,826	388,235	382,138	465,250	0.60	0.90	0.74	0.50	0.80

Appendix A.2

Population and Growth Rate Projections

Year	Population					Growth Rate (Percent)				
	Expected Growth	Accelerated Growth	2021 Region O Plan	2013 SWSP Probable	2013 SWSP Accelerated	Expected Growth	Accelerated Growth	2021 Region O Plan	2013 SWSP Probable	2013 SWSP Accelerated
2067	400,748	482,126	391,106	384,049	468,972	0.60	0.90	0.74	0.50	0.80
2068	403,152	486,466	393,998	385,969	472,724	0.60	0.90	0.74	0.50	0.80
2069	405,168	490,357	396,911	387,899	476,506	0.50	0.80	0.74	0.50	0.80
2070	407,194	494,280	399,846	389,838	480,318	0.50	0.80	0.74	0.50	0.80
2071	409,230	498,234	n/a	391,787	484,160	0.50	0.80	n/a	0.50	0.80
2072	411,276	502,220	n/a	393,746	488,033	0.50	0.80	n/a	0.50	0.80
2073	413,333	506,238	n/a	395,715	491,938	0.50	0.80	n/a	0.50	0.80
2074	415,399	510,288	n/a	397,298	495,381	0.50	0.80	n/a	0.40	0.70
2075	417,476	514,370	n/a	398,887	498,849	0.50	0.80	n/a	0.40	0.70
2076	419,564	518,485	n/a	400,483	502,341	0.50	0.80	n/a	0.40	0.70
2077	421,661	522,633	n/a	402,085	505,857	0.50	0.80	n/a	0.40	0.70
2078	423,770	526,814	n/a	403,693	509,398	0.50	0.80	n/a	0.40	0.70
2079	425,465	530,502	n/a	405,308	512,964	0.40	0.70	n/a	0.40	0.70
2080	427,167	534,215	n/a	406,929	516,555	0.40	0.70	n/a	0.40	0.70
2081	428,875	537,955	n/a	408,557	520,171	0.40	0.70	n/a	0.40	0.70
2082	430,591	541,721	n/a	410,191	523,812	0.40	0.70	n/a	0.40	0.70
2083	432,313	545,513	n/a	411,832	527,479	0.40	0.70	n/a	0.40	0.70
2084	434,042	549,331	n/a	413,479	530,643	0.40	0.70	n/a	0.40	0.60
2085	435,779	553,177	n/a	415,133	533,827	0.40	0.70	n/a	0.40	0.60
2086	437,522	557,049	n/a	416,793	537,030	0.40	0.70	n/a	0.40	0.60
2087	439,272	560,948	n/a	418,461	540,252	0.40	0.70	n/a	0.40	0.60
2088	441,029	564,875	n/a	420,134	543,494	0.40	0.70	n/a	0.40	0.60
2089	442,793	568,264	n/a	421,815	546,755	0.40	0.60	n/a	0.40	0.60
2090	444,564	571,674	n/a	423,502	550,035	0.40	0.60	n/a	0.40	0.60
2091	446,342	575,104	n/a	425,196	553,336	0.40	0.60	n/a	0.40	0.60
2092	448,128	578,554	n/a	426,897	556,656	0.40	0.60	n/a	0.40	0.60
2093	449,920	582,026	n/a	428,605	559,996	0.40	0.60	n/a	0.40	0.60
2094	451,720	585,518	n/a	430,319	562,516	0.40	0.60	n/a	0.40	0.45
2095	453,527	589,031	n/a	432,040	565,047	0.40	0.60	n/a	0.40	0.45
2096	455,341	592,565	n/a	433,768	567,590	0.40	0.60	n/a	0.40	0.45
2097	457,162	596,120	n/a	435,504	570,144	0.40	0.60	n/a	0.40	0.45
2098	458,991	599,697	n/a	437,246	572,709	0.40	0.60	n/a	0.40	0.45
2099	460,827	602,396	n/a	438,994	575,287	0.40	0.45	n/a	0.40	0.45
2100	462,670	605,107	n/a	440,750	577,875	0.40	0.45	n/a	0.40	0.45
2101	464,521	607,830	n/a	442,513	580,476	0.40	0.45	n/a	0.40	0.45
2102	466,379	610,565	n/a	444,284	583,088	0.40	0.45	n/a	0.40	0.45
2103	468,245	613,312	n/a	446,061	585,712	0.40	0.45	n/a	0.40	0.45
2104	470,118	616,072	n/a	447,845	587,469	0.40	0.45	n/a	0.40	0.30
2105	471,998	618,845	n/a	449,636	589,231	0.40	0.45	n/a	0.40	0.30
2106	473,886	621,629	n/a	451,435	590,999	0.40	0.45	n/a	0.40	0.30
2107	475,782	624,427	n/a	453,241	592,772	0.40	0.45	n/a	0.40	0.30
2108	477,685	627,237	n/a	455,054	594,550	0.40	0.45	n/a	0.40	0.30
2109	479,595	629,118	n/a	456,874	596,334	0.40	0.30	n/a	0.40	0.30
2110	481,514	631,006	n/a	458,701	598,123	0.40	0.30	n/a	0.40	0.30
2111	483,440	632,899	n/a	460,536	599,917	0.40	0.30	n/a	0.40	0.30
2112	485,374	634,797	n/a	462,378	601,717	0.40	0.30	n/a	0.40	0.30
2113	487,315	636,702	n/a	464,228	603,522	0.40	0.30	n/a	0.40	0.30
2114	489,264	638,612	n/a	n/a	n/a	0.40	0.30	n/a	n/a	n/a
2115	491,221	640,528	n/a	n/a	n/a	0.40	0.30	n/a	n/a	n/a
2116	493,186	642,449	n/a	n/a	n/a	0.40	0.30	n/a	n/a	n/a
2117	495,159	644,377	n/a	n/a	n/a	0.40	0.30	n/a	n/a	n/a
2118	497,140	646,310	n/a	n/a	n/a	0.40	0.30	n/a	n/a	n/a

Appendix A.3

Per Capita Consumption and Water Demand Projections

Year	Gallons per Capita per Day (gpcd)					Water Demand (ac-ft/yr)						
	Conservation Consumption	Drought Consumption	2021 Region O Plan	2013 SWSP Drought	2013 SWSP Conserv.	Conservation	Expected Drought	Accelerated Growth	2021 Region O Plan	2013 SWSP Probable	2013 SWSP Accelerated Growth	2013 SWSP Conservation
Data by Decade												
2018	143	171	162	173	148	41,266	49,344	41,266	n/a	49,553	50,292	42,289
2028	136	163	157	164	142	44,221	52,878	45,999	48,664	52,888	56,388	45,922
2038	135	155	154	158	139	49,624	56,664	54,228	52,634	56,401	62,866	49,397
2048	133	153	152	156	136	52,945	60,571	60,194	57,178	59,799	69,006	52,227
2058	131	151	151	153	134	55,929	64,108	65,508	61,931	62,776	74,629	54,673
2068	130	149	151	151	131	58,498	67,180	70,587	66,740	65,248	79,914	56,667
2078	128	147	n/a	148	129	60,580	69,703	75,311	n/a	67,147	84,729	58,153
2088	126	145	n/a	146	126	62,114	71,604	79,556	n/a	68,758	88,947	59,381
2098	124	143	n/a	144	124	63,687	73,558	83,211	n/a	70,408	92,221	60,635
2108	122	141	n/a	141	121	65,300	75,564	85,744	n/a	72,097	94,198	61,916
2118	120	139	n/a	n/a	n/a	66,954	77,625	87,044	n/a	n/a	n/a	n/a
Data by Year												
2018	143	171	162	173	148	41,266	49,344	41,266	n/a	49,553	50,292	42,289
2019	142	170	161	172	147	41,552	49,687	41,593	n/a	49,877	50,870	42,591
2020	142	169	160	171	146	41,840	50,032	41,964	45,622	50,203	51,456	42,896
2021	141	168	160	170	146	42,131	50,379	42,381	46,003	50,531	52,048	43,263
2022	140	168	159	170	145	42,423	50,729	42,844	46,383	50,861	52,647	43,633
2023	139	167	159	169	145	42,718	51,081	43,354	46,763	51,193	53,253	44,006
2024	139	166	158	168	144	43,014	51,435	43,871	47,143	51,528	53,866	44,383
2025	138	165	158	167	144	43,313	51,792	44,394	47,524	51,865	54,486	44,763
2026	137	164	158	166	143	43,613	52,151	44,923	47,904	52,204	55,113	45,146
2027	137	163	157	165	143	43,916	52,513	45,458	48,284	52,545	55,747	45,533
2028	136	163	157	164	142	44,221	52,878	45,999	48,664	52,888	56,388	45,922
2029	136	162	156	163	142	44,733	53,245	46,763	49,044	53,234	57,037	46,315
2030	136	161	156	162	142	45,252	53,614	47,539	49,423	53,582	57,694	46,712
2031	136	160	156	161	141	45,777	53,986	48,327	49,825	53,932	58,358	47,112
2032	136	159	155	161	141	46,308	54,361	49,129	50,227	54,284	59,029	47,515
2033	136	159	155	160	140	46,844	54,738	49,945	50,628	54,639	59,709	47,921
2034	136	158	155	159	140	47,388	55,118	50,773	51,029	54,987	60,327	48,213
2035	136	157	155	159	140	47,937	55,501	51,616	51,431	55,337	60,952	48,506
2036	136	156	154	159	139	48,493	55,886	52,472	51,832	55,690	61,584	48,802
2037	136	155	154	159	139	49,055	56,274	53,343	52,233	56,044	62,222	49,099
2038	135	155	154	158	139	49,624	56,664	54,228	52,634	56,401	62,866	49,397
2039	135	154	153	158	139	49,946	57,043	54,797	53,036	56,760	63,518	49,698
2040	135	154	153	158	138	50,271	57,425	55,372	53,437	57,121	64,176	50,000
2041	135	154	153	158	138	50,598	57,809	55,953	53,905	57,485	64,841	50,304
2042	135	154	153	157	138	50,926	58,196	56,540	54,372	57,851	65,512	50,611
2043	134	154	153	157	137	51,257	58,585	57,133	54,840	58,220	66,191	50,919
2044	134	153	153	157	137	51,590	58,977	57,733	55,307	58,532	66,745	51,178
2045	134	153	153	157	137	51,926	59,372	58,338	55,775	58,846	67,303	51,438
2046	134	153	152	156	137	52,263	59,769	58,951	56,243	59,162	67,866	51,700
2047	134	153	152	156	136	52,603	60,169	59,569	56,710	59,480	68,434	51,962
2048	133	153	152	156	136	52,945	60,571	60,194	57,178	59,799	69,006	52,227
2049	133	152	152	156	136	53,236	60,916	60,705	57,645	60,120	69,583	52,492
2050	133	152	152	155	136	53,529	61,262	61,221	58,112	60,443	70,165	52,759
2051	133	152	152	155	135	53,823	61,611	61,741	58,590	60,767	70,752	53,028
2052	133	152	152	155	135	54,119	61,962	62,266	59,068	61,094	71,344	53,298
2053	132	152	152	155	135	54,417	62,314	62,795	59,545	61,422	71,940	53,569
2054	132	151	152	154	135	54,716	62,669	63,328	60,022	61,690	72,470	53,788
2055	132	151	152	154	134	55,017	63,026	63,866	60,500	61,960	73,004	54,008
2056	132	151	151	154	134	55,319	63,384	64,409	60,977	62,231	73,542	54,228
2057	132	151	151	154	134	55,624	63,745	64,956	61,454	62,502	74,083	54,450
2058	131	151	151	153	134	55,929	64,108	65,508	61,931	62,776	74,629	54,673
2059	131	151	151	153	133	56,181	64,409	65,999	62,409	63,050	75,179	54,896
2060	131	150	151	153	133	56,434	64,711	66,493	62,886	63,326	75,732	55,121
2061	131	150	151	153	133	56,688	65,014	66,992	63,368	63,602	76,290	55,346
2062	131	150	151	152	133	56,943	65,319	67,494	63,849	63,880	76,852	55,572
2063	131	150	151	152	132	57,200	65,626	68,000	64,331	64,159	77,418	55,800
2064	130	150	151	152	132	57,457	65,934	68,510	64,813	64,376	77,911	55,972
2065	130	149	151	152	132	57,716	66,243	69,023	65,295	64,593	78,407	56,145
2066	130	149	151	151	132	57,975	66,554	69,541	65,776	64,811	78,906	56,319
2067	130	149	151	151	131	58,236	66,866	70,062	66,258	65,029	79,409	56,493
2068	130	149	151	151	131	58,498	67,180	70,587	66,740	65,248	79,914	56,667
2069	129	149	151	151	131	58,703	67,428	71,046	67,221	65,468	80,423	56,842
2070	129	148	151	150	131	58,909	67,677	71,508	67,702	65,689	80,935	57,018
2071	129	148	n/a	150	130	59,115	67,927	71,972	n/a	65,911	81,451	57,194
2072	129	148	n/a	150	130	59,322	68,178	72,440	n/a	66,133	81,969	57,371
2073	129	148	n/a	150	130	59,530	68,430	72,911	n/a	66,356	82,491	57,548
2074	128	148	n/a	149	130	59,739	68,683	73,385	n/a	66,513	82,934	57,669
2075	128	147	n/a	149	129	59,948	68,936	73,861	n/a	66,671	83,379	57,789
2076	128	147	n/a	149	129	60,158	69,191	74,341	n/a	66,830	83,827	57,910
2077	128	147	n/a	149	129	60,369	69,447	74,824	n/a	66,988	84,277	58,031
2078	128	147	n/a	148	129	60,580	69,703	75,311	n/a	67,147	84,729	58,153
2079	127	147	n/a	148	128	60,732	69,891	75,725	n/a	67,307	85,184	58,275
2080	127	146	n/a	148	128	60,884	70,079	76,141	n/a	67,466	85,642	58,397

