DRAFT FEASIBILITY REPORT
FEASIBILITY ANALYSIS OF WATER SUPPLY FOR SMALL PUBLIC WATER SYSTEMS

SOUTHWEST GARDENS WATER SYSTEM
PWS ID# 1520217, CCN# 12735

Prepared for:

THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Prepared by:

THE UNIVERSITY OF TEXAS BUREAU OF ECONOMIC GEOLOGY

AND

PARSONS

Preparation of this report was financed by the Texas Commission on Environmental Quality through the Drinking Water State Revolving Fund Small Systems Assistance Program

AUGUST 2007

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AUGUST 2007

EXECUTIVE SUMMARY

INTRODUCTION

The University of Texas Bureau of Economic Geology (BEG) and its subcontractor, Parsons Infrastructure and Technology Group Inc. (Parsons), was contracted by the Texas Commission on Environmental Quality (TCEQ) to conduct a project to assist with identifying and analyzing alternatives for use by Public Water Systems (PWS) to meet and maintain Texas drinking water standards.

The overall goal of this project was to promote compliance using sound engineering and financial methods and data for PWSs that had recently recorded sample results exceeding maximum contaminant levels (MCL) of the Safe Drinking Water Act (SDWA). The primary objectives of this project were to provide feasibility studies for PWSs and the TCEQ Water Supply Division that evaluate water supply compliance options, and to suggest a list of compliance alternatives that may be further investigated by the subject PWS for future implementation.

This feasibility report provides an evaluation of water supply alternatives for the Southwest Gardens PWS. The Southwest Gardens PWS is located approximately 3 miles south of the City of Lubbock. The water system supplies water to the 110 service connections of the Southwest Gardens Mobile Home Park (MHP). The water system is a separate operation from the MHP. The initial water system was built in 1987 and then upgraded to its current size during 1995-1997.

The Southwest Gardens PWS recorded fluoride concentrations that ranging between 5.2 mg/L and 5.9 mg/L between April 1998 and April 2005 exceeding the fluoride maximum contaminant level (MCL) of 4.0 mg/L. Arsenic concentrations of 0.0104 mg/L and 0.0114 mg/L were recorded between April 1998 and April 2005, which exceed the 0.010 mg/L MCL for arsenic that went into effect on January 23, 2006 (USEPA 2005; TCEQ 2004). Therefore, Southwest Gardens PWS faces compliance issues under these SDWA standards.

Basic system information for the Southwest Gardens PWS is shown in Table ES.1.

Table ES.1 Southwest Gardens PWS
Basic System Information

Population served	375
Connections	125
Average daily flow rate	0.028 million gallons per day (mgd)
Peak demand flow rate	32.9 gallons per minute (0.0474 mgd)
Water system peak capacity	0.200 mgd
Typical arsenic range	0.0104 – 0.0114 mg/L
Typical fluoride range	5.2 mg/L to 5.9 mg/L

STUDY METHODS

The methods used for this project were based on a pilot project performed in 2004 and 2005 by TCEQ, BEG, and Parsons. Methods for identifying and analyzing compliance options were developed in the pilot project (a decision tree approach).

The process for developing the feasibility study used the following general steps:

- Gather data from the TCEQ and Texas Water Development Board databases, from TCEQ files, and from information maintained by the PWS;
- Conduct financial, managerial, and technical (FMT) evaluations of the PWS;
- Perform a geologic and hydrogeologic assessment of the study area;
- Develop treatment and non-treatment compliance alternatives which, in general, consist of the following possible options:
- Connecting to neighboring PWSs via new pipeline or by pumping water from a newly installed well or an available surface water supply within the jurisdiction of the neighboring PWS;
- Installing new wells within the vicinity of the PWS into other aquifers with confirmed water quality standards meeting the MCLs;
- Installing a new intake system within the vicinity of the PWS to obtain water from a surface water supply with confirmed water quality standards meeting the MCLs;
- Treating the existing non-compliant water supply by various methods depending on the type of contaminant; and
- Delivering potable water by way of a bottled water program or a treated water dispenser as an interim measure only.
- Assess each of the potential alternatives with respect to economic and non-economic criteria;

- Prepare a feasibility report and present the results to the PWS.

This basic approach is summarized in Figure ES-1.

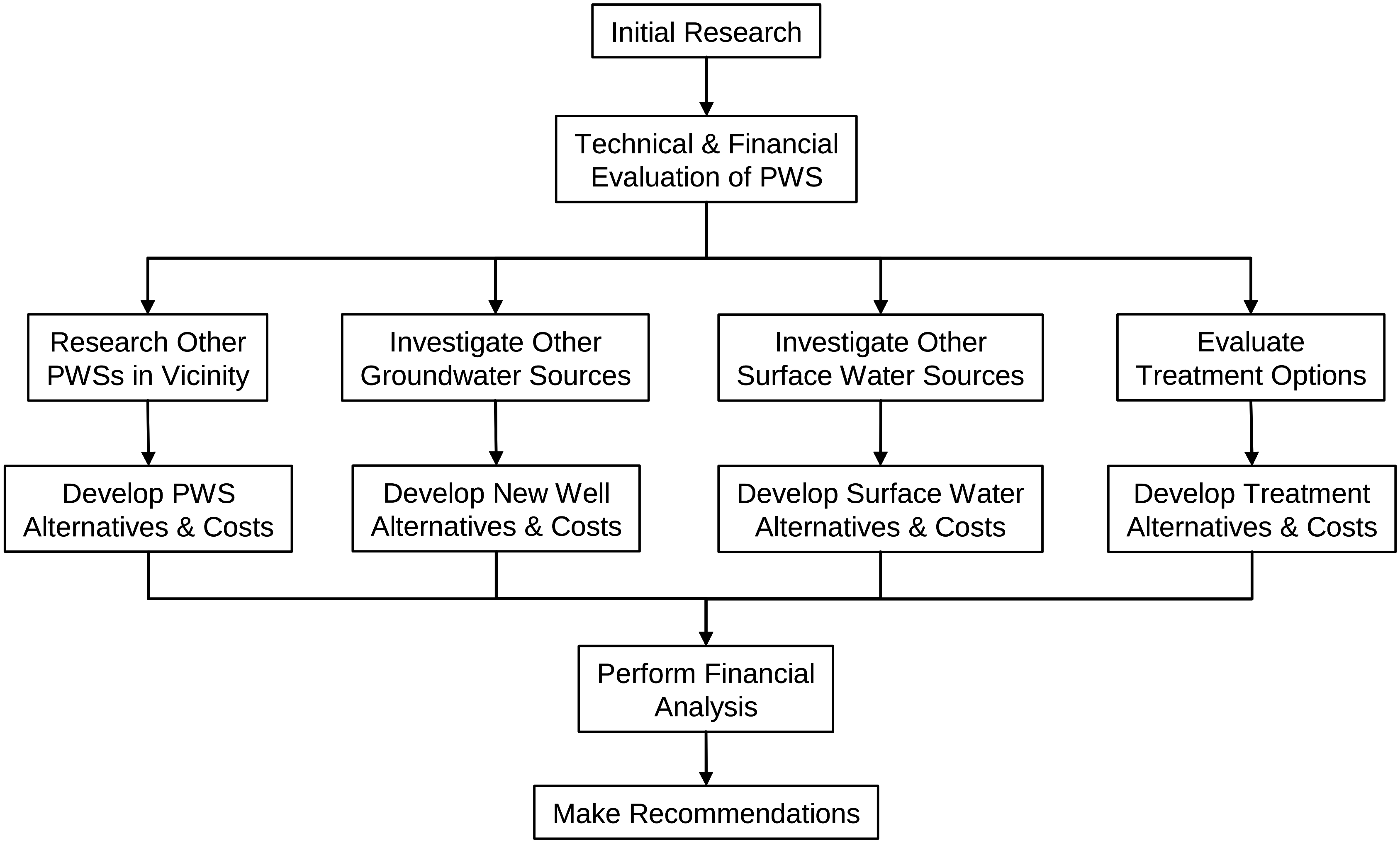
HYDROGEOLOGICAL ANALYSIS

The major aquifer in the study area is the Ogallala aquifer, which consists of coarse fluvial sandstones and conglomerates. The Southwest Gardens PWS obtains groundwater from wells ranging in depth from 110 to 160 feet. All these wells are designated as being within the Ogallala aquifer.

There are no obvious groundwater sources in the vicinity (10 km) of the PWS that can serve as alternative sources. Because no wells in the vicinity of the PWS wells show fluoride levels under the MCL (4 mg/L), it may be necessary to look for new supplies in or near wells farther from the PWS. Acceptable fluoride levels are also present to the northeast, coinciding with a regional change in water quality in the Ogallala aquifer. Although this area is a significant distance away, the consistent low levels indicate that chances of finding fluoride concentrations below the MCL are good.

In addition, regional analyses show that fluoride and arsenic levels tend to decrease with depth. This suggests that tapping deeper water by increasing the depth of one or more wells and screening only the deeper portion may decrease concentrations of these constituents in drinking water. However, there are not enough local data available to evaluate this option.

1 **Figure ES-1 Summary of Project Methods**



COMPLIANCE ALTERNATIVES

Overall, the system has a good level of FMT capacity. The system had some areas that needed improvement to be able to address future compliance issues; however, the system does have a knowledgeable and dedicated staff, a written plant operations manual, written water conservation plan, a good and well-maintained appearance, and a low level of water loss. Deficiencies and areas of concern for the system included lack of long term capital improvement planning for compliance and sustainability, lack of compliance with water quality standards, inadequate emergency preparedness, lack of a source and wellhead protection, and lack of a reserve fund. The deficiencies noted could prevent the water system from being able to meet compliance now or in the future and may also impact the water system's long-term sustainability.

There are several PWSs within 15 miles of Southwest Gardens. Many of these nearby systems also have water quality problems, but the City of Lubbock and the Canadian River Municipal Water Authority (CRMWA) have good quality water. Separate feasibility alternatives were developed based on obtaining water from the City of Lubbock and the CRMWA, which both utilize a mix of surface and ground water as a source of water.

Installing a pipeline connection to the City of Lubbock is likely to be one of the lower cost purchased water alternatives in terms of capital costs and annual O&M costs. The cost of installing a new well nearby would also be reasonable, but the costs of the other alternatives quickly increase with pipeline length, making proximity of the alternate source a key concern. A new compliant well or obtaining water from a neighboring compliant PWS has the advantage of providing compliant water to all taps in the system.

Reverse osmosis and EDR centralized treatment alternatives for fluoride and arsenic removal have been developed and were considered for this report. Point-of-use (POU) and point-of-entry (POE) treatment alternatives were also considered. Temporary solutions such as providing bottled water or providing a centralized dispenser for treated or trucked-in water, were also considered as alternatives.

Central treatment can be cost-competitive with the alternative of new nearby wells, but would require significant institutional changes to manage and operate. Like obtaining an alternate compliant water source, central treatment would provide compliant water to all water taps.

POU treatment can be cost competitive, but does not supply compliant water to all taps. Additionally, significant efforts would be required for maintenance and monitoring of the POU treatment units.

Providing compliant water through a central dispenser is significantly less expensive than providing bottled water to 100 percent of the population, but a significant effort is required for clients to fill their containers at the central dispenser.

FINANCIAL ANALYSIS

Financial analysis of the Southwest Gardens PWS indicated that current water rates are funding operations, and a rate increase is not necessary to meet operating expenses. The current average water bill of $390 per month represents approximately 1.1 percent of the median household income (MHI). Table ES.2 provides a summary of the financial impact of implementing selected compliance alternatives, including the rate increase necessary to meet current operating expenses. The alternatives were selected to highlight results for the best alternatives from each different type or category.

Some of the compliance alternatives offer potential for shared or regional solutions. A group of PWSs could work together to implement alternatives for developing a new groundwater source or expanding an existing source, obtaining compliant water from a large regional provider, or for central treatment. Sharing the cost for implementation of these alternatives could reduce the cost on a per user basis. Additionally, merging PWSs or management of several PWSs by a single entity offers the potential for reduction in administrative costs.

Table ES.2 Selected Financial Analysis Results

Alternative	Funding Option	Average Annual Water Bill	Percent of MHI
Current	NA	$390	1.1
To meet current expenses	NA	$192	0.5
Purchase Water from Lubbock PWS	100% Grant	$487	1.4
	Loan/Bond	$933	2.7
Purchase Water from CRA Lubbock-Tahoka	100% Grant	$399	1.1
	Loan/Bond	$1,895	5.3
Central treatment – Electro-dialysis Reversal	100% Grant	$745	2.1
	Loan/Bond	$1,231	3.5
Point-of-use	100% Grant	$1,134	3.2
	Loan/Bond	$1,232	3.5
Public dispenser	100% Grant	$497	1.4
	Loan/Bond	$508	1.4

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ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
°F	degrees Fahrenheit
BAT	best available technology
BEG	Bureau of Economic Geology
CA	chemical analysis
CCN	Certificate of Convenience and Necessity
CFR	Code of Federal Regulations
CO	correspondence
CRWMA	Canadian River Municipal Water Authority
ED	electrodialysis
EDR	electrodialysis reversal
FMT	financial, managerial, and technical
GAM	groundwater availability model
gpd	gallons per day
gpm	gallons per minute
IX	ion exchange
MCL	maximum contaminant level
mg/L	milligram per liter
mgd	million gallons per day
MHI	median household income
MHP	mobile home park
MOR	monthly operating report
NMEFC	New Mexico Environmental Financial Center
NURE	National Uranium Resource Evaluation
O&M	operation and maintenance
Parsons	Parsons Infrastructure and Technology, Inc.
POE	point-of-entry
POU	point-of-use
psi	pounds per square inch
PVC	polyvinyl chloride
PWS	public water system
RO	reverse osmosis
SDWA	Safe Drinking Water Act
SRF	state revolving fund
TCEQ	Texas Commission on Environmental Quality
TDS	total dissolved solids
TFC	thin film composite
TWDB	Texas Water Development Board
USEPA	United States Environmental Protection Agency
WAM	water availability model

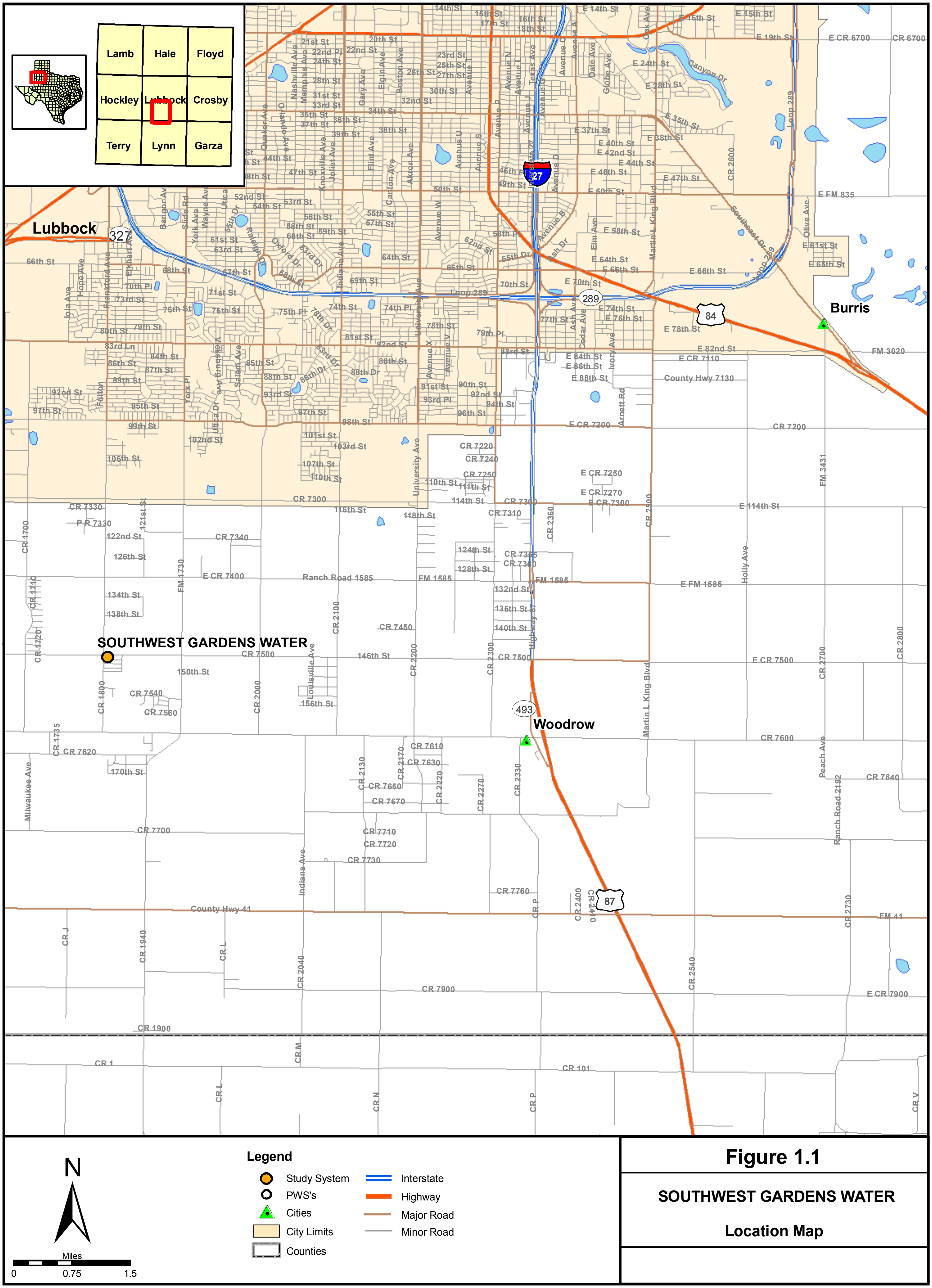
SECTION 1
INTRODUCTION

The University of Texas Bureau of Economic Geology (BEG) and its subcontractor, Parsons Infrastructure and Technology Group Inc. (Parsons), have been contracted by the Texas Commission on Environmental Quality (TCEQ) to assist with identifying and analyzing compliance alternatives for use by Public Water Systems (PWS) to meet and maintain Texas drinking water standards.

The overall goal of this project is to promote compliance using sound engineering and financial methods and data from PWSs that have recently had sample results that exceed maximum contaminant levels (MCL). The primary objectives of this project are to provide feasibility studies for PWSs and the TCEQ Water Supply Division that evaluate water supply compliance options, and to suggest a list of compliance alternatives that may be further investigated by the subject PWS with regard to future implementation. The feasibility studies identify a range of potential compliance alternatives and present basic data that can be used for evaluating feasibility. The compliance alternatives addressed include a description of what would be required for implementation, conceptual cost estimates for implementation, and non-cost factors that could be used to differentiate between alternatives. The cost estimates are intended for comparing compliance alternatives and to give a preliminary indication of potential impacts on water rates resulting from implementation.

It is anticipated that the PWS will review the compliance alternatives in this report to determine if there are promising alternatives, and then select the most attractive alternative(s) for more detailed evaluation and possible subsequent implementation. This report contains a decision tree approach that guided the efforts for this project and also contains steps to guide a PWS through the subsequent evaluation, selection, and implementation of a compliance alternative.

This feasibility report provides an evaluation of water supply compliance options for the Southwest Gardens Water, PWS ID# 1520217, Certificate of Convenience and Necessity (CCN) #12891, located in Lubbock County. Recent sample results from the Southwest Gardens Water PWS exceeded the MCL for arsenic of 10 micrograms per liter (µg/L) that went into effect January 23, 2006 (USEPA 2005; TCEQ 2004). Recent sample results also exceeded the MCL for fluoride of 4.0 milligrams per liter (mg/L). The location of the Southwest Gardens Water PWS is shown on Figure 1.1. Various water supply and planning jurisdictions are shown on Figure 1.2. These water supply and planning jurisdictions are used in the evaluation of alternate water supplies that may be available in the area.



Legend

- Study System
- PWS's
- Cities
- City Limits
- Counties
- Interstate
- Highway
- Major Road
- Minor Road

Figure 1.1

SOUTHWEST GARDENS WATER

Location Map

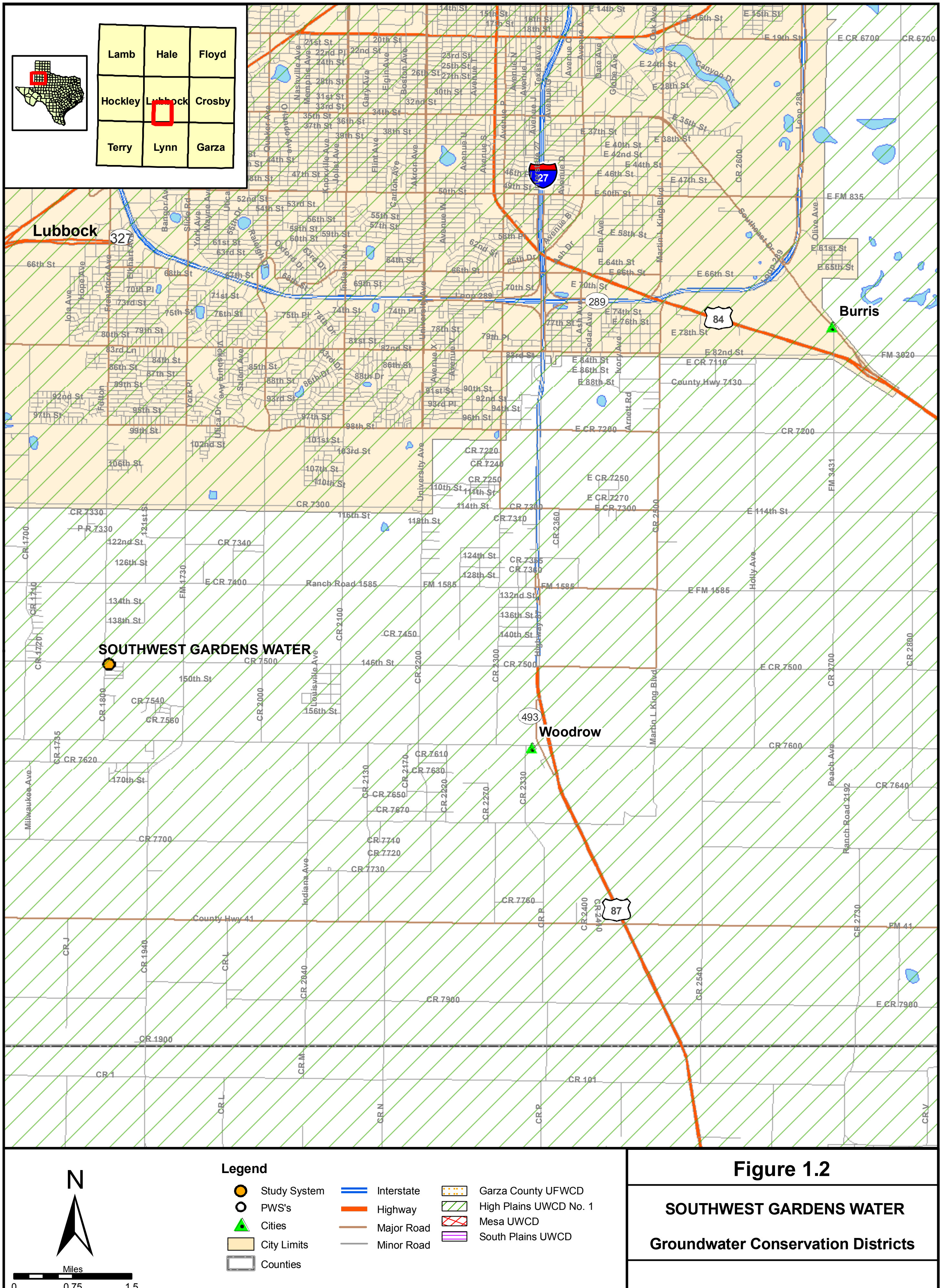


Figure 1.2

SOUTHWEST GARDENS WATER

Groundwater Conservation Districts

1.1 PUBLIC HEALTH AND COMPLIANCE WITH MCLS

The goal of this project is to promote compliance for PWSs that supply drinking water exceeding regulatory MCLs. This project only addresses those contaminants and does not address any other violations that may exist for a PWS. As mentioned above, Southwest Gardens Water system had recent sample results that exceed the MCL for arsenic and fluoride. In general, contaminant(s) in drinking water above the MCL(s) can have both short-term (acute) and long-term or lifetime (chronic) effects. Health concerns related to drinking water above MCLs for these two chemicals are briefly described below.

Potential health effects from long-term ingestion of water with levels of arsenic above the MCL (0.01 mg/L) include non-cancerous effects, such as cardiovascular, pulmonary, immunological, neurological and endocrine effects, and cancerous effects, including skin, bladder, lung, kidney, nasal passage, liver, and prostate cancer (USEPA 2007a).