Appendix A.3

Per Capita Consumption and Water Demand Projections

Year	Gallons per Capita per Day (gpcd)					Water Demand (ac-ft/yr)						
	Conservation Consumption	Drought Consumption	2021 Region O Plan	2013 SWSP Drought	2013 SWSP Conserv.	Conservation	Expected Drought	Accelerated Growth	2021 Region O Plan	2013 SWSP Probable	2013 SWSP Accelerated Growth	2013 SWSP Conservation
2081	127	146	n/a	148	128	61,036	70,268	76,560	n/a	67,626	86,101	58,519
2082	127	146	n/a	148	128	61,189	70,457	76,981	n/a	67,787	86,564	58,641
2083	127	146	n/a	147	127	61,342	70,647	77,404	n/a	67,948	87,028	58,764
2084	126	146	n/a	147	127	61,496	70,838	77,830	n/a	68,109	87,409	58,887
2085	126	146	n/a	147	127	61,650	71,029	78,258	n/a	68,271	87,791	59,010
2086	126	145	n/a	147	127	61,804	71,220	78,689	n/a	68,433	88,174	59,133
2087	126	145	n/a	146	126	61,959	71,412	79,121	n/a	68,595	88,560	59,257
2088	126	145	n/a	146	126	62,114	71,604	79,556	n/a	68,758	88,947	59,381
2089	126	145	n/a	146	126	62,270	71,797	79,915	n/a	68,921	89,335	59,505
2090	125	145	n/a	146	126	62,426	71,991	80,274	n/a	69,085	89,726	59,630
2091	125	144	n/a	145	125	62,582	72,185	80,636	n/a	69,249	90,118	59,755
2092	125	144	n/a	145	125	62,739	72,379	80,999	n/a	69,413	90,512	59,880
2093	125	144	n/a	145	125	62,896	72,574	81,363	n/a	69,578	90,907	60,005
2094	125	144	n/a	145	125	63,053	72,770	81,729	n/a	69,743	91,169	60,131
2095	124	144	n/a	144	125	63,211	72,966	82,097	n/a	69,909	91,430	60,256
2096	124	143	n/a	144	124	63,369	73,163	82,467	n/a	70,075	91,693	60,383
2097	124	143	n/a	144	124	63,528	73,360	82,838	n/a	70,241	91,957	60,509
2098	124	143	n/a	144	124	63,687	73,558	83,211	n/a	70,408	92,221	60,635
2099	124	143	n/a	144	124	63,847	73,756	83,461	n/a	70,575	92,486	60,762
2100	124	143	n/a	143	123	64,007	73,955	83,711	n/a	70,742	92,751	60,889
2101	123	143	n/a	143	123	64,167	74,154	83,963	n/a	70,910	93,018	61,017
2102	123	142	n/a	143	123	64,327	74,354	84,215	n/a	71,078	93,285	61,145
2103	123	142	n/a	143	123	64,489	74,554	84,468	n/a	71,247	93,553	61,273
2104	123	142	n/a	142	122	64,650	74,755	84,722	n/a	71,416	93,682	61,401
2105	123	142	n/a	142	122	64,812	74,956	84,976	n/a	71,586	93,810	61,529
2106	122	142	n/a	142	122	64,974	75,158	85,231	n/a	71,756	93,939	61,658
2107	122	141	n/a	142	122	65,137	75,361	85,487	n/a	71,926	94,069	61,787
2108	122	141	n/a	141	121	65,300	75,564	85,744	n/a	72,097	94,198	61,916
2109	122	141	n/a	141	121	65,464	75,768	85,873	n/a	72,268	94,327	62,046
2110	122	141	n/a	141	121	65,627	75,972	86,002	n/a	72,439	94,457	62,176
2111	121	141	n/a	141	121	65,792	76,177	86,132	n/a	72,611	94,587	62,306
2112	121	140	n/a	141	121	65,957	76,382	86,261	n/a	72,784	94,717	62,436
2113	121	140	n/a	140	120	66,122	76,588	86,391	n/a	72,956	94,847	62,567
2114	121	140	n/a	n/a	n/a	66,287	76,794	86,521	n/a	n/a	n/a	n/a
2115	121	140	n/a	n/a	n/a	66,453	77,001	86,652	n/a	n/a	n/a	n/a
2116	121	140	n/a	n/a	n/a	66,620	77,208	86,782	n/a	n/a	n/a	n/a
2117	120	140	n/a	n/a	n/a	66,786	77,417	86,913	n/a	n/a	n/a	n/a
2118	120	139	n/a	n/a	n/a	66,954	77,625	87,044	n/a	n/a	n/a	n/a

Appendix A.4

Peaking Factor, Average Annual Day, and Peak Day Demand

Year	Peaking Factor		Average Annual Day - AAD (mgd)			Peak Day Demand - PDD (mgd)					
	Conservation	Expected	Conservation	Expected Drought	Accelerated Growth	Conservation	Expected Drought	Accelerated Growth	2013 SWSP Probable Peak	2013 SWSP Accelerated Peak	2013 SWSP Conservation Peak
Data by Decade											
2018	1.62	1.80	36.84	44.05	36.84	59.68	79.29	66.31	79.63	80.82	67.66
2028	1.61	1.80	39.48	47.21	41.07	63.57	84.97	73.92	84.99	90.61	72.84
2038	1.60	1.80	44.30	50.59	48.41	70.91	91.06	87.14	90.63	101.02	77.67
2048	1.59	1.80	47.27	54.07	53.74	75.20	97.33	96.73	96.09	110.89	81.41
2058	1.58	1.80	49.93	57.23	58.48	78.97	103.02	105.27	100.88	119.92	84.48
2068	1.57	1.80	52.22	59.97	63.02	82.10	107.95	113.43	104.85	128.42	86.80
2078	1.56	1.80	54.08	62.23	67.23	84.51	112.01	121.02	107.90	136.15	88.31
2088	1.55	1.80	55.45	63.92	71.02	86.14	115.06	127.84	110.49	142.93	89.39
2098	1.54	1.80	56.86	65.67	74.29	87.79	118.20	133.71	113.14	148.19	90.49
2108	1.53	1.80	58.30	67.46	76.55	89.47	121.43	137.79	115.85	151.37	91.60
2118	1.53	1.80	59.77	69.30	77.71	91.19	124.74	139.87	n/a	n/a	n/a
Data by Year											
2018	1.62	1.80	36.84	44.05	36.84	59.68	79.29	66.31	79.63	80.82	67.66
2019	1.62	1.80	37.10	44.36	37.13	60.06	79.84	66.84	80.15	81.75	68.09
2020	1.62	1.80	37.35	44.67	37.46	60.44	80.40	67.43	80.67	82.69	68.51
2021	1.62	1.80	37.61	44.98	37.84	60.82	80.96	68.10	81.20	83.64	69.04
2022	1.62	1.80	37.87	45.29	38.25	61.21	81.52	68.85	81.73	84.60	69.57
2023	1.62	1.80	38.14	45.60	38.70	61.59	82.08	69.67	82.26	85.57	70.10
2024	1.61	1.80	38.40	45.92	39.17	61.99	82.65	70.50	82.80	86.56	70.64
2025	1.61	1.80	38.67	46.24	39.63	62.38	83.23	71.34	83.34	87.55	71.18
2026	1.61	1.80	38.94	46.56	40.10	62.77	83.80	72.19	83.89	88.56	71.73
2027	1.61	1.80	39.21	46.88	40.58	63.17	84.39	73.05	84.44	89.58	72.28
2028	1.61	1.80	39.48	47.21	41.07	63.57	84.97	73.92	84.99	90.61	72.84
2029	1.61	1.80	39.94	47.53	41.75	64.27	85.56	75.14	85.54	91.66	73.40
2030	1.61	1.80	40.40	47.86	42.44	64.98	86.15	76.39	86.10	92.71	73.96
2031	1.61	1.80	40.87	48.20	43.14	65.69	86.75	77.66	86.67	93.78	74.53
2032	1.61	1.80	41.34	48.53	43.86	66.41	87.35	78.95	87.23	94.86	75.10
2033	1.61	1.80	41.82	48.87	44.59	67.14	87.96	80.26	87.80	95.95	75.68
2034	1.60	1.80	42.30	49.21	45.33	67.88	88.57	81.59	88.36	96.94	76.07
2035	1.60	1.80	42.80	49.55	46.08	68.62	89.19	82.94	88.92	97.95	76.47
2036	1.60	1.80	43.29	49.89	46.84	69.38	89.81	84.32	89.49	98.96	76.87
2037	1.60	1.80	43.79	50.24	47.62	70.14	90.43	85.72	90.06	99.99	77.27
2038	1.60	1.80	44.30	50.59	48.41	70.91	91.06	87.14	90.63	101.02	77.67
2039	1.60	1.80	44.59	50.93	48.92	71.33	91.67	88.06	91.21	102.07	78.07
2040	1.60	1.80	44.88	51.27	49.43	71.75	92.28	88.98	91.79	103.13	78.48
2041	1.60	1.80	45.17	51.61	49.95	72.17	92.90	89.91	92.38	104.20	78.89
2042	1.60	1.80	45.46	51.95	50.48	72.60	93.52	90.86	92.96	105.27	79.30
2043	1.60	1.80	45.76	52.30	51.01	73.03	94.14	91.81	93.56	106.37	79.71
2044	1.59	1.80	46.06	52.65	51.54	73.46	94.77	92.77	94.06	107.25	80.05
2045	1.59	1.80	46.36	53.00	52.08	73.89	95.41	93.75	94.56	108.15	80.39
2046	1.59	1.80	46.66	53.36	52.63	74.33	96.04	94.73	95.07	109.06	80.73
2047	1.59	1.80	46.96	53.72	53.18	74.76	96.69	95.72	95.58	109.97	81.07
2048	1.59	1.80	47.27	54.07	53.74	75.20	97.33	96.73	96.09	110.89	81.41
2049	1.59	1.80	47.53	54.38	54.19	75.57	97.89	97.55	96.61	111.82	81.75
2050	1.59	1.80	47.79	54.69	54.65	75.94	98.44	98.38	97.13	112.75	82.09
2051	1.59	1.80	48.05	55.00	55.12	76.31	99.01	99.21	97.65	113.69	82.44
2052	1.59	1.80	48.31	55.32	55.59	76.69	99.57	100.06	98.17	114.64	82.79
2053	1.59	1.80	48.58	55.63	56.06	77.06	100.14	100.91	98.70	115.60	83.14
2054	1.59	1.80	48.85	55.95	56.54	77.44	100.71	101.76	99.13	116.46	83.40
2055	1.58	1.80	49.12	56.27	57.02	77.82	101.28	102.63	99.57	117.31	83.67
2056	1.58	1.80	49.39	56.59	57.50	78.20	101.85	103.50	100.00	118.18	83.94
2057	1.58	1.80	49.66	56.91	57.99	78.58	102.43	104.38	100.44	119.05	84.21
2058	1.58	1.80	49.93	57.23	58.48	78.97	103.02	105.27	100.88	119.92	84.48
2059	1.58	1.80	50.16	57.50	58.92	79.28	103.50	106.06	101.32	120.81	84.75
2060	1.58	1.80	50.38	57.77	59.36	79.59	103.99	106.85	101.76	121.70	85.03
2061	1.58	1.80	50.61	58.04	59.81	79.90	104.47	107.65	102.20	122.59	85.30
2062	1.58	1.80	50.84	58.31	60.25	80.21	104.96	108.46	102.65	123.50	85.57
2063	1.58	1.80	51.06	58.59	60.71	80.52	105.46	109.27	103.10	124.41	85.85
2064	1.58	1.80	51.29	58.86	61.16	80.83	105.95	110.09	103.45	125.20	86.04
2065	1.57	1.80	51.53	59.14	61.62	81.15	106.45	110.92	103.80	126.00	86.23
2066	1.57	1.80	51.76	59.42	62.08	81.47	106.95	111.75	104.15	126.80	86.42
2067	1.57	1.80	51.99	59.69	62.55	81.78	107.45	112.59	104.50	127.61	86.61
2068	1.57	1.80	52.22	59.97	63.02	82.10	107.95	113.43	104.85	128.42	86.80
2069	1.57	1.80	52.41	60.20	63.43	82.34	108.35	114.17	105.20	129.24	87.00
2070	1.57	1.80	52.59	60.42	63.84	82.58	108.75	114.91	105.56	130.06	87.19
2071	1.57	1.80	52.77	60.64	64.25	82.82	109.15	115.66	105.91	130.89	87.38
2072	1.57	1.80	52.96	60.87	64.67	83.06	109.56	116.41	106.27	131.72	87.58
2073	1.57	1.80	53.15	61.09	65.09	83.30	109.96	117.16	106.63	132.56	87.77
2074	1.57	1.80	53.33	61.32	65.51	83.54	110.37	117.92	106.88	133.27	87.88