Potential health effects from the ingestion of water with levels of fluoride above the MCL (4 mg/L) over many years include bone disease, including pain and tenderness of the bones. Additionally, the U.S. Environmental Protection Agency (USEPA) has set a secondary fluoride standard of 2 mg/L to protect against dental fluorosis, which in its moderate or severe forms may result in a brown staining and/or pitting of the permanent teeth in children under 9 years old (USEPA 2007b).

1.2 METHOD

The method for this project follows that of a pilot project performed by TCEQ, BEG, and Parsons. The pilot project evaluated water supply alternatives for PWSs that supply drinking water with nitrate concentrations above USEPA and Texas drinking water standards. Three PWSs were evaluated in the pilot project to develop the method (*i.e.*, decision tree approach) for analyzing options for provision of compliant drinking water. This project is performed using the decision tree approach that was developed for the pilot project, and which was also used for subsequent projects in 2005 and 2006.

Other tasks of the feasibility study are as follows:

- Identifying available data sources;
- Gathering and compiling data;
- Conducting financial, managerial, and technical (FMT) evaluations of the selected PWSs;
- Performing a geologic and hydrogeologic assessment of the area;
- Developing treatment and non-treatment compliance alternatives;
- Assessing potential alternatives with respect to economic and non-economic criteria;
- Preparing a feasibility report; and

- Suggesting refinements to the approach for future studies.

The remainder of Section 1 of this report addresses the regulatory background, and provides a summary of arsenic and fluoride abatement options. Section 2 describes the method used to develop and assess compliance alternatives. The groundwater sources of arsenic and fluoride are addressed in Section 3. Findings for the Southwest Gardens Water PWS, along with compliance alternatives development and evaluation, can be found in Section 4. Section 5 references the sources used in this report.

1.3 REGULATORY PERSPECTIVE

The Utilities & Districts and Public Drinking Water Sections of the TCEQ Water Supply Division are responsible for implementing requirements of the Federal Safe Drinking Water Act (SDWA) which include oversight of PWSs and water utilities. These responsibilities include:

- Monitoring public drinking water quality;
- Processing enforcement referrals for MCL violators;
- Tracking and analyzing compliance options for MCL violators;
- Providing FMT assessment and assistance to PWSs;
- Participating in the Drinking Water State Revolving Fund program to assist PWSs in achieving regulatory compliance; and
- Setting rates for privately-owned water utilities.

This project was conducted to assist in achieving these responsibilities.

1.4 ABATEMENT OPTIONS

When a PWS exceeds a regulatory MCL, the PWS must take action to correct the violation. The MCL exceedances at the Southwest Gardens Water PWS involve arsenic and fluoride. The following subsections explore alternatives considered as potential options for obtaining/providing compliant drinking water.

1.4.1 Existing Public Water Supply Systems

A common approach to achieving compliance is for the PWS to make arrangements with a neighboring PWS for water supply. For this arrangement to work, the PWS from which water is being purchased (supplier PWS) must have water in sufficient quantity and quality, the political will must exist, and it must be economically feasible.

1.4.1.1 Quantity

For purposes of this report, quantity refers to water volume, flowrate, and pressure. Before approaching a potential supplier PWS, the non-compliant PWS should determine its water demand on the basis of average day and maximum day. Peak instantaneous demands can be met through proper sizing of storage facilities. Further, the potential for obtaining the appropriate quantity of water to blend to achieve compliance should be considered. The concept of blending involves combining water with low levels of contaminants with non-compliant water in sufficient quantity that the resulting blended water is compliant. The exact blend ratio would depend on the quality of the water a potential supplier PWS can provide, and would likely vary over time. If high quality water is purchased, produced or otherwise obtained, blending can reduce the amount of high quality water required. Implementation of blending will require a control system to ensure the blended water is compliant.

If the supplier PWS does not have sufficient quantity, the non-compliant community could pay for the facilities necessary to increase the quantity to the extent necessary to supply the needs of the non-compliant PWS. Potential improvements might include, but are not limited to:

- Additional wells;
- Developing a new surface water supply,
- Additional or larger-diameter piping;
- Increasing water treatment plant capacity
- Additional storage tank volume;
- Reduction of system losses,
- Higher-pressure pumps; or
- Upsized, or additional, disinfection equipment.

In addition to the necessary improvements, a transmission pipeline would need to be constructed to tie the two PWSs together. The pipeline must tie-in at a point in the supplier PWS where all the upstream pipes and appurtenances are of sufficient capacity to handle the new demand. In the non-compliant PWS, the pipeline must tie in at a point where no down stream bottlenecks are present. If blending is the selected method of operation, the tie-in point must be at the proper point of the existing non-compliant PWS to ensure that all the water in the system is blended to achieve regulatory compliance.

1.4.1.2 Quality

If a potential supplier PWS obtains its water from the same aquifer (or same portion of the aquifer) as the non-compliant PWS, the quality of water may not be significantly better. However, water quality can vary significantly due to well location, even within the same aquifer. If localized areas with good water quality cannot be identified, the non-compliant PWS would need to find a potential supplier PWS that obtains its water from a different aquifer or from a surface water source. Additionally, a potential supplier PWS may treat non-compliant raw water to an acceptable level.

Surface water sources may offer a potential higher-quality source. Since there are significant treatment requirements, utilization of surface water for drinking water is typically most feasible for larger local or regional authorities or other entities that may provide water to several PWSs. Where PWSs that obtain surface water are neighbors, the non-compliant PWS may need to deal with those systems as well as with the water authorities that supply the surface water.

1.4.2 Potential for New Groundwater Sources

1.4.2.1 Existing Non-Public Supply Wells

Often there are wells not associated with PWSs that are located in the vicinity of the non-compliant PWS. The current use of these wells may be for irrigation, industrial purposes, domestic supply, stock watering, and other purposes. The process for investigating existing wells is as follows:

- Existing data sources (see below) will be used to identify wells in the areas that have satisfactory quality. For the Southwest Gardens Water, the following standards could be used in a rough screening to identify compliant groundwater in surrounding systems:
  - Nitrate (measured as nitrogen) concentrations less than 8 mg/L (below the MCL of 10 mg/L);
  - Fluoride concentration less than 2.0 mg/L (below the Secondary MCL of 2 mg/L);
  - Arsenic concentration less than 0.008 mg/L (below the MCL of 0.01 mg/L);
  - Uranium concentration less than 24 µg/L (below the MCL of 30 µg/L; and
  - Selenium concentration less than 0.04 mg/L (below the MCL of 0.05 mg/L).
- The recorded well information will be reviewed to eliminate those wells that appear to be unsuitable for the application. Often, the “Remarks” column in the Texas Water Development Board (TWDB) hard-copy database provides helpful information. Wells eliminated from consideration generally include domestic and stock wells, dug wells, test holes, observation wells, seeps and springs, destroyed wells, *etc*;
- Wells of sufficient size are identified. Some may be used for industrial or irrigation purposes. Often the TWDB database will include well yields, which may indicate the likelihood that a particular well is a satisfactory source;
- At this point in the process, the local groundwater control district (if one exists) should be contacted to obtain information about pumping restrictions. Also, preliminary cost estimates should be made to establish the feasibility of pursuing further well development options;
- If particular wells appear to be acceptable, the owner(s) should be contacted to ascertain their willingness to work with the PWS. Once the owner agrees to participate in the program, questions should be asked about the wells. Many owners

have more than one well, and would probably be the best source of information regarding the latest test dates, who tested the water, flowrates, and other well characteristics;

- After collecting as much information as possible from cooperative owners, the PWS would then narrow the selection of wells and sample and analyze them for quality. Wells with good quality would then be potential candidates for test pumping. In some cases, a particular well may need to be refurbished before test pumping. Information obtained from test pumping would then be used in combination with information about the general characteristics of the aquifer to determine whether a well at this location would be suitable as a supply source;
- It is recommended that new wells be installed instead of using existing wells to ensure the well characteristics are known and the well meets construction standards; and
- Permit(s) would then be obtained from the groundwater control district or other regulatory authority, and an agreement with the owner (purchase or lease, access easements, *etc*.) would then be negotiated.

1.4.2.2 Develop New Wells

If no existing wells are available for development, the PWS or group of PWSs has an option of developing new wells. Records of existing wells, along with other hydrogeologic information and modern geophysical techniques, should be used to identify potential locations for new wells. In some areas, the TWDB's Groundwater Availability Model (GAM) may be applied to indicate potential sources. Once a general area has been identified, land owners and regulatory agencies should be contacted to determine an exact location for a new well or well field. Pump tests and water quality tests would be required to determine if a new well will produce an adequate quantity of good quality water. Permits from the local groundwater control district or other regulatory authority could also be required for a new well.

1.4.3 Potential for Surface Water Sources

Water rights law dominates the acquisition of water from surface water sources. For a PWS, 100 percent availability of water is required, except where a back-up source is available. For PWSs with an existing water source, although it may be non-compliant because of elevated concentrations of one or more parameters, water rights may not need to be 100 percent available.

1.4.3.1 Existing Surface Water Sources

"Existing surface water sources" of water refers to municipal water authorities and cities that obtain water from surface water sources. The process of obtaining water from such a source is generally less time consuming and less costly than the process of developing a new source; therefore, it should be a primary course of investigation. An existing source would be limited by its water rights, the safe yield of a reservoir or river, or by its water treatment or water conveyance capability. The source must be able to meet the current demand and honor contracts with communities it currently supplies. In many cases, the contract amounts reflect projected future water demand based on population or industrial growth.

A non-compliant PWS would look for a source with sufficient spare capacity. Where no such capacity exists, the non-compliant PWS could offer to fund the improvements necessary to obtain the capacity. This approach would work only where the safe yield could be increased (perhaps by enlarging a reservoir) or where treatment capacity could be increased. In some instances water rights, where they are available, could possibly be purchased.

In addition to securing the water supply from an existing source, the non-compliant PWS would need to arrange for transmission of the water to the PWS. In some cases, that could require negotiations with, contracts with, and payments to an intermediate PWS (an intermediate PWS is one where the infrastructure is used to transmit water from a "supplier" PWS to a "supplied" PWS, but does not provide any additional treatment to the supplied water). The non-compliant PWS could be faced with having to fund improvements to the intermediate PWS in addition to constructing its own necessary transmission facilities.

1.4.3.2 New Surface Water Sources

Communication with the TCEQ and relevant planning groups from the beginning is essential in the process of obtaining a new surface water source. Preliminary assessment of the potential for acquiring new rights may be based on surface water availability maps located on the TWDB website. Where water rights appear to be available, the following activities need to occur:

- Discussions with TCEQ to indicate the likelihood of obtaining those rights. The TCEQ may use the Water Availability Model (WAM) to assist in the determination.
- Discussions with land owners to indicate potential treatment plant locations.
- Coordination with US Army Corps of Engineers and local river authorities.
- Preliminary engineering design to determine the feasibility, costs, and environmental issues of a new treatment plant.

Should these discussions indicate that a new surface water source is the best option, the community would proceed with more intensive planning (initially obtaining funding), permitting, land acquisition, and detailed designs.

1.4.4 Identification of Treatment Technologies for Fluoride and Arsenic

Various treatment technologies were also investigated as compliance alternatives for treatment of fluoride and arsenic to regulatory levels (*i.e.*, MCLs). Numerous options have been identified by the USEPA as best available technologies (BAT) for non-compliant constituents. Identification and descriptions of the various BATs are provided in the following sections.

1.4.4.1 Treatment Technologies for Fluoride

Fluoride is a soluble anion and is not easily removed by particle filtration. The secondary MCL for fluoride is 2 mg/L. The USEPA BATs for fluoride removal include activated alumina adsorption and reverse osmosis. Other treatment technologies that can potentially remove fluoride from water include lime softening (modified), alum coagulation, electrodialysis (ED or EDR) and anion exchange.

1.4.4.2 Treatment Technologies for Arsenic

In January 2001, the USEPA published a final rule in the Federal Register that established an MCL for arsenic of 0.01 mg/L (USEPA 2001). The regulation applies to all community water systems and non-transient, non-community water systems, regardless of size.

The new arsenic MCL of 0.01 mg/L became effective January 23, 2006, at which time the running average annual arsenic level would have to be at or below 0.01 mg/L at each entry point to the distribution system, although point-of-use (POU) treatment could be instituted in place of centralized treatment. All surface water systems had to complete initial monitoring for the new arsenic MCL or have a state-approved waiver by December 31, 2006. All groundwater systems need to complete initial monitoring or have a state-approved waiver by December 31, 2007.

Various treatment technologies were investigated as compliance alternatives for treatment of arsenic to regulatory levels (*i.e.,* MCL). According to a recent USEPA report for small water systems with less than 10,000 customers (EPA/600/R-05/001) a number of drinking water treatment technologies are available to reduce arsenic concentrations in source water to below the new MCL of 10 μg/L, including:

- Ion exchange (IX);
- Reverse osmosis (RO);
- Electrodialysis reversal (EDR);
- Adsorption; and
- Coagulation/filtration.

1.4.5 Treatment Technologies Description

Reverse Osmosis EDR and adsorption are identified by USEPA as BATs for removal of both fluoride and arsenic. In this case, adsorption is not a feasible technology because of the high alkalinity of the groundwater. RO is also a viable option for POE and POU systems. A description of these technologies follows.

1.4.5.1 Reverse Osmosis

<u>Process</u>**.** RO is a physical process in which contaminants are removed by applying pressure on the feed water to force it through a semi-permeable membrane. RO membranes

reject ions based on size and electrical charge. The raw water is typically called feed; the product water is called permeate; and the concentrated reject is called concentrate. Common RO membrane materials include asymmetric cellulose acetate (CA) or polyamide thin film composite (TFC). The TFC membrane operates at much lower pressure and can achieve higher salt rejection than the CA membranes but is less chlorine resistant. Common membrane construction includes spiral wound or hollow fine fiber. Each material and construction method has specific benefits and limitations depending on the raw water characteristics and pre-treatment. Spiral wound has been the dominant configuration in common RO systems. A typical RO installation includes a high pressure feed pump; parallel first and second stage membrane elements (in pressure vessels); and valves and piping for feed, permeate, and concentrate streams. Factors influencing membrane selection are cost, recovery, rejection, raw water characteristics, and pre-treatment. Factors influencing performance are raw water characteristics, pressure, temperature, and regular monitoring and maintenance. Depending on the membrane type and operating pressure, RO is capable of removing 85-95 percent of fluoride, and over 95 percent of nitrate and arsenic. The treatment process is relatively insensitive to pH. Water recovery is 60-80 percent, depending on raw water characteristics. The concentrate volume for disposal can be significant. The conventional RO treatment train for well water uses anti-scalant addition, cartridge filtration, RO membranes, chlorine disinfection, and clearwell storage.

Pre-treatment. RO requires careful review of raw water characteristics, and pre-treatment needs to prevent membranes from fouling, scaling, or other membrane degradation. Removal or sequestering of suspended solids is necessary to prevent colloidal and bio-fouling, and removal of sparingly soluble constituents such as calcium, magnesium, silica, sulfate, barium, *etc*., may be required to prevent scaling. Pretreatment can include media filters to remove suspended particles; IX softening to remove hardness; antiscalant feed; temperature and pH adjustment to maintain efficiency; acid to prevent scaling and membrane damage; activated carbon or bisulfite to remove chlorine (post-disinfection may be required); and cartridge filters to remove any remaining suspended particles to protect membranes from upsets.

Maintenance. Rejection percentages must be monitored to ensure contaminant removal below MCLs. Regular monitoring of membrane performance is necessary to determine fouling, scaling, or other membrane degradation. Use of monitoring equipment to track membrane performance is recommended. Acidic or caustic solutions are regularly flushed through the system at high volume/low pressure with a cleaning agent to remove fouling and scaling. The system is flushed and returned to service. RO stages are cleaned sequentially. Frequency of membrane replacement is dependent on raw water characteristics, pre-treatment, and maintenance.

Waste Disposal. Pre-treatment waste streams, concentrate flows, and spent filters and membrane elements all require approved disposal methods. Disposal of the significant volume of the concentrate stream is a problem for many utilities.

ADVANTAGES (RO)

- Produces the highest water quality.
- Can effectively treat a wide range of dissolved salts and minerals, turbidity, health and aesthetic contaminants, and certain organics. Some highly-maintained units are capable of treating biological contaminants.
- Low pressure - less than 100 pounds per square inch (psi), compact, self-contained, single membrane units are available for small installations.

DISADVANTAGES (RO)

- Relatively expensive to install and operate.
- Frequent membrane monitoring and maintenance; pressure, temperature, and pH requirements to meet membrane tolerances. Membranes can be chemically sensitive.
- Additional water usage depending on rejection rate.

A concern with RO for treatment of inorganics is that if the full stream is treated, then most of the alkalinity and hardness would also be removed. In that event, post-treatment may be necessary to avoid corrosion problems. If feasible, a way to avoid this issue is to treat a slip stream of raw water and blend the slip stream back with the raw water rather than treat the full stream. The amount of water rejected is also an issue with RO. Discharge concentrate can be between 20 and 40 percent of the influent flow.

1.4.5.2 Electrodialysis Reversal

Process. EDR is an electrochemical process in which ions migrate through ion-selective semi-permeable membranes as a result of their attraction to two electrically charged electrodes. A typical EDR system includes a membrane stack with a number of cell pairs, each consisting of a cation transfer membrane, a demineralized flow spacer, an anion transfer membrane, and a concentrate flow spacer. Electrode compartments are at opposite ends of the stack. The influent feed water (chemically treated to prevent precipitation) and the concentrated reject flow in parallel across the membranes and through the demineralized and concentrate flow spacers, respectively. The electrodes are continually flushed to reduce fouling or scaling. Careful consideration of flush feed water is required. Typically, the membranes are cation or anion exchange resins cast in sheet form; the spacers are high density polyethylene; and the electrodes are inert metal. EDR stacks are tank-contained and often staged. Membrane selection is based on review of raw water characteristics. A single-stage EDR system usually removes 40-50 percent of fluoride, nitrate, arsenic, and total dissolved solids (TDS). Additional stages are required to achieve higher removal efficiency (85-95% for fluoride). EDR uses the technique of regularly reversing the polarity of the electrodes, thereby freeing accumulated ions on the membrane surface. This process requires additional plumbing and electrical controls, but it increases membrane life, may require less added chemicals, and eases cleaning. The conventional EDR treatment train typically includes EDR membranes, chlorine disinfection, and clearwell storage. Treatment of surface water may also require pre-treatment steps such as raw water pumps, debris screens, rapid mix with addition of an anti-scalant, slow mix flocculator, sedimentation basin or clarifier, and gravity filters. Microfiltration could be used in place of flocculation, sedimentation, and filtration. Additional treatment or management of the concentrate and the removed solids would be necessary prior to disposal.

Pre-treatment**.** There are pretreatment requirements for pH, organics, turbidity, and other raw water characteristics. EDR typically requires chemical feed to prevent scaling, acid addition for pH adjustment, and a cartridge filter for prefiltration.

Maintenance. EDR membranes are durable, can tolerate a pH range from 1 to 10, and temperatures to 115 degrees Fahrenheit (^oF) for cleaning. They can be removed from the unit and scrubbed. Solids can be washed off by turning the power off and letting water circulate through the stack. Electrode washes flush out byproducts of electrode reaction. The byproducts are hydrogen, formed in the cathode space, and oxygen and chlorine gas, formed in the anode space. If the chlorine is not removed, toxic chlorine gas may form. Depending on raw water characteristics, the membranes would require regular maintenance or replacement. EDR requires reversing the polarity. Flushing at high volume/low pressure continuously is required to clean electrodes. If used, pre-treatment filter replacement and backwashing would be required. The EDR stack must be disassembled, mechanically cleaned, and reassembled at regular intervals.

Waste Disposal. Highly concentrated reject flows, electrode cleaning flows, and spent membranes require approved disposal methods. Pre-treatment processes and spent materials also require approved disposal methods.

ADVANTAGES (EDR)

- EDR can operate with minimal fouling or scaling, or chemical addition.
- Low pressure requirements; typically quieter than RO.
- Long membrane life expectancy; EDR extends membrane life and reduces maintenance.
- More flexible than RO in tailoring treated water quality requirements.

DISADVANTAGES (EDR)

- Not suitable for high levels of iron, manganese, and hydrogen sulfide.
- High energy usage at higher TDS water.

EDR can be quite expensive to run because of the energy it uses. However, because it is generally automated and allows for part-time operation, it may be an appropriate technology for small systems. It can be used to simultaneously reduce fluoride, selenium, nitrate, arsenic and TDS.

1.4.6 Point-of-Entry and Point-of-Use Treatment Systems

Point-of-entry (POE) and Point-of-use (POU) treatment devices or systems rely on many of the same treatment technologies that have been used in central treatment plants. However, while central treatment plants treat all water distributed to consumers to the same level, POU and POE treatment devices are designed to treat only a portion of the total flow. POU devices treat only the water intended for direct consumption, typically at a single tap or limited number of taps, while POE treatment devices are typically installed to treat all water entering a single home, business, school, or facility. POU and POE treatment systems may be an option for PWSs where central treatment is not affordable. Updated USEPA guidance on use of POU and POE treatment devices is provided in "*Point-of-Use or Point-of-Entry Treatment Options for Small Drinking Water Systems,*" EPA 815-R-06-010, April 2006 (USEPA 2006).

POE and POU treatment systems can be used to provide compliant drinking water. These systems typically use small treatment units that are installed "under the sink" in the case of point-of-use, and where water enters a house or building in the case of point-of-entry. It should be noted that the POU treatment units would need to be more complex than units typically found in commercial retail outlets in order to meet regulatory requirements, making purchase and installation more expensive. Point-of-entry and point-of-use treatment units would be purchased and owned by the PWS. These solutions are decentralized in nature, and require utility personnel entry into houses or at least onto private property for installation, maintenance, and testing. Due to the large number of treatment units that would be employed and would be largely out of the control of the PWS, it is very difficult to ensure 100 percent compliance. Prior to selection of a point-of-entry or point-of-use program for implementation, consultation with TCEQ would be required to address measurement and determination of level of compliance.

According to 40 CFR Section 141.100 (July 2005 Edition), the PWS must develop and obtain TCEQ approval for a monitoring plan before POE devices are installed for compliance with an MCL. Under the plan, POE devices must provide health protection equivalent to central water treatment meaning the water must meet all National Primary Drinking Water Regulations and would be of acceptable quality similar to water distributed by a well-operated central treatment plant. In addition, monitoring must include physical measurements and observations such as total flow treated and mechanical condition of the treatment equipment. The system would have to track the POE flow for a given time period, such as monthly, and maintain records of device inspection. The monitoring plan should include frequency of monitoring for the contaminant of concern and number of units to be monitored. For instance, the system may propose to monitor every POE device during the first year for the contaminant of concern and then monitor one-third of the units annually, each on a rotating schedule, such that each unit would be monitored every 3 years. To satisfy the requirement that POE devices must provide health protection, the water system may be required to conduct a pilot study to verify the POE device can provide treatment equivalent to central treatment.

The SDWA [§1412(b)(4)(E)(ii)] regulates the design, management and operation of POU and POE treatment units used to achieve compliance with an MCL. These restrictions, relevant to MCL compliance, are:

- POU and POE treatment units must be owned, controlled, and maintained by the water system, although the utility may hire a contractor to ensure proper operation and maintenance (O&M) and MCL compliance. The water system must retain unit ownership and oversight of unit installation, maintenance and sampling; the utility ultimately is the responsible party for regulatory compliance. The water system staff need not perform all installation, maintenance, or management functions, as these tasks may be contracted to a third party, but the final responsibility for the quality and quantity of the water supplied to the community resides with the water system, and the utility must monitor all contractors closely. Responsibility for O&M of POU or POE devices installed for SDWA compliance may not be delegated to homeowners.
- POU and POE units must have mechanical warning systems to automatically notify customers of operational problems. Each POU or POE treatment device must be equipped with a warning device (*e.g.,* alarm, light) that would alert users when their unit is no longer adequately treating their water. As an alternative, units may be equipped with an automatic shut-off mechanism to meet this requirement.
- If the American National Standards Institute has issued product standards for a specific type of POU or POE treatment unit, only those units that have been independently certified according to those standards may be used as part of a compliance strategy.

The following observations with regard to using POE and POU devices for SDWA compliance were made by Raucher, *et al.* (2004):

- If POU devices are used as an SDWA compliance strategy, certain consumer behavioral changes will be necessary (e.g., encouraging people to drink water only from certain treated taps) to ensure comprehensive consumer health protection.
- Although not explicitly prohibited in the SDWA, USEPA indicates that POU treatment devices should not be used to treat for radon or for most volatile organic contaminants to achieve compliance, because POU devices do not provide 100 percent protection against inhalation or contact exposure to those contaminants at untreated taps (*e.g.,* shower heads).
- Liability – PWSs considering unconventional treatment options (POU, POE, or bottled water) must address liability issues. These could be meeting drinking water standards, property entry and ensuing liabilities, and damage arising from improper installation or improper function of the POU and POE devices.