Appendix A.4

Peaking Factor, Average Annual Day, and Peak Day Demand

Year	Peaking Factor		Average Annual Day - AAD (mgd)			Peak Day Demand - PDD (mgd)					
	Conservation	Expected	Conservation	Expected Drought	Accelerated Growth	Conservation	Expected Drought	Accelerated Growth	2013 SWSP Probable Peak	2013 SWSP Accelerated Peak	2013 SWSP Conservation Peak
2075	1.57	1.80	53.52	61.54	65.94	83.78	110.78	118.69	107.14	133.99	87.99
2076	1.56	1.80	53.71	61.77	66.37	84.03	111.19	119.46	107.39	134.70	88.09
2077	1.56	1.80	53.89	62.00	66.80	84.27	111.60	120.24	107.65	135.43	88.20
2078	1.56	1.80	54.08	62.23	67.23	84.51	112.01	121.02	107.90	136.15	88.31
2079	1.56	1.80	54.22	62.39	67.60	84.68	112.31	121.69	108.16	136.89	88.42
2080	1.56	1.80	54.35	62.56	67.97	84.84	112.61	122.35	108.41	137.62	88.52
2081	1.56	1.80	54.49	62.73	68.35	85.00	112.92	123.03	108.67	138.36	88.63
2082	1.56	1.80	54.63	62.90	68.72	85.16	113.22	123.70	108.93	139.10	88.74
2083	1.56	1.80	54.76	63.07	69.10	85.32	113.53	124.38	109.19	139.85	88.85
2084	1.56	1.80	54.90	63.24	69.48	85.48	113.83	125.07	109.45	140.46	88.96
2085	1.56	1.80	55.04	63.41	69.86	85.65	114.14	125.76	109.71	141.07	89.07
2086	1.56	1.80	55.18	63.58	70.25	85.81	114.45	126.45	109.97	141.69	89.17
2087	1.55	1.80	55.31	63.75	70.64	85.97	114.75	127.14	110.23	142.31	89.28
2088	1.55	1.80	55.45	63.92	71.02	86.14	115.06	127.84	110.49	142.93	89.39
2089	1.55	1.80	55.59	64.10	71.34	86.30	115.37	128.42	110.75	143.56	89.50
2090	1.55	1.80	55.73	64.27	71.66	86.46	115.68	129.00	111.02	144.18	89.61
2091	1.55	1.80	55.87	64.44	71.99	86.63	116.00	129.58	111.28	144.81	89.72
2092	1.55	1.80	56.01	64.62	72.31	86.79	116.31	130.16	111.54	145.45	89.83
2093	1.55	1.80	56.15	64.79	72.64	86.96	116.62	130.75	111.81	146.08	89.94
2094	1.55	1.80	56.29	64.96	72.96	87.12	116.94	131.33	112.07	146.50	90.05
2095	1.55	1.80	56.43	65.14	73.29	87.29	117.25	131.93	112.34	146.92	90.16
2096	1.55	1.80	56.57	65.32	73.62	87.46	117.57	132.52	112.61	147.35	90.27
2097	1.54	1.80	56.71	65.49	73.95	87.62	117.88	133.12	112.87	147.77	90.38
2098	1.54	1.80	56.86	65.67	74.29	87.79	118.20	133.71	113.14	148.19	90.49
2099	1.54	1.80	57.00	65.84	74.51	87.96	118.52	134.12	113.41	148.62	90.60
2100	1.54	1.80	57.14	66.02	74.73	88.12	118.84	134.52	113.68	149.05	90.71
2101	1.54	1.80	57.28	66.20	74.96	88.29	119.16	134.92	113.95	149.47	90.82
2102	1.54	1.80	57.43	66.38	75.18	88.46	119.48	135.33	114.22	149.90	90.93
2103	1.54	1.80	57.57	66.56	75.41	88.63	119.80	135.73	114.49	150.33	91.04
2104	1.54	1.80	57.72	66.74	75.63	88.80	120.13	136.14	114.76	150.54	91.15
2105	1.54	1.80	57.86	66.92	75.86	88.97	120.45	136.55	115.03	150.75	91.27
2106	1.54	1.80	58.01	67.10	76.09	89.13	120.77	136.96	115.31	150.95	91.38
2107	1.54	1.80	58.15	67.28	76.32	89.30	121.10	137.37	115.58	151.16	91.49
2108	1.53	1.80	58.30	67.46	76.55	89.47	121.43	137.79	115.85	151.37	91.60
2109	1.53	1.80	58.44	67.64	76.66	89.64	121.75	137.99	116.13	151.58	91.71
2110	1.53	1.80	58.59	67.82	76.78	89.81	122.08	138.20	116.41	151.79	91.82
2111	1.53	1.80	58.74	68.01	76.89	89.99	122.41	138.41	116.68	152.00	91.94
2112	1.53	1.80	58.88	68.19	77.01	90.16	122.74	138.62	116.96	152.20	92.05
2113	1.53	1.80	59.03	68.37	77.13	90.33	123.07	138.83	117.24	152.41	92.16
2114	1.53	1.80	59.18	68.56	77.24	90.50	123.40	139.03	n/a	n/a	n/a
2115	1.53	1.80	59.33	68.74	77.36	90.67	123.74	139.24	n/a	n/a	n/a
2116	1.53	1.80	59.47	68.93	77.47	90.84	124.07	139.45	n/a	n/a	n/a
2117	1.53	1.80	59.62	69.11	77.59	91.02	124.40	139.66	n/a	n/a	n/a
2118	1.53	1.80	59.77	69.30	77.71	91.19	124.74	139.87	n/a	n/a	n/a