1.4.7 Water Delivery or Central Drinking Water Dispensers

Current USEPA regulations 40 Code of Federal Regulations (CFR) 141.101 prohibit the use of bottled water to achieve compliance with an MCL, except on a temporary basis. State regulations do not directly address the use of bottled water. Use of bottled water at a non-compliant PWS would be on a temporary basis. Every 3 years, the PWSs that employ interim measures are required to present the TCEQ with estimates of costs for piping compliant water to their systems. As long as the projected costs remain prohibitively high, the bottled water interim measure is extended. Until USEPA amends the noted regulation, the TCEQ is unable to accept water delivery or central drinking water dispensers as compliance solutions.

Central provision of compliant drinking water would consist of having one or more dispensers of compliant water where customers could come to fill containers with drinking water. The centralized water source could be from small to medium-sized treatment units or could be compliant water delivered to the central point by truck.

Water delivery is an interim measure for providing compliant water. As an interim measure for a small impacted population, providing delivered drinking water may be cost effective. If the susceptible population is large, the cost of water delivery would increase significantly.

- Water delivery programs require consumer participation to a varying degree. Ideally, consumers would have to do no more than they currently do for a piped-water delivery system. Least desirable are those systems that require maximum effort on the part of the customer (*e.g.,* customer has to travel to get the water, transport the water, and physically handle the bottles).

SECTION 2
EVALUATION METHOD

2.1 DECISION TREE

The decision tree is a flow chart for conducting feasibility studies for a non-compliant PWS. The decision tree is shown in Figures 2.1 through 2.4. The tree guides the user through a series of phases in the design process. Figure 2.1 shows Tree 1, which outlines the process for defining the existing system parameters, followed by optimizing the existing treatment system operation. If optimizing the existing system does not correct the deficiency, the tree leads to six alternative preliminary branches for investigation. The groundwater branch leads through investigating existing wells to developing a new well field. The treatment alternatives address centralized and on-site treatment. The objective of this phase is to develop conceptual designs and cost estimates for the six types of alternatives. The work done for this report follows through Tree 1 and Tree 2, as well as a preliminary pass through Tree 4.

Tree 3, which begins at the conclusion of the work for this report, starts with a comparison of the conceptual designs, selecting the two or three alternatives that appear to be most promising, and eliminating those alternatives which are obviously infeasible. It is envisaged that a process similar to this would be used by the study PWS to refine the list of viable alternatives. The selected alternatives are then subjected to intensive investigation, and highlighted by an investigation into the socio-political aspects of implementation. Designs are further refined and compared, resulting in the selection of a preferred alternative. The steps for assessing the financial and economic aspects of the alternatives (one of the steps in Tree 3) are given in Tree 4 in Figure 2.4.

2.2 DATA SOURCES AND DATA COLLECTION

2.2.1 Data Search

2.2.1.1 Water Supply Systems

The TCEQ maintains a set of files on public water systems, utilities, and districts at its headquarters in Austin, Texas. The files are organized under two identifiers: a PWS identification number and a CCN number. The PWS identification number is used to retrieve four types of files:

- CO – Correspondence,
- CA – Chemical analysis,
- MOR – Monthly operating reports (quality/quantity), and
- FMT – Financial, managerial and technical issues.

Figure 2.1
TREE 1 – EXISTING FACILITY ANALYSIS

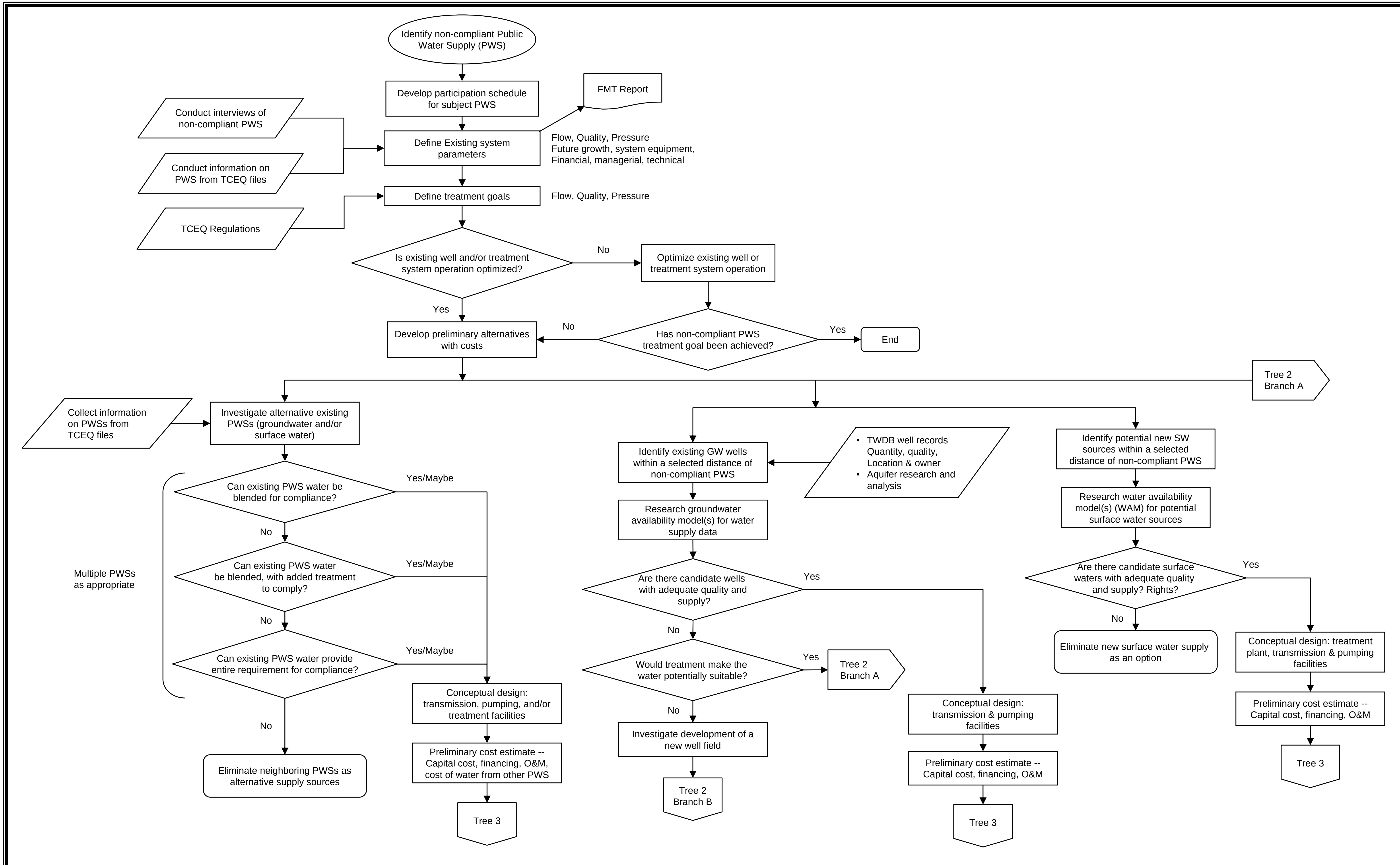
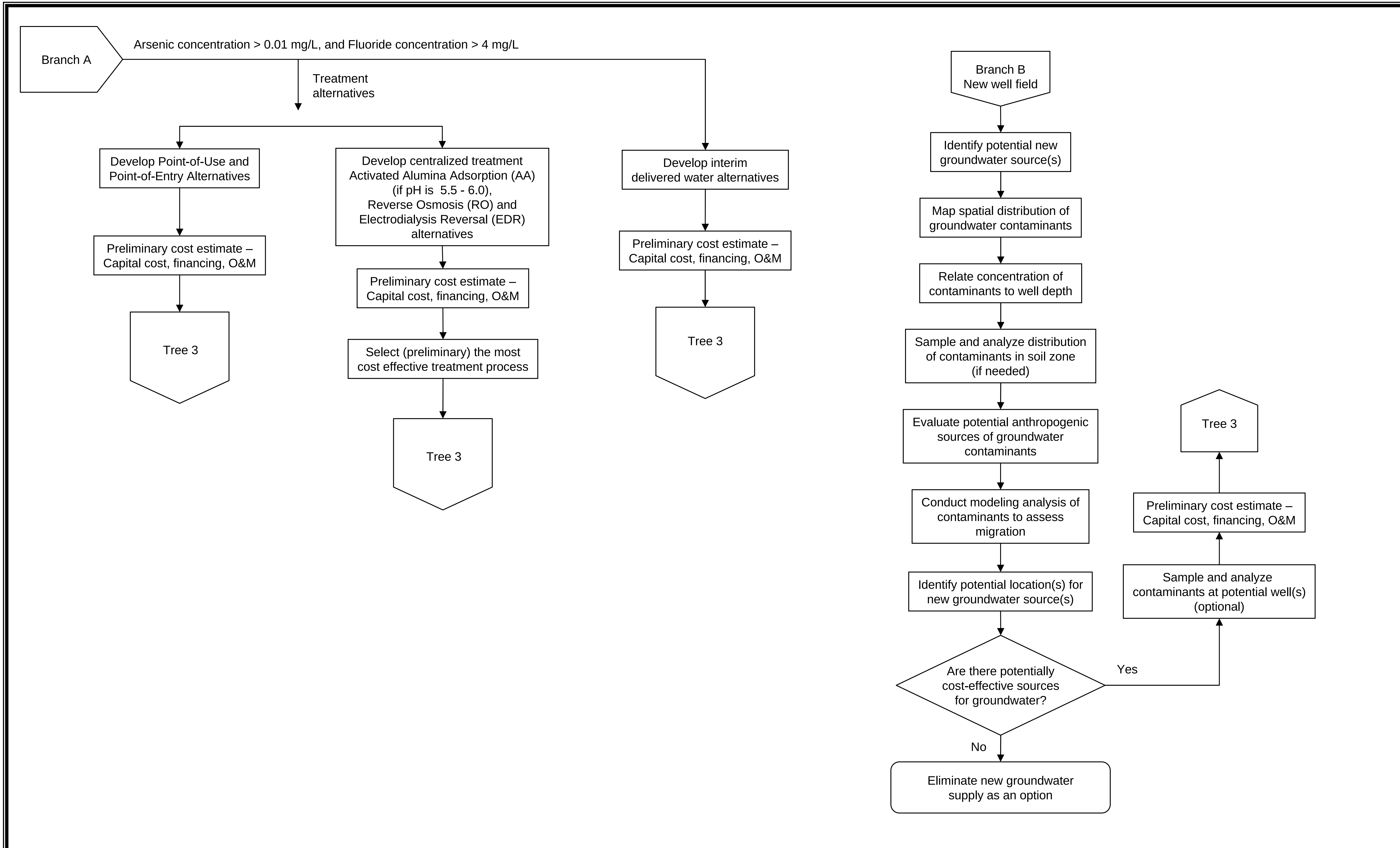