HDR

City of Lubbock TEXAS

B

Current Water Supplies, Demands and Net Supplies

Appendix B.1

Current Annual and Peak Day Water Supply Projections

Year	Current Annual Supplies (ac-ft/yr)				Total Annual Water Supply (ac-ft/yr)	Current Peak Day Supplies (mgd)				Total Peak Day Supply (mgd)
	Lake Meredith	Roberts County Well Field	Bailey County Well Field	Lake Alan Henry		Lake Meredith	Roberts County Well Field	Bailey County Well Field	Lake Alan Henry	
Data by Decade										
2018	7,412	25,570	5,000	8,000	45,982	10.00	24.00	30.00	10.00	74.00
2028	7,412	25,570	4,748	8,000	45,730	10.00	24.00	29.24	10.00	73.24
2038	0	24,829	4,268	8,000	37,097	0.00	23.30	24.03	10.00	57.33
2048	0	23,087	3,713	8,000	34,800	0.00	21.67	18.00	10.00	49.67
2058	0	22,437	3,082	8,000	33,519	0.00	21.06	11.15	10.00	42.21
2068	0	21,780	2,376	8,000	32,156	0.00	20.44	3.48	10.00	33.92
2078	0	21,130	0	8,000	29,130	0.00	19.83	0.00	10.00	29.83
2088	0	20,480	0	8,000	28,480	0.00	19.22	0.00	10.00	29.22
2098	0	19,830	0	8,000	27,830	0.00	18.61	0.00	10.00	28.61
2108	0	19,180	0	8,000	27,180	0.00	18.00	0.00	10.00	28.00
2118	0	18,530	0	8,000	26,530	0.00	17.39	0.00	10.00	27.39
Data by Year										
2018	7,412	25,570	5,000	8,000	45,982	10.00	24.00	30.00	10.00	74.00
2019	7,412	25,570	5,000	8,000	45,982	10.00	24.00	30.00	10.00	74.00
2020	7,412	25,570	5,000	8,000	45,982	10.00	24.00	30.00	10.00	74.00
2021	7,412	25,570	5,000	8,000	45,982	10.00	24.00	30.00	10.00	74.00
2022	7,412	25,570	5,000	8,000	45,982	10.00	24.00	30.00	10.00	74.00
2023	7,412	25,570	4,960	8,000	45,942	10.00	24.00	30.00	10.00	74.00
2024	7,412	25,570	4,919	8,000	45,901	10.00	24.00	30.00	10.00	74.00
2025	7,412	25,570	4,877	8,000	45,859	10.00	24.00	30.00	10.00	74.00
2026	7,412	25,570	4,835	8,000	45,817	10.00	24.00	30.00	10.00	74.00
2027	7,412	25,570	4,792	8,000	45,774	10.00	24.00	29.72	10.00	73.72
2028	7,412	25,570	4,748	8,000	45,730	10.00	24.00	29.24	10.00	73.24
2029	7,412	25,570	4,704	8,000	45,686	10.00	24.00	28.76	10.00	72.76
2030	7,412	25,570	4,658	8,000	45,640	10.00	24.00	28.27	10.00	72.27
2031	7,412	25,570	4,612	8,000	45,594	10.00	24.00	27.76	10.00	71.76
2032	0	25,570	4,565	8,000	38,135	0.00	24.00	27.26	10.00	61.26
2033	0	25,570	4,518	8,000	38,088	0.00	24.00	26.74	10.00	60.74
2034	0	25,570	4,469	8,000	38,039	0.00	24.00	26.21	10.00	60.21
2035	0	25,570	4,420	8,000	37,990	0.00	24.00	25.68	10.00	59.68
2036	0	25,323	4,370	8,000	37,693	0.00	23.77	25.14	10.00	58.91
2037	0	25,076	4,320	8,000	37,396	0.00	23.54	24.59	10.00	58.13
2038	0	24,829	4,268	8,000	37,097	0.00	23.30	24.03	10.00	57.33
2039	0	24,582	4,216	8,000	36,798	0.00	23.07	23.46	10.00	56.53
2040	0	24,335	4,163	8,000	36,498	0.00	22.84	22.89	10.00	55.73
2041	0	24,088	4,110	8,000	36,198	0.00	22.61	22.31	10.00	54.92
2042	0	23,841	4,055	8,000	35,896	0.00	22.38	21.72	10.00	54.10
2043	0	23,594	4,000	8,000	35,594	0.00	22.14	21.12	10.00	53.26
2044	0	23,347	3,944	8,000	35,291	0.00	21.91	20.51	10.00	52.42
2045	0	23,282	3,887	8,000	35,169	0.00	21.85	19.89	10.00	51.74
2046	0	23,217	3,830	8,000	35,047	0.00	21.79	19.27	10.00	51.06
2047	0	23,152	3,772	8,000	34,924	0.00	21.73	18.64	10.00	50.37
2048	0	23,087	3,713	8,000	34,800	0.00	21.67	18.00	10.00	49.67
2049	0	23,022	3,653	8,000	34,675	0.00	21.61	17.35	10.00	48.96
2050	0	22,957	3,593	8,000	34,550	0.00	21.55	16.69	10.00	48.24
2051	0	22,892	3,532	8,000	34,424	0.00	21.49	16.03	10.00	47.52
2052	0	22,827	3,470	8,000	34,297	0.00	21.42	15.36	10.00	46.78
2053	0	22,762	3,407	8,000	34,169	0.00	21.36	14.68	10.00	46.04
2054	0	22,697	3,344	8,000	34,041	0.00	21.30	13.99	10.00	45.29
2055	0	22,632	3,279	8,000	33,911	0.00	21.24	13.29	10.00	44.53
2056	0	22,567	3,214	8,000	33,781	0.00	21.18	12.58	10.00	43.76
2057	0	22,502	3,149	8,000	33,651	0.00	21.12	11.87	10.00	42.99
2058	0	22,437	3,082	8,000	33,519	0.00	21.06	11.15	10.00	42.21
2059	0	22,372	3,015	8,000	33,387	0.00	21.00	10.42	10.00	41.42
2060	0	22,307	2,947	8,000	33,254	0.00	20.94	9.68	10.00	40.62
2061	0	22,235	2,878	8,000	33,113	0.00	20.87	8.93	10.00	39.80
2062	0	22,170	2,809	8,000	32,979	0.00	20.81	8.18	10.00	38.99
2063	0	22,105	2,739	8,000	32,844	0.00	20.75	7.42	10.00	38.17
2064	0	22,040	2,668	8,000	32,708	0.00	20.69	6.65	10.00	37.34
2065	0	21,975	2,596	8,000	32,571	0.00	20.63	5.87	10.00	36.50
2066	0	21,910	2,524	8,000	32,434	0.00	20.56	5.08	10.00	35.64
2067	0	21,845	2,450	8,000	32,295	0.00	20.50	4.29	10.00	34.79
2068	0	21,780	2,376	8,000	32,156	0.00	20.44	3.48	10.00	33.92
2069	0	21,715	2,302	8,000	32,017	0.00	20.38	2.67	10.00	33.05
2070	0	21,650	0	8,000	29,650	0.00	20.32	0.00	10.00	30.32
2071	0	21,585	0	8,000	29,585	0.00	20.26	0.00	10.00	30.26
2072	0	21,520	0	8,000	29,520	0.00	20.20	0.00	10.00	30.20
2073	0	21,455	0	8,000	29,455	0.00	20.14	0.00	10.00	30.14
2074	0	21,390	0	8,000	29,390	0.00	20.08	0.00	10.00	30.08
2075	0	21,325	0	8,000	29,325	0.00	20.02	0.00	10.00	30.02
2076	0	21,260	0	8,000	29,260	0.00	19.95	0.00	10.00	29.95
2077	0	21,195	0	8,000	29,195	0.00	19.89	0.00	10.00	29.89
2078	0	21,130	0	8,000	29,130	0.00	19.83	0.00	10.00	29.83
2079	0	21,065	0	8,000	29,065	0.00	19.77	0.00	10.00	29.77
2080	0	21,000	0	8,000	29,000	0.00	19.71	0.00	10.00	29.71
2081	0	20,935	0	8,000	28,935	0.00	19.65	0.00	10.00	29.65
2082	0	20,870	0	8,000	28,870	0.00	19.59	0.00	10.00	29.59
2083	0	20,805	0	8,000	28,805	0.00	19.53	0.00	10.00	29.53

Appendix B.1

Current Annual and Peak Day Water Supply Projections

Year	Current Annual Supplies (ac-ft/yr)				Total Annual Water Supply (ac-ft/yr)	Current Peak Day Supplies (mgd)				Total Peak Day Supply (mgd)
	Lake Meredith	Roberts County Well Field	Bailey County Well Field	Lake Alan Henry		Lake Meredith	Roberts County Well Field	Bailey County Well Field	Lake Alan Henry	
2084	0	20,740	0	8,000	28,740	0.00	19.47	0.00	10.00	29.47
2085	0	20,675	0	8,000	28,675	0.00	19.40	0.00	10.00	29.40
2086	0	20,610	0	8,000	28,610	0.00	19.34	0.00	10.00	29.34
2087	0	20,545	0	8,000	28,545	0.00	19.28	0.00	10.00	29.28
2088	0	20,480	0	8,000	28,480	0.00	19.22	0.00	10.00	29.22
2089	0	20,415	0	8,000	28,415	0.00	19.16	0.00	10.00	29.16
2090	0	20,350	0	8,000	28,350	0.00	19.10	0.00	10.00	29.10
2091	0	20,285	0	8,000	28,285	0.00	19.04	0.00	10.00	29.04
2092	0	20,220	0	8,000	28,220	0.00	18.98	0.00	10.00	28.98
2093	0	20,155	0	8,000	28,155	0.00	18.92	0.00	10.00	28.92
2094	0	20,090	0	8,000	28,090	0.00	18.86	0.00	10.00	28.86
2095	0	20,025	0	8,000	28,025	0.00	18.79	0.00	10.00	28.79
2096	0	19,960	0	8,000	27,960	0.00	18.73	0.00	10.00	28.73
2097	0	19,895	0	8,000	27,895	0.00	18.67	0.00	10.00	28.67
2098	0	19,830	0	8,000	27,830	0.00	18.61	0.00	10.00	28.61
2099	0	19,765	0	8,000	27,765	0.00	18.55	0.00	10.00	28.55
2100	0	19,700	0	8,000	27,700	0.00	18.49	0.00	10.00	28.49
2101	0	19,635	0	8,000	27,635	0.00	18.43	0.00	10.00	28.43
2102	0	19,570	0	8,000	27,570	0.00	18.37	0.00	10.00	28.37
2103	0	19,505	0	8,000	27,505	0.00	18.31	0.00	10.00	28.31
2104	0	19,440	0	8,000	27,440	0.00	18.25	0.00	10.00	28.25
2105	0	19,375	0	8,000	27,375	0.00	18.18	0.00	10.00	28.18
2106	0	19,310	0	8,000	27,310	0.00	18.12	0.00	10.00	28.12
2107	0	19,245	0	8,000	27,245	0.00	18.06	0.00	10.00	28.06
2108	0	19,180	0	8,000	27,180	0.00	18.00	0.00	10.00	28.00
2109	0	19,115	0	8,000	27,115	0.00	17.94	0.00	10.00	27.94
2110	0	19,050	0	8,000	27,050	0.00	17.88	0.00	10.00	27.88
2111	0	18,985	0	8,000	26,985	0.00	17.82	0.00	10.00	27.82
2112	0	18,920	0	8,000	26,920	0.00	17.76	0.00	10.00	27.76
2113	0	18,855	0	8,000	26,855	0.00	17.70	0.00	10.00	27.70
2114	0	18,790	0	8,000	26,790	0.00	17.64	0.00	10.00	27.64
2115	0	18,725	0	8,000	26,725	0.00	17.57	0.00	10.00	27.57
2116	0	18,660	0	8,000	26,660	0.00	17.51	0.00	10.00	27.51
2117	0	18,595	0	8,000	26,595	0.00	17.45	0.00	10.00	27.45
2118	0	18,530	0	8,000	26,530	0.00	17.39	0.00	10.00	27.39

Appendix B.2
Current Annual Water Demand, Supply, and Net

Year	Annual Water Demand (ac-ft/yr)			Total Annual Water Supply (ac-ft/yr) (for details see Appendix B.1)	Annual Shortages/Surplus (ac-ft/yr)		
	Conservation	Expected Drought	Accelerated Growth		Conservation	Expected Drought	Accelerated Growth
Data by Decade							
2018	41,266	49,344	41,266	45,982	4,716	-3,362	4,716
2028	44,221	52,878	45,999	45,730	1,510	-7,148	-269
2038	49,624	56,664	54,228	37,097	-12,527	-19,567	-17,131
2048	52,945	60,571	60,194	34,800	-18,145	-25,771	-25,394
2058	55,929	64,108	65,508	33,519	-22,410	-30,588	-31,988
2068	58,498	67,180	70,587	32,156	-26,342	-35,024	-38,431
2078	60,580	69,703	75,311	29,130	-31,450	-40,573	-46,181
2088	62,114	71,604	79,556	28,480	-33,634	-43,124	-51,076
2098	63,687	73,558	83,211	27,830	-35,857	-45,728	-55,381
2108	65,300	75,564	85,744	27,180	-38,120	-48,384	-58,564
2118	66,954	77,625	87,044	26,530	-40,424	-51,095	-60,514

Data by Year							
2018	41,266	49,344	41,266	45,982	4,716	-3,362	4,716
2019	41,552	49,687	41,593	45,982	4,430	-3,705	4,389
2020	41,840	50,032	41,964	45,982	4,142	-4,050	4,018
2021	42,131	50,379	42,381	45,982	3,851	-4,397	3,601
2022	42,423	50,729	42,844	45,982	3,559	-4,747	3,138
2023	42,718	51,081	43,354	45,942	3,224	-5,139	2,588
2024	43,014	51,435	43,871	45,901	2,887	-5,534	2,030
2025	43,313	51,792	44,394	45,859	2,547	-5,933	1,466
2026	43,613	52,151	44,923	45,817	2,204	-6,334	895
2027	43,916	52,513	45,458	45,774	1,858	-6,739	316
2028	44,221	52,878	45,999	45,730	1,510	-7,148	-269
2029	44,733	53,245	46,763	45,686	952	-7,559	-1,077
2030	45,252	53,614	47,539	45,640	388	-7,974	-1,898
2031	45,777	53,986	48,327	45,594	-183	-8,392	-2,733
2032	46,308	54,361	49,129	38,135	-8,172	-16,226	-10,994
2033	46,844	54,738	49,945	38,088	-8,757	-16,651	-11,857
2034	47,388	55,118	50,773	38,039	-9,348	-17,079	-12,734
2035	47,937	55,501	51,616	37,990	-9,947	-17,511	-13,626
2036	48,493	55,886	52,472	37,693	-10,800	-18,193	-14,779
2037	49,055	56,274	53,343	37,396	-11,660	-18,878	-15,947
2038	49,624	56,664	54,228	37,097	-12,527	-19,567	-17,131
2039	49,946	57,043	54,797	36,798	-13,148	-20,245	-17,999
2040	50,271	57,425	55,372	36,498	-13,773	-20,927	-18,874
2041	50,598	57,809	55,953	36,198	-14,400	-21,612	-19,755
2042	50,926	58,196	56,540	35,896	-15,030	-22,300	-20,644
2043	51,257	58,585	57,133	35,594	-15,663	-22,991	-21,539
2044	51,590	58,977	57,733	35,291	-16,299	-23,686	-22,442
2045	51,926	59,372	58,338	35,169	-16,756	-24,202	-23,169
2046	52,263	59,769	58,951	35,047	-17,216	-24,722	-23,904
2047	52,603	60,169	59,569	34,924	-17,679	-25,245	-24,645
2048	52,945	60,571	60,194	34,800	-18,145	-25,771	-25,394
2049	53,236	60,916	60,705	34,675	-18,561	-26,241	-26,030
2050	53,529	61,262	61,221	34,550	-18,979	-26,713	-26,671
2051	53,823	61,611	61,741	34,424	-19,399	-27,187	-27,318
2052	54,119	61,962	62,266	34,297	-19,822	-27,665	-27,969
2053	54,417	62,314	62,795	34,169	-20,248	-28,145	-28,626
2054	54,716	62,669	63,328	34,041	-20,675	-28,628	-29,287
2055	55,017	63,026	63,866	33,911	-21,105	-29,114	-29,955
2056	55,319	63,384	64,409	33,781	-21,538	-29,603	-30,627
2057	55,624	63,745	64,956	33,651	-21,973	-30,094	-31,305
2058	55,929	64,108	65,508	33,519	-22,410	-30,588	-31,988
2059	56,181	64,409	65,999	33,387	-22,794	-31,021	-32,612
2060	56,434	64,711	66,493	33,254	-23,180	-31,457	-33,239
2061	56,688	65,014	66,992	33,113	-23,575	-31,901	-33,878
2062	56,943	65,319	67,494	32,979	-23,964	-32,340	-34,515
2063	57,200	65,626	68,000	32,844	-24,356	-32,782	-35,156
2064	57,457	65,934	68,510	32,708	-24,749	-33,226	-35,802
2065	57,716	66,243	69,023	32,571	-25,145	-33,672	-36,452

Appendix B.2
Current Annual Water Demand, Supply, and Net

Year	Annual Water Demand (ac-ft/yr)			Total Annual Water Supply (ac-ft/yr) (for details see Appendix B.1)	Annual Shortages/Surplus (ac-ft/yr)		
	Conservation	Expected Drought	Accelerated Growth		Conservation	Expected Drought	Accelerated Growth
2066	57,975	66,554	69,541	32,434	-25,542	-34,120	-37,107
2067	58,236	66,866	70,062	32,295	-25,941	-34,571	-37,767
2068	58,498	67,180	70,587	32,156	-26,342	-35,024	-38,431
2069	58,703	67,428	71,046	32,017	-26,687	-35,412	-39,029
2070	58,909	67,677	71,508	29,650	-29,259	-38,027	-41,858
2071	59,115	67,927	71,972	29,585	-29,530	-38,342	-42,387
2072	59,322	68,178	72,440	29,520	-29,802	-38,658	-42,920
2073	59,530	68,430	72,911	29,455	-30,075	-38,975	-43,456
2074	59,739	68,683	73,385	29,390	-30,349	-39,293	-43,995
2075	59,948	68,936	73,861	29,325	-30,623	-39,611	-44,536
2076	60,158	69,191	74,341	29,260	-30,898	-39,931	-45,081
2077	60,369	69,447	74,824	29,195	-31,174	-40,252	-45,629
2078	60,580	69,703	75,311	29,130	-31,450	-40,573	-46,181
2079	60,732	69,891	75,725	29,065	-31,667	-40,826	-46,660
2080	60,884	70,079	76,141	29,000	-31,884	-41,079	-47,141
2081	61,036	70,268	76,560	28,935	-32,101	-41,333	-47,625
2082	61,189	70,457	76,981	28,870	-32,319	-41,587	-48,111
2083	61,342	70,647	77,404	28,805	-32,537	-41,842	-48,599
2084	61,496	70,838	77,830	28,740	-32,756	-42,098	-49,090
2085	61,650	71,029	78,258	28,675	-32,975	-42,354	-49,583
2086	61,804	71,220	78,689	28,610	-33,194	-42,610	-50,079
2087	61,959	71,412	79,121	28,545	-33,414	-42,867	-50,576
2088	62,114	71,604	79,556	28,480	-33,634	-43,124	-51,076
2089	62,270	71,797	79,915	28,415	-33,855	-43,382	-51,500
2090	62,426	71,991	80,274	28,350	-34,076	-43,641	-51,924
2091	62,582	72,185	80,636	28,285	-34,297	-43,900	-52,351
2092	62,739	72,379	80,999	28,220	-34,519	-44,159	-52,779
2093	62,896	72,574	81,363	28,155	-34,741	-44,419	-53,208
2094	63,053	72,770	81,729	28,090	-34,963	-44,680	-53,639
2095	63,211	72,966	82,097	28,025	-35,186	-44,941	-54,072
2096	63,369	73,163	82,467	27,960	-35,409	-45,203	-54,507
2097	63,528	73,360	82,838	27,895	-35,633	-45,465	-54,943
2098	63,687	73,558	83,211	27,830	-35,857	-45,728	-55,381
2099	63,847	73,756	83,461	27,765	-36,082	-45,991	-55,696
2100	64,007	73,955	83,711	27,700	-36,307	-46,255	-56,011
2101	64,167	74,154	83,963	27,635	-36,532	-46,519	-56,328
2102	64,327	74,354	84,215	27,570	-36,757	-46,784	-56,645
2103	64,489	74,554	84,468	27,505	-36,984	-47,049	-56,963
2104	64,650	74,755	84,722	27,440	-37,210	-47,315	-57,282
2105	64,812	74,956	84,976	27,375	-37,437	-47,581	-57,601
2106	64,974	75,158	85,231	27,310	-37,664	-47,848	-57,921
2107	65,137	75,361	85,487	27,245	-37,892	-48,116	-58,242
2108	65,300	75,564	85,744	27,180	-38,120	-48,384	-58,564
2109	65,464	75,768	85,873	27,115	-38,349	-48,653	-58,758
2110	65,627	75,972	86,002	27,050	-38,577	-48,922	-58,952
2111	65,792	76,177	86,132	26,985	-38,807	-49,192	-59,147
2112	65,957	76,382	86,261	26,920	-39,037	-49,462	-59,341
2113	66,122	76,588	86,391	26,855	-39,267	-49,733	-59,536
2114	66,287	76,794	86,521	26,790	-39,497	-50,004	-59,731
2115	66,453	77,001	86,652	26,725	-39,728	-50,276	-59,927
2116	66,620	77,208	86,782	26,660	-39,960	-50,548	-60,122
2117	66,786	77,417	86,913	26,595	-40,191	-50,822	-60,318
2118	66,954	77,625	87,044	26,530	-40,424	-51,095	-60,514