Figure 2.2
TREE 2 – DEVELOP TREATMENT ALTERNATIVES



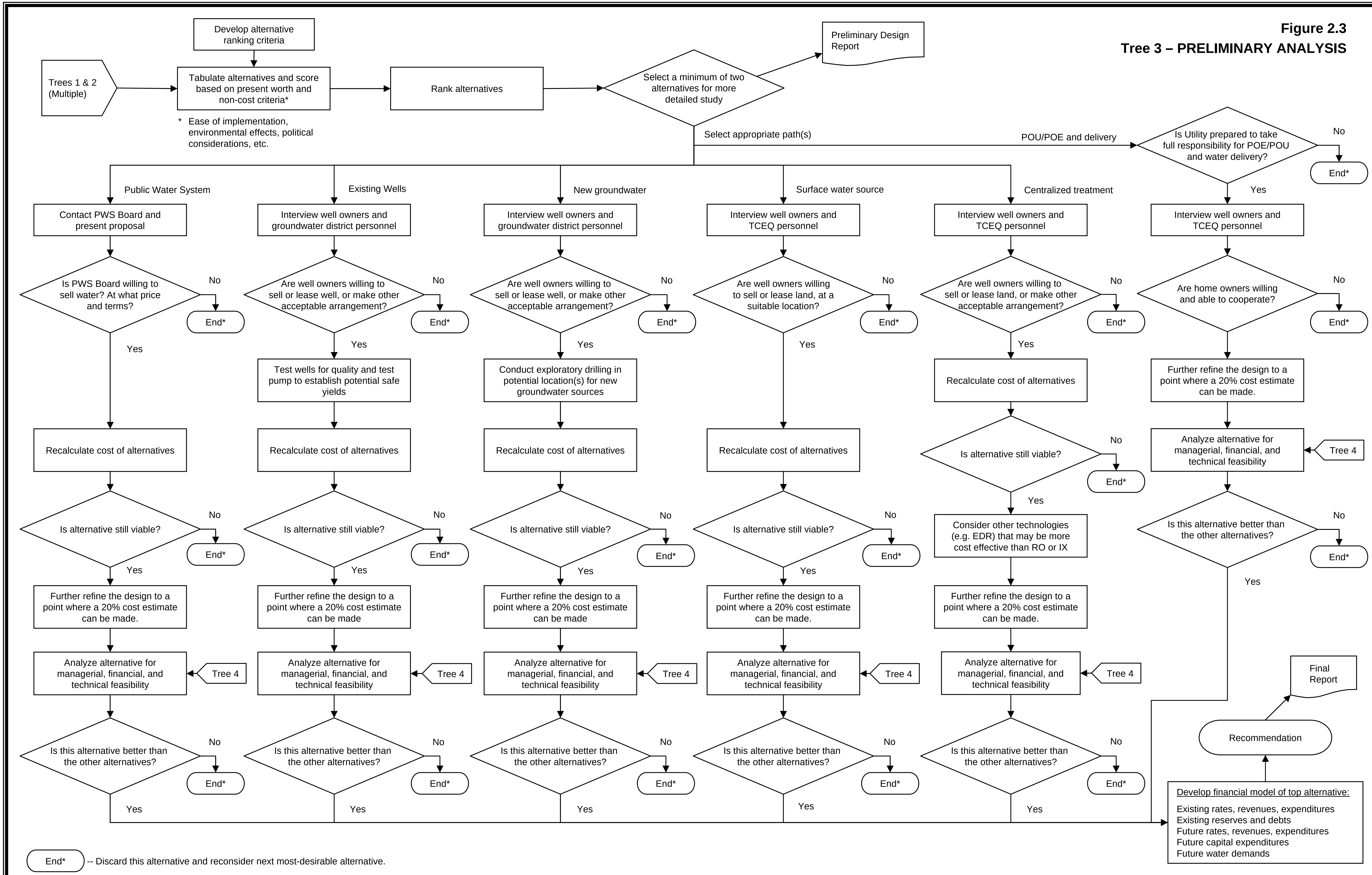
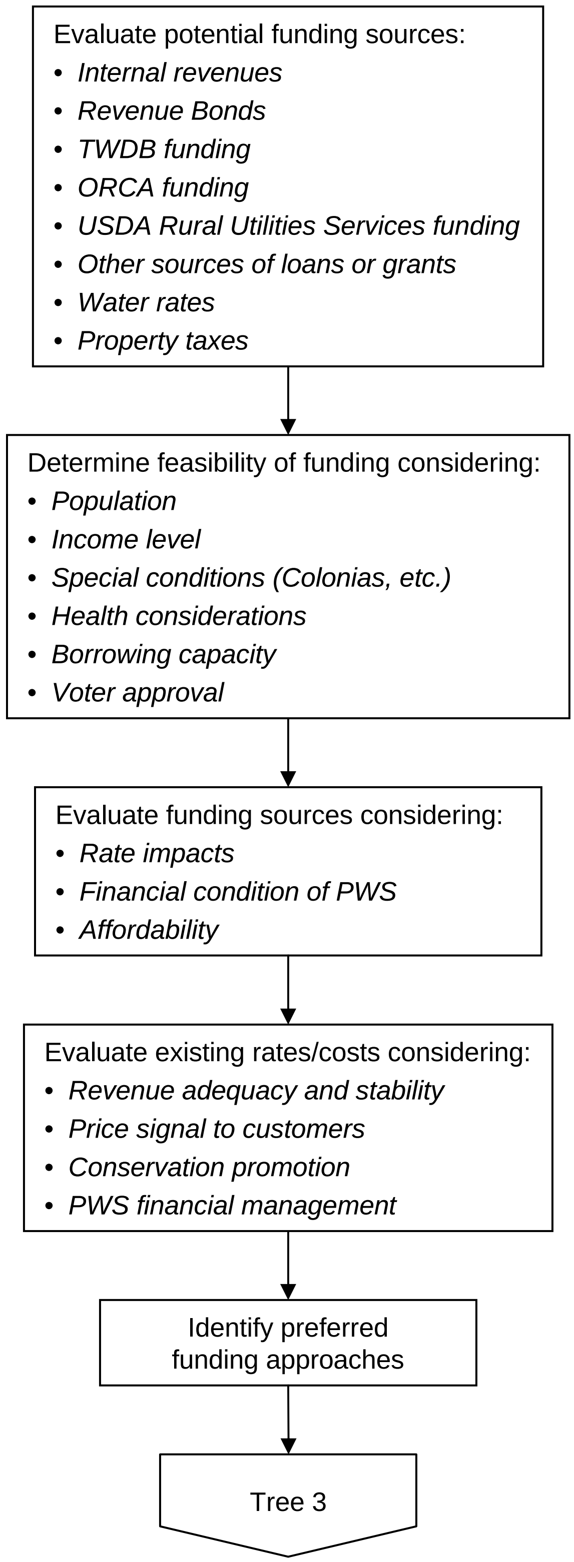


Figure 2.3
Tree 3 – PRELIMINARY ANALYSIS

Figure 2.4
TREE 4 – FINANCIAL



The CCN files generally contain a copy of the system's Certificate of Convenience and Necessity, along with maps and other technical data.

These files were reviewed for the PWS and surrounding systems.

The following websites were consulted to identify the water supply systems in the area:

- Texas Commission on Environmental Quality http://www3.tceq.state.tx.us/iwud/. Under "Advanced Search", type in the name(s) of the County(ies) in the area to get a listing of the public water supply systems.
- USEPA Safe Drinking Water Information System www.epa.gov/safewater/data/getdata.html

Groundwater Control Districts were identified on the TWDB web site, which has a series of maps covering various groundwater and surface water subjects. One of those maps shows groundwater control districts in the State of Texas.

2.2.1.2 Existing Wells

The TWDB maintains a groundwater database available at www.twdb.state.tx.us that has two tables with helpful information. The "Well Data Table" provides a physical description of the well, owner, location in terms of latitude and longitude, current use, and for some wells, items such as flowrate, and nature of the surrounding formation. The "Water Quality Table" provides information on the aquifer and the various chemical concentrations in the water.

The TWDB maintains a groundwater database available at www.twdb.state.tx.us that has two tables with helpful information. The "Well Data Table" provides a physical description of the well, owner, location in terms of latitude and longitude, current use, and for some wells, items such as flowrate, and nature of the surrounding formation. The "Water Quality Table" provides information on the aquifer and the various chemical concentrations in the water.

2.2.1.3 Surface Water Sources

Regional planning documents were consulted for lists of surface water sources.

2.2.1.4 Groundwater Availability Model

GAMs, developed by the TWDB, are planning tools and should be consulted as part of a search for new or supplementary water sources. The GAM for the Ogallala aquifer was investigated as a potential tool for identifying available and suitable groundwater resources.

2.2.1.5 Water Availability Model

The WAM is a computer-based simulation predicting the amount of water that would be in a river or stream under a specified set of conditions. WAMs are used to determine whether water would be available for a newly requested water right or amendment. If water is available, these models estimate how often the applicant could count on water under various conditions (*e.g.*, whether water would be available only 1 month out of the year, half the year, or all year, and whether that water would be available in a repeat of the drought of record).

WAMs provide information that assist TCEQ staff in determining whether to recommend the granting or denial of an application.

2.2.1.6 Financial Data

Financial data were collected through a site visit. Data sought included:

- Annual Budget
- Audited Financial Statements
  - Balance Sheet
  - Income & Expense Statement
  - Cash Flow Statement
  - Debt Schedule
- Water Rate Structure
- Water Use Data
  - Production
  - Billing
  - Customer Counts

2.2.1.7 Demographic Data

Basic demographic data were collected from the 2000 Census to establish incomes and eligibility for potential low cost funding for capital improvements. Median household income (MHI) and number of families below poverty level were the primary data points of significance. If available, MHI for the customers of the PWS should be used. In addition, unemployment data were collected from current U.S. Bureau of Labor Statistics. These data were collected for the following levels: national, state, and county.

2.2.2 PWS Interviews

2.2.2.1 PWS Capacity Assessment Process

A capacity assessment is the industry standard term for an evaluation of a water system's financial, managerial, and technical capacity to effectively deliver safe drinking water to its customers now and in the future at a reasonable cost, and to achieve, maintain and plan for compliance with applicable regulations. The assessment process involves interviews with staff and management who have a responsibility in the operations and management of the system.

Financial, managerial, and technical capacity are individual yet highly interrelated components of a system's capacity. A system cannot sustain capacity without maintaining adequate capability in all three components.

Financial capacity is a water system's ability to acquire and manage sufficient financial resources to allow the system to achieve and maintain compliance with SDWA regulations. Financial capacity refers to the financial resources of the water system, including but not limited to revenue sufficiency, credit worthiness, and fiscal controls.

Managerial capacity is the ability of a water system to conduct its affairs so that the system is able to achieve and maintain compliance with SDWA requirements. Managerial capacity refers to the management structure of the water system, including but not limited to ownership accountability, staffing and organization, and effective relationships to customers and regulatory agencies.

Technical capacity is the physical and operational ability of a water system to achieve and maintain compliance with the SDWA regulations. It refers to the physical infrastructure of the water system, including the adequacy of the source water, treatment, storage and distribution infrastructure. It also refers to the ability of system personnel to effectively operate and maintain the system and to otherwise implement essential technical knowledge.

Many aspects of water system operations involve more than one component of capacity. Infrastructure replacement or improvement, for example, requires financial resources, management planning and oversight, and technical knowledge. A deficiency in any one area could disrupt the entire effort. A system that is able to meet both its immediate and long-term challenges demonstrates that it has sufficient financial, managerial, and technical capacity.

Assessment of the FMT capacity of the PWS was based on an approach developed by the New Mexico Environmental Finance Center (NMEFC), which is consistent with TCEQ FMT assessment process. This method was developed from work the NMEFC did while assisting USEPA Region 6 in developing and piloting groundwater comprehensive performance evaluations. The NMEFC developed a standard list of questions that could be asked of water system personnel. The list was then tailored slightly to have two sets of questions – one for managerial and financial personnel, and one for operations personnel (the questions are included in Appendix A). Each person with a role in the FMT capacity of the system was asked the applicable standard set of questions individually. The interviewees were not given the questions in advance and were not told the answers others provided. Also, most of the questions are open ended type questions so they were not asked in a fashion to indicate what would be the "right" or "wrong" answer. The interviews lasted between 45 minutes to 75 minutes depending on the individual's role in the system and the length of the individual's answers.

In addition to the interview process, visual observations of the physical components of the system were made. A technical information form was created to capture this information. This form is also contained in Appendix A. This information was considered supplemental to the interviews because it served as a check on information provided in the interviews. For example, if an interviewee stated he or she had an excellent preventative maintenance schedule and the visit to the facility indicated a significant amount of deterioration (more than would be expected for the age of the facility) then the preventative maintenance program could be further investigated or the assessor could decide that the preventative maintenance program was inadequate.

Following interviews and observations of the facility, answers that all personnel provided were compared and contrasted to provide a clearer picture of the true operations at the water system. The intent was to go beyond simply asking the question, "Do you have a budget?" to actually finding out if the budget was developed and being used appropriately. For example, if a water system manager was asked the question, "Do you have a budget?" he or she may say, "yes" and the capacity assessor would be left with the impression that the system is doing well in this area. However, if several different people are asked about the budget in more detail, the assessor may find that although a budget is present, operations personnel do not have input into the budget, the budget is not used by the financial personnel, the budget is not updated regularly, or the budget is not used in setting or evaluating rates. With this approach, the inadequacy of the budget would be discovered and the capacity deficiency in this area would be noted.