Appendix B.3
Current Peak Day Demand, Supply, and Net

Year	Peak Day Demand (mgd)			Peak Day Supply (mgd) (for details see Appendix B.1)	Peak Day Shortages/Surpluses (mgd)		
	Conservation	Expected Drought	Accelerated Growth		Conservation	Expected Drought	Accelerated Growth
Data by Decade							
2018	59.68	79.29	66.31	74.00	14.32	-5.29	7.69
2028	63.57	84.97	73.92	73.24	9.67	-11.73	-0.68
2038	70.91	91.06	87.14	57.33	-13.58	-33.73	-29.81
2048	75.20	97.33	96.73	49.67	-25.54	-47.67	-47.06
2058	78.97	103.02	105.27	42.21	-36.76	-60.81	-63.06
2068	82.10	107.95	113.43	33.92	-48.18	-74.03	-79.51
2078	84.51	112.01	121.02	29.83	-54.68	-82.18	-91.19
2088	86.14	115.06	127.84	29.22	-56.92	-85.84	-98.62
2098	87.79	118.20	133.71	28.61	-59.18	-89.59	-105.10
2108	89.47	121.43	137.79	28.00	-61.47	-93.43	-109.79
2118	91.19	124.74	139.87	27.39	-63.80	-97.35	-112.48
Data by Year							
2018	59.68	79.29	66.31	74.00	14.32	-5.29	7.69
2019	60.06	79.84	66.84	74.00	13.94	-5.84	7.16
2020	60.44	80.40	67.43	74.00	13.56	-6.40	6.57
2021	60.82	80.96	68.10	74.00	13.18	-6.96	5.90
2022	61.21	81.52	68.85	74.00	12.79	-7.52	5.15
2023	61.59	82.08	69.67	74.00	12.41	-8.08	4.33
2024	61.99	82.65	70.50	74.00	12.01	-8.65	3.50
2025	62.38	83.23	71.34	74.00	11.62	-9.23	2.66
2026	62.77	83.80	72.19	74.00	11.23	-9.80	1.81
2027	63.17	84.39	73.05	73.72	10.55	-10.67	0.67
2028	63.57	84.97	73.92	73.24	9.67	-11.73	-0.68
2029	64.27	85.56	75.14	72.76	8.49	-12.80	-2.39
2030	64.98	86.15	76.39	72.27	7.29	-13.89	-4.13
2031	65.69	86.75	77.66	71.76	6.08	-14.99	-5.89
2032	66.41	87.35	78.95	61.26	-5.16	-26.10	-17.69
2033	67.14	87.96	80.26	60.74	-6.40	-27.22	-19.52
2034	67.88	88.57	81.59	60.21	-7.67	-28.36	-21.38
2035	68.62	89.19	82.94	59.68	-8.95	-29.51	-23.26
2036	69.38	89.81	84.32	58.91	-10.47	-30.90	-25.41
2037	70.14	90.43	85.72	58.13	-12.01	-32.30	-27.59
2038	70.91	91.06	87.14	57.33	-13.58	-33.73	-29.81
2039	71.33	91.67	88.06	56.53	-14.80	-35.13	-31.52
2040	71.75	92.28	88.98	55.73	-16.02	-36.55	-33.25
2041	72.17	92.90	89.91	54.92	-17.26	-37.98	-35.00
2042	72.60	93.52	90.86	54.10	-18.50	-39.42	-36.76
2043	73.03	94.14	91.81	53.26	-19.77	-40.89	-38.55
2044	73.46	94.77	92.77	52.42	-21.04	-42.35	-40.35
2045	73.89	95.41	93.75	51.74	-22.15	-43.66	-42.00
2046	74.33	96.04	94.73	51.06	-23.27	-44.98	-43.67
2047	74.76	96.69	95.72	50.37	-24.40	-46.32	-45.36
2048	75.20	97.33	96.73	49.67	-25.54	-47.67	-47.06
2049	75.57	97.89	97.55	48.96	-26.61	-48.93	-48.59
2050	75.94	98.44	98.38	48.24	-27.70	-50.20	-50.13
2051	76.31	99.01	99.21	47.52	-28.80	-51.49	-51.69
2052	76.69	99.57	100.06	46.78	-29.91	-52.79	-53.28
2053	77.06	100.14	100.91	46.04	-31.03	-54.10	-54.87
2054	77.44	100.71	101.76	45.29	-32.15	-55.42	-56.48
2055	77.82	101.28	102.63	44.53	-33.29	-56.75	-58.10
2056	78.20	101.85	103.50	43.76	-34.44	-58.09	-59.74
2057	78.58	102.43	104.38	42.99	-35.59	-59.44	-61.39
2058	78.97	103.02	105.27	42.21	-36.76	-60.81	-63.06
2059	79.28	103.50	106.06	41.42	-37.86	-62.08	-64.64
2060	79.59	103.99	106.85	40.62	-38.96	-63.37	-66.23
2061	79.90	104.47	107.65	39.80	-40.09	-64.67	-67.85
2062	80.21	104.96	108.46	38.99	-41.22	-65.97	-69.47
2063	80.52	105.46	109.27	38.17	-42.35	-67.29	-71.10
2064	80.83	105.95	110.09	37.34	-43.50	-68.62	-72.75
2065	81.15	106.45	110.92	36.50	-44.65	-69.95	-74.42

Appendix B.3
Current Peak Day Demand, Supply, and Net

Year	Peak Day Demand (mgd)			Peak Day Supply (mgd) (for details see Appendix B.1)	Peak Day Shortages/Surpluses (mgd)		
	Conservation	Expected Drought	Accelerated Growth		Conservation	Expected Drought	Accelerated Growth
2066	81.47	106.95	111.75	35.64	-45.83	-71.31	-76.11
2067	81.78	107.45	112.59	34.79	-47.00	-72.67	-77.80
2068	82.10	107.95	113.43	33.92	-48.18	-74.03	-79.51
2069	82.34	108.35	114.17	33.05	-49.29	-75.30	-81.12
2070	82.58	108.75	114.91	30.32	-52.26	-78.43	-84.59
2071	82.82	109.15	115.66	30.26	-52.56	-78.89	-85.40
2072	83.06	109.56	116.41	30.20	-52.86	-79.36	-86.21
2073	83.30	109.96	117.16	30.14	-53.16	-79.82	-87.02
2074	83.54	110.37	117.92	30.08	-53.46	-80.29	-87.84
2075	83.78	110.78	118.69	30.02	-53.76	-80.76	-88.67
2076	84.03	111.19	119.46	29.95	-54.08	-81.24	-89.51
2077	84.27	111.60	120.24	29.89	-54.38	-81.71	-90.35
2078	84.51	112.01	121.02	29.83	-54.68	-82.18	-91.19
2079	84.68	112.31	121.69	29.77	-54.91	-82.54	-91.92
2080	84.84	112.61	122.35	29.71	-55.13	-82.90	-92.64
2081	85.00	112.92	123.03	29.65	-55.35	-83.27	-93.38
2082	85.16	113.22	123.70	29.59	-55.57	-83.63	-94.11
2083	85.32	113.53	124.38	29.53	-55.79	-84.00	-94.85
2084	85.48	113.83	125.07	29.47	-56.01	-84.36	-95.60
2085	85.65	114.14	125.76	29.40	-56.25	-84.74	-96.36
2086	85.81	114.45	126.45	29.34	-56.47	-85.11	-97.11
2087	85.97	114.75	127.14	29.28	-56.69	-85.47	-97.86
2088	86.14	115.06	127.84	29.22	-56.92	-85.84	-98.62
2089	86.30	115.37	128.42	29.16	-57.14	-86.21	-99.26
2090	86.46	115.68	129.00	29.10	-57.36	-86.58	-99.90
2091	86.63	116.00	129.58	29.04	-57.59	-86.96	-100.54
2092	86.79	116.31	130.16	28.98	-57.81	-87.33	-101.18
2093	86.96	116.62	130.75	28.92	-58.04	-87.70	-101.83
2094	87.12	116.94	131.33	28.86	-58.26	-88.08	-102.47
2095	87.29	117.25	131.93	28.79	-58.50	-88.46	-103.14
2096	87.46	117.57	132.52	28.73	-58.73	-88.84	-103.79
2097	87.62	117.88	133.12	28.67	-58.95	-89.21	-104.45
2098	87.79	118.20	133.71	28.61	-59.18	-89.59	-105.10
2099	87.96	118.52	134.12	28.55	-59.41	-89.97	-105.57
2100	88.12	118.84	134.52	28.49	-59.63	-90.35	-106.03
2101	88.29	119.16	134.92	28.43	-59.86	-90.73	-106.49
2102	88.46	119.48	135.33	28.37	-60.09	-91.11	-106.96
2103	88.63	119.80	135.73	28.31	-60.32	-91.49	-107.42
2104	88.80	120.13	136.14	28.25	-60.55	-91.88	-107.89
2105	88.97	120.45	136.55	28.18	-60.79	-92.27	-108.37
2106	89.13	120.77	136.96	28.12	-61.01	-92.65	-108.84
2107	89.30	121.10	137.37	28.06	-61.24	-93.04	-109.31
2108	89.47	121.43	137.79	28.00	-61.47	-93.43	-109.79
2109	89.64	121.75	137.99	27.94	-61.70	-93.81	-110.05
2110	89.81	122.08	138.20	27.88	-61.93	-94.20	-110.32
2111	89.99	122.41	138.41	27.82	-62.17	-94.59	-110.59
2112	90.16	122.74	138.62	27.76	-62.40	-94.98	-110.86
2113	90.33	123.07	138.83	27.70	-62.63	-95.37	-111.13
2114	90.50	123.40	139.03	27.64	-62.86	-95.76	-111.39
2115	90.67	123.74	139.24	27.57	-63.10	-96.17	-111.67
2116	90.84	124.07	139.45	27.51	-63.33	-96.56	-111.94
2117	91.02	124.40	139.66	27.45	-63.57	-96.95	-112.21
2118	91.19	124.74	139.87	27.39	-63.80	-97.35	-112.48

C

Conservation Information

Appendix C.1
Lubbock Water Rate Structure, 1980-2018

Decreasing Block Rate Structure					
Effective Dates		Base Rate + first 1,000 Gallons	2,000 - 49,000 Gallons Water Rate per 1,000 Gallons	50,000 - 250,000 Gallons Water Rate per 1,000 Gallons	> 250,000 Gallons Water Rate per 1,000 Gallons
Start	End				
1980	1983	4.50	0.93	0.80	0.75
1983	1987	5.46	1.13	0.97	0.91
1987	1989	6.21	1.13	0.97	0.91
1989	1990	6.76	1.28	1.12	1.06
1990	1992	7.31	1.53	1.37	1.31

Uniform Rate Structure						
Effective Dates		Base Rate for 3/4" Meter	Base Rate for 1" Meter	Single-Family Water Rate per 1,000 Gallons	Commercial Water Rate per 1,000 Gallons	Irrigation Water Rate per 1,000 Gallons
Start	End					
1992	1993	7.31	9.31	1.34	1.23	1.68
1993	1994	7.68	9.78	1.41	1.29	1.76
1994	1999	8.06	10.26	1.48	1.36	1.85
1999	2000	8.30	10.57	1.52	1.40	1.85
2000	2001	8.63	10.99	1.58	1.46	1.85
2001	2002	8.89	11.32	1.63	1.50	1.91
2002	2003	9.16	11.66	1.68	1.55	1.96
2003	2004	9.43	12.01	1.73	1.60	2.02
2004	2005	10.01	12.74	1.83	1.69	2.14
2005	2006	11.11	14.14	2.03	1.88	2.38

Conservation Block Rate Structure						
Effective Dates		Base Rate for 3/4" Meter	Base Rate for 1" Meter	Block 1 (0 - AWC) Water Rate per 1,000 Gallons	Block 2 (AWC - 40,000) Water Rate per 1,000 Gallons	Block 3 (AWC + 40,000) & Up Water Rate per 1,000 Gallons
Start	End					
2007	2008	7.66	12.79	2.09	2.61	3.61
2008	2009	8.89	14.84	2.42	3.03	4.19
2009	2011	18.00	30.05	2.67	4.29	5.93
2011	2012	24.00	40.06	2.67	4.29	5.93
2012	2013	28.00	46.74	2.67	4.29	5.93
2013	2014	21.00	35.06	4.00	5.46	6.55
2014	2015	18.00	30.05	4.31	5.88	7.06
2015	2016	18.00	30.05	4.53	6.18	7.41
2016	2017	16.00	26.71	4.76	6.50	7.79
2017	2018	16.00	26.71	4.76	6.50	7.79

Conservation Block Rate Structure Residential								
Effective Dates		Base Rate for 3/4" Meter	Base Rate for 1" Meter	Block 1 (0 - 1000) Water Rate per	Block 2 (1001 - 5,000) Water Rate per	Block 3 (5001 - 10,000) Water Rate per	Block 4 (10,001 - 30,000)	Block 5 (30,001) & Up Water Rate per
Start	End							
2018	-	18.00	30.06	0.00	4.03	6.97	8.36	8.57

Conservation Block Rate Structure Commercial						
Effective Dates		Base Rate for 3/4" Meter	Base Rate for 1" Meter	Block 1 (0 - AWC) Water Rate per	Block 2 (AWC - AWC * 50%)	Block 3 (AWC + (AWC*50%) & Up Water
Start	End					
2018	-	18.00	30.06	4.76	6.50	7.79

Appendix C.2

Residential Water Bill Comparison for Major Texas Cities During May 2018 for 5/8" or 3/4" Meters

Monthly Residential Water Bill ($)

City	Water Used (gallons)						
	0	5,000	10,000	20,000	30,000	40,000	50,000
Amarillo	13.91	18.87	31.27	63.76	96.26	144.36	192.46
Arlington	9.00	21.41	35.36	79.41	127.31	186.70	246.10
Austin(R)	13.00	38.41	83.60	229.34	374.04	518.74	663.44
Brownsville	12.06	22.38	33.84	66.36	107.16	147.96	188.76
Corpus Christi	12.70	31.75	67.30	143.55	223.05	302.55	382.05
Dallas(R)	7.40	19.42	41.12	115.85	203.35	290.85	378.35
El Paso`	7.16	11.48	29.63	97.15	170.15	243.15	316.15
Fort Worth(R)*	12.35	23.38	38.23	73.29	117.00	162.60	208.20
Garland(R)	26.80	52.89	82.34	157.89	250.09	342.29	434.49
Grand Prairie	14.18	22.28	41.63	80.33	149.63	218.93	288.23
Houston	5.39	29.57	55.74	127.70	215.30	302.90	390.50
Irving(S)	11.38	20.06	41.76	88.56	138.56	188.56	238.56
Laredo	9.82	15.71	25.96	47.16	69.66	93.66	118.76
Lubbock	18.00	34.12	68.97	152.57	236.17	321.87	407.57
Pasadena	10.97	20.15	36.47	85.43	136.43	192.53	248.63
Plano	23.35	25.95	43.60	78.90	149.50	220.10	305.60
San Antonio(R)	16.97	21.98	32.73	63.12	110.93	159.03	207.13
Median Value	12.35	22.28	41.12	85.43	149.50	218.93	288.23
Lowest Value	5.39	11.48	25.96	47.16	69.66	93.66	118.76
Highest Value	26.80	52.89	83.60	229.34	374.04	518.74	663.44
Monthly Water Bill Range	21.41	41.41	57.64	182.18	304.38	425.08	544.68

R = City has 5/8" *and* 3/4" meters - 3/4" rate used in calculations * = AWC of 7,000 gal S = summer rates

Appendix C.3

Public-School Program Lessons

Lesson Title	Grade(s)	Description
Listen to the Rain	PK-2	Learn about rain in its many forms and sounds through creating rain sticks. The students will create rain sticks using craft roles, fabric, cotton balls, foil, & dried pasta, rice, beans, and rock salt.
The Watermelon Seed	PK-2	Learn about the parts of a plant, different kinds of seeds, what seeds need to grow, and attempt to grow a watermelon seedling in a plastic bag.
Birdfeeders: Sustaining Lubbock 6R's	PK-2	Students will learn about reusing objects to help the environment; students will make bird feeders from used plastic bottles
The Tiny Seed	1-3	Students explore the parts of a plant and life cycle through the seasons as they use watercolors to depict Eric Carle's timeless story.
Water Warriors	1-3	Explore the world's water resources, discover very little is consumable; create water necklace; become water warriors by discussing ways to conserve our water. Discuss the stages of the water cycle and importance; create bracelets to represent each component.
The Adventures of Fred the Fish	2-12	Travel with Fred the Fish as he swims in a polluted river; explore the water treatment process for the City of Lubbock; create a filtering system.
What Goes In Must Come Out	4-12	Explore the world of wastewater; discuss ways in which people add waste into our water system; explore the wastewater treatment process for the City of Lubbock.
Outbreak! Viruses in Our Water	9-12	Explore viruses, bacteria, and how Lubbock's water is cleaned.
Water Careers	K-12	A position in the treatment, distribution, or protection of drinking water is a career, not a job. In the Water and Stormwater industries, there will always be a demand for workers. Students can learn about the diversity in careers available, education needed, and job outlook.

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D

Reclaimed Water Projections

Appendix D.1

Gross Reclaimed Water Projections

Year	Reclaimed Water Population			Reclaimed Water Gallons per Capita per Day (gpcd)			Effluent Flows (mgd)		
	Expected Growth (for details see Section 7.3.1)	2013 SWSP	2009 Wastewater Master Plan	Expected	2013 SWSP	2009 Wastewater Master Plan	Expected	2013 SWSP	2009 Wastewater Master Plan
Data by Decade									
2018	253,061	250,990	243,917	78	79	95	19.70	19.88	23.17
2028	285,122	282,788	267,109	77	78	95	21.81	21.99	25.38
2038	321,244	312,368	292,118	75	76	95	24.15	23.84	27.75
2048	347,889	336,602	319,471	74	75	95	25.69	25.20	30.35
2058	373,023	359,132	349,388	73	73	95	27.07	26.36	33.19
2068	396,018	379,380	.	71	72	.	28.24	27.29	.
2078	416,271	396,801	.	70	70	.	29.16	27.97	.
2088	433,224	412,962	.	69	69	.	29.82	28.51	.
2098	450,869	429,781	.	68	68	.	30.49	29.04	.
2108	469,231	447,285	.	66	66	.	31.18	29.58	.
2118	488,342	.	.	65	.	.	31.88	.	.
Historic Data									
1995	191,020	191,020	191,020	109			20.80		
1996	193,064	193,064	193,064	102			19.67		
1997	195,367	195,367	195,367	96			18.83		
1998	196,679	196,679	196,679	103			20.22		
1999	197,117	197,117	197,117	94			18.59		
2000	199,564	199,564	199,864	106			21.06		
2001	201,217	201,217	201,217	99			19.91		
2002	202,000	202,000	202,000	98			19.82		
2003	204,737	204,737	204,737	89			18.27		
2004	206,290	206,290	206,290	97			20.06		
2005	209,120	209,120	209,120	95			19.93		
2006	211,187	211,187	211,487	97			20.40		
2007	212,365	212,365	215,015	92			19.56		
2008	214,847	214,847	218,542	91			19.65		
2009	218,327	218,327	222,070	87			19.06		
2010	229,573	229,573	225,597	85			19.53		
2011	231,937	231,938	227,887	80			18.47		
2012	233,651	234,327	230,177	80			18.72		
2013	236,362	236,740	232,467	76			17.90		
2014	238,706	239,179	234,757	77			18.28		
2015	241,322	241,642	237,047	79			19.00		
2016	247,095	244,131	239,337	78			19.19		
Data by Year									
2015	241,322	242,167	237,047	79	80	95	19.00	19.29	22.52
2016	247,095	245,073	239,337	78	80	95	19.19	19.49	22.74
2017	250,060	248,014	241,627	78	79	95	19.50	19.68	22.95
2018	253,061	250,990	243,917	78	79	95	19.70	19.88	23.17
2019	256,098	254,002	246,207	78	79	95	19.91	20.08	23.39
2020	259,171	257,050	248,497	78	79	95	20.11	20.29	23.61
2021	262,281	260,134	250,824	77	79	95	20.31	20.49	23.83
2022	265,428	263,256	253,150	77	79	95	20.52	20.70	24.05
2023	268,613	266,415	255,477	77	78	95	20.73	20.91	24.27
2024	271,837	269,612	257,803	77	78	95	20.94	21.12	24.49
2025	275,099	272,847	260,130	77	78	95	21.16	21.34	24.71
2026	278,400	276,122	262,456	77	78	95	21.37	21.55	24.93
2027	281,741	279,435	264,783	77	78	95	21.59	21.77	25.15
2028	285,122	282,788	267,109	77	78	95	21.81	21.99	25.38
2029	288,543	286,182	269,436	76	78	95	22.04	22.21	25.60

Appendix D.1

Gross Reclaimed Water Projections

Year	Reclaimed Water Population			Reclaimed Water Gallons per Capita per Day (gpcd)			Effluent Flows (mgd)		
	Expected Growth (for details see Section 7.3.1)	2013 SWSP	2009 Wastewater Master Plan	Expected	2013 SWSP	2009 Wastewater Master Plan	Expected	2013 SWSP	2009 Wastewater Master Plan
2030	292,006	289,616	271,762	76	77	95	22.26	22.44	25.82
2031	295,510	293,091	274,307	76	77	95	22.49	22.66	26.06
2032	299,056	296,608	276,851	76	77	95	22.72	22.89	26.30
2033	302,644	300,168	279,396	76	77	95	22.95	23.12	26.54
2034	306,276	302,569	281,940	76	77	95	23.18	23.26	26.78
2035	309,951	304,990	284,485	76	77	95	23.42	23.41	27.03
2036	313,671	307,429	287,029	75	77	95	23.66	23.55	27.27
2037	317,435	309,889	289,574	75	76	95	23.90	23.69	27.51
2038	321,244	312,368	292,118	75	76	95	24.15	23.84	27.75
2039	323,814	314,867	294,663	75	76	95	24.30	23.98	27.99
2040	326,405	317,386	297,207	75	76	95	24.45	24.13	28.23
2041	329,016	319,925	299,990	75	76	95	24.60	24.27	28.50
2042	331,648	322,484	302,773	75	76	95	24.75	24.42	28.76
2043	334,301	325,064	305,556	75	76	95	24.91	24.57	29.03
2044	336,976	327,340	308,339	74	75	95	25.06	24.69	29.29
2045	339,671	329,631	311,122	74	75	95	25.22	24.82	29.56
2046	342,389	331,938	313,905	74	75	95	25.38	24.94	29.82
2047	345,128	334,262	316,688	74	75	95	25.53	25.07	30.09
2048	347,889	336,602	319,471	74	75	95	25.69	25.20	30.35
2049	350,324	338,958	322,254	74	75	95	25.83	25.32	30.61
2050	352,776	341,331	325,037	74	75	95	25.96	25.45	30.88
2051	355,246	343,720	328,081	73	74	95	26.10	25.58	31.17
2052	357,733	346,126	331,125	73	74	95	26.23	25.71	31.46
2053	360,237	348,549	334,169	73	74	95	26.37	25.84	31.75
2054	362,758	350,640	337,213	73	74	95	26.51	25.94	32.04
2055	365,298	352,744	340,257	73	74	95	26.65	26.04	32.32
2056	367,855	354,861	343,300	73	74	95	26.79	26.15	32.61
2057	370,430	356,990	346,344	73	74	95	26.93	26.25	32.90
2058	373,023	359,132	349,388	73	73	95	27.07	26.36	33.19
2059	375,261	361,287	352,432	72	73	95	27.18	26.47	33.48
2060	377,512	363,454	355,476	72	73	95	27.30	26.57	33.77
2061	379,777	365,635	.	72	73	.	27.41	26.68	.
2062	382,056	367,829	.	72	73	.	27.53	26.78	.
2063	384,348	370,036	.	72	73	.	27.65	26.89	.
2064	386,655	371,886	.	72	73	.	27.76	26.97	.
2065	388,974	373,745	.	72	72	.	27.88	27.05	.
2066	391,308	375,614	.	72	72	.	28.00	27.13	.
2067	393,656	377,492	.	71	72	.	28.12	27.21	.
2068	396,018	379,380	.	71	72	.	28.24	27.29	.
2069	397,998	381,277	.	71	72	.	28.33	27.37	.
2070	399,988	383,183	.	71	72	.	28.42	27.46	.
2071	401,988	385,099	.	71	72	.	28.51	27.54	.
2072	403,998	387,024	.	71	71	.	28.60	27.62	.
2073	406,018	388,959	.	71	71	.	28.69	27.70	.
2074	408,048	390,515	.	71	71	.	28.79	27.75	.
2075	410,088	392,077	.	70	71	.	28.88	27.81	.
2076	412,139	393,646	.	70	71	.	28.97	27.86	.
2077	414,200	395,220	.	70	71	.	29.07	27.92	.
2078	416,271	396,801	.	70	70	.	29.16	27.97	.
2079	417,936	398,388	.	70	70	.	29.23	28.02	.
2080	419,607	399,982	.	70	70	.	29.29	28.08	.