Following the comparison of answers, the next step was to determine which items noted as a potential deficiency truly had a negative effect on the system's operations. If a system had what appeared to be a deficiency, but this deficiency was not creating a problem in terms of the operations or management of the system, it was not considered critical and may not have needed to be addressed as a high priority. As an example, the assessment may have revealed an insufficient number of staff members to operate the facility. However, it may also have been revealed that the system was able to work around that problem by receiving assistance from a neighboring system, so no severe problems resulted from the number of staff members. Although staffing may not be ideal, the system does not need to focus on this particular issue. The system needs to focus on items that are truly affecting operations. As an example of this type of deficiency, a system may lack a reserve account which can then lead the system to delay much-needed maintenance or repair on its storage tank. In this case, the system needs to address the reserve account issue so that proper maintenance can be completed.

The intent was to develop a list of capacity deficiencies with the greatest impact on the system's overall capacity. Those were the most critical items to address through follow-up technical assistance or by the system itself.

2.2.2.2 Interview Process

PWS personnel were interviewed by the project team, and each was interviewed separately. Interview forms were completed during each interview.

2.3 ALTERNATIVE DEVELOPMENT AND ANALYSIS

The initial objective for developing alternatives to address compliance issues is to identify a comprehensive range of possible options that can be evaluated to determine which are the most promising for implementation. Once the possible alternatives are identified, they must be defined in sufficient detail so a conceptual cost estimate (capital and O&M costs) can be developed. These conceptual cost estimates are used to compare the affordability of compliance alternatives, and to give a preliminary indication of rate impacts. Consequently, these costs are pre-planning level and should not be viewed as final estimated costs for alternative implementation. The basis for the unit costs used for the compliance alternative cost estimates is summarized in Appendix B. Other non-economic factors for the alternatives, such as reliability and ease of implementation, are also addressed

2.3.1 Existing PWS

The neighboring PWSs were identified, and the extents of their systems were investigated. PWSs farther than 15 miles from the non-compliant PWSs were not considered because the length of the pipeline required would make the alternative cost prohibitive. The quality of water provided was also investigated. For neighboring PWSs with compliant water, options for water purchase and/or expansion of existing well fields were considered. The neighboring PWSs with non-compliant water were considered as possible partners in sharing the cost for obtaining compliant water either through treatment or developing an alternate source.

The neighboring PWSs were investigated to get an idea of the water sources in use and the quantity of water that might be available for sale. They were contacted to identify key locations in their systems where a connection might be made to obtain water and to explore on a preliminary basis their willingness to partner or sell water. Then, the major system components that would be required to provide compliant water were identified. The major system components included treatment units, wells, storage tanks, pump stations, and pipelines.

Once the major components were identified, a preliminary design was developed to identify sizing requirements and routings. A capital cost estimate was then developed based on the preliminary design of the required system components. An annual O&M cost was also estimated to reflect the change in O&M expenditures that would be needed if the alternative was implemented.

Non-economic factors were also identified. Ease of implementation was considered, as well as the reliability for providing adequate quantities of compliant water. Additional factors were whether implementation of an alternative would require significant increase in the management or technical capability of the PWS, and whether the alternative had the potential for regionalization.

2.3.2 New Groundwater Source

It was not possible in the scope of this project to determine conclusively whether new wells could be installed to provide compliant drinking water. In order to evaluate potential new groundwater source alternatives, three test cases were developed based on distance from the PWS intake point. The test cases were based on distances of 10 miles, 5 miles, and 1 mile. It was assumed that a pipeline would be required for all three test cases. A storage tank and pump station would be required for the 10-mile and 5-mile alternatives. It was also assumed that new wells would be installed, and that their depths would be similar to the depths of the existing wells, or other existing drinking water wells in the area.

A preliminary design was developed to identify sizing requirements for the required system components. A capital cost estimate was then developed based on the preliminary design of the required system components. An annual O&M cost was also estimated to reflect the change (*i.e.*, from current expenditures) in O&M expenditures that would be needed if the alternative was implemented.

Non-economic factors were also identified. Ease of implementation was considered, as well as the reliability for providing adequate quantities of compliant water. Additional factors were whether implementation of an alternative would require significant increase in the management or technical capability of the PWS, and whether the alternative had the potential for regionalization.

2.3.3 New Surface Water Source

New surface water sources were investigated. Availability of adequate quality water was investigated for the main rivers in the area, as well as the major reservoirs. TCEQ WAMs were inspected, and the WAM was run, where appropriate.

2.3.4 Treatment

The only common treatment technologies considered potentially applicable for removal of fluoride and arsenic are RO and EDR. Adsorption is not economically feasible because of the high alkalinity of the water, which would result in high acid consumption for pH adjustment. RO and EDR can remove fluoride as well as arsenic, selenium, nitrate, TDS and other dissolved constituents. RO treatment is considered for central treatment alternatives, as well as POU and POE alternatives. EDR is considered for central treatment only. Both RO and EDR treatment produce a liquid waste: a reject stream from RO treatment and a concentrate stream from EDR treatment. As a result, the treated volume of water is less than the volume of raw water that enters the treatment system. The amount of raw water used increases to produce the same amount of treated water if RO or EDR treatment is implemented. Partial RO treatment and blending treated and untreated water to meet the fluoride MCL would reduce the amount of raw water used. The EDR operation can be tailored to provide a desired fluoride effluent concentration by controlling the electrical energy applied. The treatment units were sized based on flow rates, and capital and annual O&M cost estimates were made based on the size of the treatment equipment required and the average water consumption rate, respectively. Neighboring non-compliant PWSs were identified to look for opportunities where the costs and benefits of central treatment could be shared between systems.

Non-economic factors were also identified. Ease of implementation was considered, as well as reliability for providing adequate quantities of compliant water. Additional factors were whether implementation of an alternative would require significant increase in the management or technical capability of the PWS, and whether the alternative had the potential for regionalization.

2.4 COST OF SERVICE AND FUNDING ANALYSIS

The primary purpose of the cost of service and funding analysis is to determine the financial impact of implementing compliance alternatives, primarily by examining the required rate increases, and also the fraction of household income that water bills represent. The current financial situation is also reviewed to determine what rate increases are necessary for the PWS to achieve or maintain financial viability.

2.4.1 Financial Feasibility

A key financial metric is the comparison of average annual household water bill for a PWS customer to the MHI for the area. MHI data from the 2000 Census are used, at the most detailed level available for the community. Typically, county level data are used for small rural water utilities due to small population sizes. Annual water bills are determined for existing, base conditions, including consideration of additional rate increases needed under current conditions. Annual water bills are also calculated after adding incremental capital and operating costs for each of the alternatives to determine feasibility under several potential funding sources.

Additionally, the use of standard ratios provides insight into the financial condition of any business. Three ratios are particularly significant for water utilities:

- Current Ratio = current assets divided by current liabilities provides insight into the ability to meet short-term payments. For a healthy utility, the value should be greater than 1.0.
- Debt to Net Worth Ratio = total debt divided by net worth shows to what degree assets of the company have been funded through borrowing. A lower ratio indicates a healthier condition.
- Operating Ratio = total operating revenues divided by total operating expenses show the degree to which revenues cover ongoing expenses. The value is greater than 1.0 if the utility is covering its expenses.

2.4.2 Median Household Income

The 2000 U.S. Census is used as the basis for MHI. In addition to consideration of affordability, the annual MHI may also be an important factor for sources of funds for capital programs needed to resolve water quality issues. Many grant and loan programs are available to lower income rural areas, based on comparisons of local income to statewide incomes. In the 2000 Census, MHI for the State of Texas was $39,927, compared to the U.S. level of $41,994. The census broke down MHIs geographically by block group and ZIP code. The MHIs can vary significantly for the same location, depending on the geographic subdivision chosen. The MHI for each PWS was estimated by selecting the most appropriate value based on block group or ZIP code based on results of the site interview and a comparison with the surrounding area.

2.4.3 Annual Average Water Bill

The annual average household water bill was calculated for existing conditions and for future conditions incorporating the alternative solutions. Average residential consumption is estimated and applied to the existing rate structure to estimate the annual water bill. The estimates are generated from a long-term financial planning model that details annual revenue, expenditure, and cash reserve requirements over a 30-year period.

2.4.4 Financial Plan Development

The financial planning model uses available data to establish base conditions under which the system operates. The model includes, as available:

- Accounts and consumption data
- Water tariff structure
- Beginning available cash balance
- Sources of receipts:
  - Customer billings
  - Membership fees
  - Capital Funding receipts from:
    - Grants
    - Proceeds from borrowing
- Operating expenditures:
  - Water purchases
  - Utilities
  - Administrative costs
  - Salaries
- Capital expenditures
- Debt service:
  - Existing principal and interest payments
  - Future principal and interest necessary to fund viable operations
- Net cash flow
- Restricted or desired cash balances:
  - Working capital reserve (based on 1-4 months of operating expenses)

- o Replacement reserves to provide funding for planned and unplanned repairs and replacements

From the model, changes in water rates are determined for existing conditions and for implementing the compliance alternatives.

2.4.5 Financial Plan Results

Results from the financial planning model are summarized in two areas: percentage of household income and total water rate increase necessary to implement the alternatives and maintain financial viability.

2.4.5.1 Funding Options

Results are summarized in a table that shows the following according to alternative and funding source:

- Percentage of the median annual household income that the average annual residential water bill represents.
- The first year in which a water rate increase would be required
- The total increase in water rates required, compared to current rates

Water rates resulting from the incremental capital costs of the alternative solutions are examined under a number of funding options. The first alternative examined is always funding from existing reserves plus future rate increases. Several funding options were analyzed to frame a range of possible outcomes.

- Grant funds for 100 percent of required capital. In this case, the PWS is only responsible for the associated O&M costs.
- Grant funds for 75 percent of required capital, with the balance treated as if revenue bond funded.
- Grant funds for 50 percent of required capital, with the balance treated as if revenue bond funded.
- State revolving fund loan at the most favorable available rates and terms applicable to the communities.
- If local MHI >75 percent of state MHI, standard terms, currently at 3.8 percent interest for non-rated entities. Additionally:
  - o If local MHI = 70-75 percent of state MHI, 1 percent interest rate on loan.
  - o If local MHI = 60-70 percent of state MHI, 0 percent interest rate on loan.
  - o If local MHI = 50-60 percent of state MHI, 0 percent interest and 15 percent forgiveness of principal.

  - o If local MHI less than 50 percent of state MHI, 0 percent interest and 35 percent forgiveness of principal.

- Terms of revenue bonds assumed to be 25-year term at 6.0 percent interest rate.

2.4.5.2 General Assumptions Embodied in Financial Plan Results

The basis used to project future financial performance for the financial plan model includes:

- No account growth (either positive or negative).
- No change in estimate of uncollectible revenues over time.
- Average consumption per account unchanged over time.
- No change in unaccounted for water as percentage of total (more efficient water use would lower total water requirements and costs).
- No inflation included in the analyses (although the model has provisions to add escalation of O&M costs, doing so would mix water rate impacts from inflation with the impacts from the alternatives being examined).
- Minimum working capital fund established for each district based on specified months of O&M expenditures.
- O&M for alternatives begins 1 year after capital implementation.
- Balance of capital expenditures not funded from primary grant program is funded through debt (bond equivalent).
- Cash balance drives rate increases, unless provision chosen to override where current net cash flow is positive.

2.4.5.3 Interpretation of Financial Plan Results

Results from the financial plan model are presented in Table 4.4. The table shows the percentage of MHI represented by the annual water bill that result from any rate increases necessary to maintain financial viability over time. In some cases, this may require rate increases even without implementing a compliance alternative (the no action alternative). The table shows any increases such as these separately. The results table shows the total increase in rates necessary, including both the no-action alternative increase and any increase required for the alternative. For example, if the no action alternative requires a 10 percent increase in rates and the results table shows a rate increase of 25 percent, then the impact from the alternative is an increase in water rates of 15 percent. Likewise, the percentage of household income in the table reflects the total impact from all rate increases.

2.4.5.4 Potential Funding Sources

A number of potential funding sources exist for rural utilities. Both state and federal agencies offer grant and loan programs to assist rural communities in meeting their infrastructure needs.

Within Texas, the following state agencies offer financial assistance if needed:

- Texas Water Development Board,
- Office of Rural Community Affairs, and
- Texas Department of Health (Texas Small Towns Environment Program).