Appendix D.1

Gross Reclaimed Water Projections

Year	Reclaimed Water Population			Reclaimed Water Gallons per Capita per Day (gpcd)			Effluent Flows (mgd)		
	Expected Growth (for details see Section 7.3.1)	2013 SWSP	2009 Wastewater Master Plan	Expected	2013 SWSP	2009 Wastewater Master Plan	Expected	2013 SWSP	2009 Wastewater Master Plan
2081	421,286	401,582	.	70	70	.	29.36	28.13	.
2082	422,971	403,188	.	70	70	.	29.42	28.19	.
2083	424,663	404,801	.	69	70	.	29.49	28.24	.
2084	426,361	406,420	.	69	70	.	29.55	28.29	.
2085	428,067	408,046	.	69	69	.	29.62	28.35	.
2086	429,779	409,678	.	69	69	.	29.69	28.40	.
2087	431,498	411,317	.	69	69	.	29.75	28.45	.
2088	433,224	412,962	.	69	69	.	29.82	28.51	.
2089	434,957	414,614	.	69	69	.	29.89	28.56	.
2090	436,697	416,272	.	69	69	.	29.95	28.62	.
2091	438,444	417,937	.	68	69	.	30.02	28.67	.
2092	440,198	419,609	.	68	68	.	30.09	28.72	.
2093	441,958	421,288	.	68	68	.	30.15	28.78	.
2094	443,726	422,973	.	68	68	.	30.22	28.83	.
2095	445,501	424,665	.	68	68	.	30.29	28.88	.
2096	447,283	426,363	.	68	68	.	30.36	28.94	.
2097	449,072	428,069	.	68	68	.	30.42	28.99	.
2098	450,869	429,781	.	68	68	.	30.49	29.04	.
2099	452,672	431,500	.	68	67	.	30.56	29.10	.
2100	454,483	433,226	.	67	67	.	30.63	29.15	.
2101	456,301	434,959	.	67	67	.	30.70	29.20	.
2102	458,126	436,699	.	67	67	.	30.76	29.26	.
2103	459,958	438,446	.	67	67	.	30.83	29.31	.
2104	461,798	440,199	.	67	67	.	30.90	29.36	.
2105	463,645	441,960	.	67	67	.	30.97	29.42	.
2106	465,500	443,728	.	67	66	.	31.04	29.47	.
2107	467,362	445,503	.	67	66	.	31.11	29.52	.
2108	469,231	447,285	.	66	66	.	31.18	29.58	.
2109	471,108	449,074	.	66	66	.	31.25	29.63	.
2110	472,993	450,870	.	66	66	.	31.32	29.68	.
2111	474,885	452,674	.	66	66	.	31.39	29.73	.
2112	476,784	454,485	.	66	66	.	31.46	29.79	.
2113	478,691	456,302	.	66	65	.	31.53	29.84	.
2114	480,606	.	.	66	.	.	31.60	.	.
2115	482,529	.	.	66	.	.	31.67	.	.
2116	484,459	.	.	66	.	.	31.74	.	.
2117	486,397	.	.	65	.	.	31.81	.	.
2118	488,342	.	.	65	.	.	31.88	.	.

Appendix D.2

Net Reclaimed Water Projections

Year	Reclaimed Water Projections (mgd)					
	Expected Gross Effluent Flows	Contractual		Operational		Expected Net Effluent Flows
		Xcel	Private Cotton Farmers	LLAS	HLAS	
Data by Decade						
2018	19.70	9.00	0	4.00	4.00	2.70
2028	21.81	9.00	0	2.00	0.00	10.81
2038	24.15	9.00	0	2.00	0.00	13.15
2048	25.69	7.00	0	2.00	0.00	16.69
2058	27.07	7.00	0	2.00	0.00	18.07
2068	28.24	7.00	0	2.00	0.00	19.24
2078	29.16	7.00	0	2.00	0.00	20.16
2088	29.82	7.00	0	2.00	0.00	20.82
2098	30.49	7.00	0	2.00	0.00	21.49
2108	31.18	7.00	0	2.00	0.00	22.18
2118	31.88	7.00	0	2.00	0.00	22.88

Data by Year						
2015	19.00	9.00	0	4.00	4.00	2.00
2016	19.19	9.00	0	4.00	4.00	2.19
2017	19.50	9.00	0	4.00	4.00	2.50
2018	19.70	9.00	0	4.00	4.00	2.70
2019	19.91	9.00	0	4.00	4.00	2.91
2020	20.11	9.00	0	4.00	4.00	3.11
2021	20.31	9.00	0	4.00	4.00	3.31
2022	20.52	9.00	0	4.00	4.00	3.52
2023	20.73	9.00	0	4.00	4.00	3.73
2024	20.94	9.00	0	4.00	4.00	3.94
2025	21.16	9.00	0	2.00	0.00	10.16
2026	21.37	9.00	0	2.00	0.00	10.37
2027	21.59	9.00	0	2.00	0.00	10.59
2028	21.81	9.00	0	2.00	0.00	10.81
2029	22.04	9.00	0	2.00	0.00	11.04
2030	22.26	9.00	0	2.00	0.00	11.26
2031	22.49	9.00	0	2.00	0.00	11.49
2032	22.72	9.00	0	2.00	0.00	11.72
2033	22.95	9.00	0	2.00	0.00	11.95
2034	23.18	9.00	0	2.00	0.00	12.18
2035	23.42	9.00	0	2.00	0.00	12.42
2036	23.66	9.00	0	2.00	0.00	12.66
2037	23.90	9.00	0	2.00	0.00	12.90
2038	24.15	9.00	0	2.00	0.00	13.15
2039	24.30	9.00	0	2.00	0.00	13.30
2040	24.45	9.00	0	2.00	0.00	13.45
2041	24.60	9.00	0	2.00	0.00	13.60
2042	24.75	9.00	0	2.00	0.00	13.75
2043	24.91	9.00	0	2.00	0.00	13.91
2044	25.06	9.00	0	2.00	0.00	14.06
2045	25.22	9.00	0	2.00	0.00	14.22
2046	25.38	7.00	0	2.00	0.00	16.38
2047	25.53	7.00	0	2.00	0.00	16.53
2048	25.69	7.00	0	2.00	0.00	16.69
2049	25.83	7.00	0	2.00	0.00	16.83
2050	25.96	7.00	0	2.00	0.00	16.96
2051	26.10	7.00	0	2.00	0.00	17.10
2052	26.23	7.00	0	2.00	0.00	17.23
2053	26.37	7.00	0	2.00	0.00	17.37
2054	26.51	7.00	0	2.00	0.00	17.51

Appendix D.2

Net Reclaimed Water Projections

Year	Reclaimed Water Projections (mgd)					
	Expected Gross Effluent Flows	Contractual		Operational		Expected Net Effluent Flows
		Xcel	Private Cotton Farmers	LLAS	HLAS	
2055	26.65	7.00	0	2.00	0.00	17.65
2056	26.79	7.00	0	2.00	0.00	17.79
2057	26.93	7.00	0	2.00	0.00	17.93
2058	27.07	7.00	0	2.00	0.00	18.07
2059	27.18	7.00	0	2.00	0.00	18.18
2060	27.30	7.00	0	2.00	0.00	18.30
2061	27.41	7.00	0	2.00	0.00	18.41
2062	27.53	7.00	0	2.00	0.00	18.53
2063	27.65	7.00	0	2.00	0.00	18.65
2064	27.76	7.00	0	2.00	0.00	18.76
2065	27.88	7.00	0	2.00	0.00	18.88
2066	28.00	7.00	0	2.00	0.00	19.00
2067	28.12	7.00	0	2.00	0.00	19.12
2068	28.24	7.00	0	2.00	0.00	19.24
2069	28.33	7.00	0	2.00	0.00	19.33
2070	28.42	7.00	0	2.00	0.00	19.42
2071	28.51	7.00	0	2.00	0.00	19.51
2072	28.60	7.00	0	2.00	0.00	19.60
2073	28.69	7.00	0	2.00	0.00	19.69
2074	28.79	7.00	0	2.00	0.00	19.79
2075	28.88	7.00	0	2.00	0.00	19.88
2076	28.97	7.00	0	2.00	0.00	19.97
2077	29.07	7.00	0	2.00	0.00	20.07
2078	29.16	7.00	0	2.00	0.00	20.16
2079	29.23	7.00	0	2.00	0.00	20.23
2080	29.29	7.00	0	2.00	0.00	20.29
2081	29.36	7.00	0	2.00	0.00	20.36
2082	29.42	7.00	0	2.00	0.00	20.42
2083	29.49	7.00	0	2.00	0.00	20.49
2084	29.55	7.00	0	2.00	0.00	20.55
2085	29.62	7.00	0	2.00	0.00	20.62
2086	29.69	7.00	0	2.00	0.00	20.69
2087	29.75	7.00	0	2.00	0.00	20.75
2088	29.82	7.00	0	2.00	0.00	20.82
2089	29.89	7.00	0	2.00	0.00	20.89
2090	29.95	7.00	0	2.00	0.00	20.95
2091	30.02	7.00	0	2.00	0.00	21.02
2092	30.09	7.00	0	2.00	0.00	21.09
2093	30.15	7.00	0	2.00	0.00	21.15
2094	30.22	7.00	0	2.00	0.00	21.22
2095	30.29	7.00	0	2.00	0.00	21.29
2096	30.36	7.00	0	2.00	0.00	21.36
2097	30.42	7.00	0	2.00	0.00	21.42
2098	30.49	7.00	0	2.00	0.00	21.49
2099	30.56	7.00	0	2.00	0.00	21.56
2100	30.63	7.00	0	2.00	0.00	21.63
2101	30.70	7.00	0	2.00	0.00	21.70
2102	30.76	7.00	0	2.00	0.00	21.76
2103	30.83	7.00	0	2.00	0.00	21.83
2104	30.90	7.00	0	2.00	0.00	21.90
2105	30.97	7.00	0	2.00	0.00	21.97
2106	31.04	7.00	0	2.00	0.00	22.04
2107	31.11	7.00	0	2.00	0.00	22.11
2108	31.18	7.00	0	2.00	0.00	22.18

Appendix D.2

Net Reclaimed Water Projections

Year	Reclaimed Water Projections (mgd)					
	Expected Gross Effluent Flows	Contractual		Operational		Expected Net Effluent Flows
		Xcel	Private Cotton Farmers	LLAS	HLAS	
2109	31.25	7.00	0	2.00	0.00	22.25
2110	31.32	7.00	0	2.00	0.00	22.32
2111	31.39	7.00	0	2.00	0.00	22.39
2112	31.46	7.00	0	2.00	0.00	22.46
2113	31.53	7.00	0	2.00	0.00	22.53
2114	31.60	7.00	0	2.00	0.00	22.60
2115	31.67	7.00	0	2.00	0.00	22.67
2116	31.74	7.00	0	2.00	0.00	22.74
2117	31.81	7.00	0	2.00	0.00	22.81
2118	31.88	7.00	0	2.00	0.00	22.88

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