Small rural communities can also get assistance from the federal government. The primary agencies providing aid are:

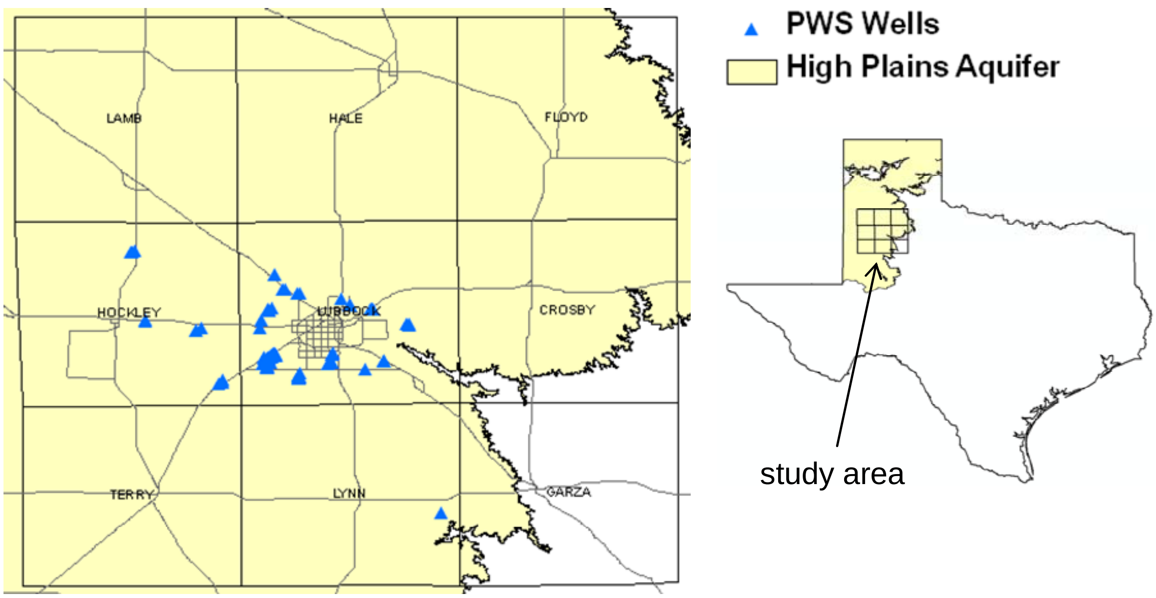
- United States Department of Agriculture, Rural Utilities Service, and
- United States Housing and Urban Development.

SECTION 3
UNDERSTANDING SOURCES OF CONTAMINANTS

3.1 REGIONAL HYDROGEOLOGY

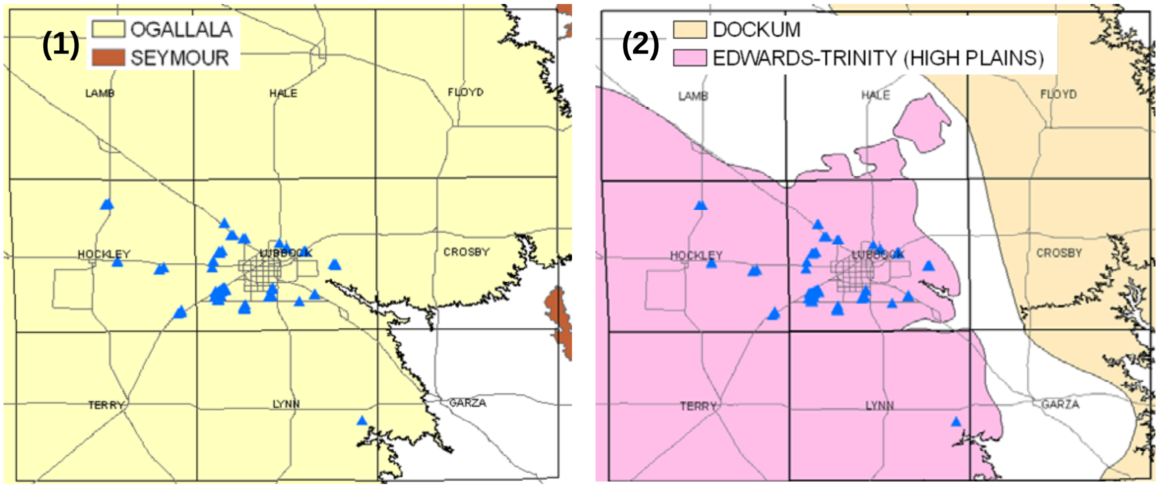
The assessed Public Water Supplies are located in Hockley, Lubbock, and Lynn Counties. For the regional analysis, data from nine counties covering the area around Lubbock were used, including: Lubbock, Lamb, Hale, Floyd, Hockley, Crosby, Terry, Lynn, and Garza Counties (Figure 3.1).

Figure 3.1 Nine Counties Study Area and PWS Well Locations



The major aquifer in the area is the Ogallala of late Tertiary age. Other aquifers in the region that may locally be hydraulically connected to the Ogallala aquifer include younger alluvial/fluvial deposits of Quaternary age (Blackwater Draw Formation) and underlying older aquifers, including the Edwards-Trinity High Plains aquifer of Cretaceous age, the Dockum aquifer of Triassic age, and undifferentiated Permian aquifers. A small pod of the Seymour aquifer is also present in southern Crosby County and northern Garza County (Figure 3.2). The PWS wells of concern are mainly completed in the Ogallala aquifer (one PWS well completed in the Edwards-Trinity High Plains aquifer). Contaminants of concern include fluoride, nitrate, arsenic, selenium, and uranium.

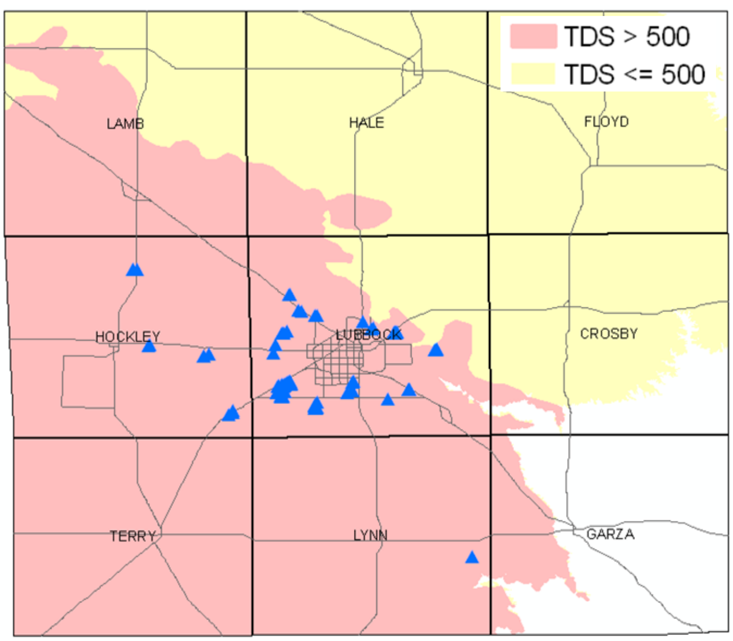
Figure 3.2 Major and Minor Aquifers in the Study Area



(1) Major aquifers include the Ogallala and Seymour aquifers, and (2) minor aquifers include the Edwards-Trinity High Plains and Dockum aquifers

Water quality in the Ogallala aquifer varies greatly between the north-east and south-west parts of the study area (Figure 3.3). Thus, two analysis zones were defined: Ogallala-North (TDS ≤500 mg/L), Ogallala-South (TDS >500 mg/L).

Figure 3.3 Water Quality Zones in the Study Area



Data in the analysis included information from three sources:

- Texas Water Development Board groundwater database available at: https://www.twdb.state.tx.us/DATA/waterwell/well_info.asp. The database includes information on well location, related aquifer, well depth, and groundwater quality information.

- Texas Commission on Environmental Quality Public Water Supply database (not publicly available). The database includes water quality data collected at PWSs in Texas, and information on the water sources such as location, depth, and related aquifers

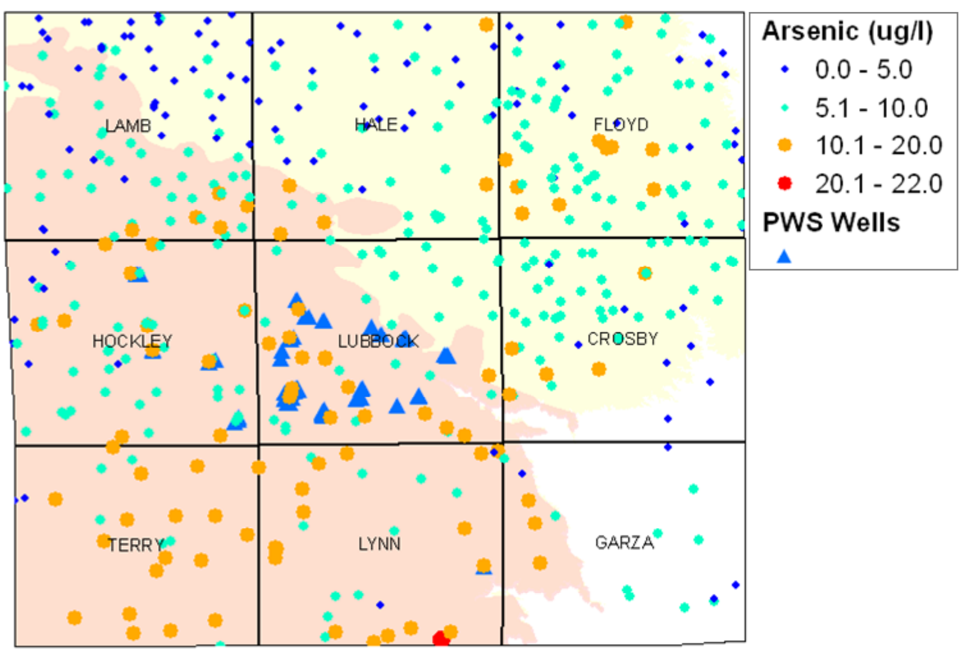
- National Uranium Resource Evaluation (NURE) database available at: http://tin.er.usgs.gov/nure/water/. The NURE dataset includes groundwater quality data collected between 1975 and 1980. The database provides well locations, and depths with an array of analyzed chemical data. The NURE dataset covers only the eastern part of the study area.

3.2 CONTAMINANTS OF CONCERN IN THE STUDY AREA

Arsenic

Arsenic concentrations exceed the MCL (10 μg/L) especially in the Ogallala-South area where 45 percent of the wells show arsenic above the MCL (Figure 3.4). In the Ogallala-North area only 8 percent of the wells have concentrations exceeding the arsenic MCL.

Figure 3.4 Arsenic Concentrations in the Ogallala Aquifer within the Study Area



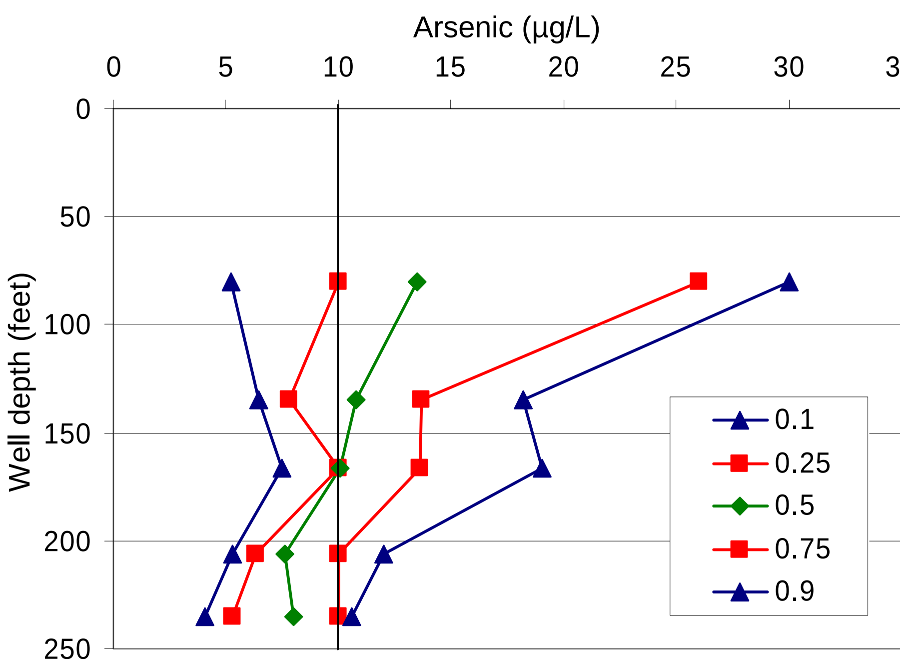
Data are from the TWDB database. The most recent sample for each well is shown. Table 3.1 gives the percentage of wells with arsenic exceeding the MCL in each of the major aquifers in the study area.

Table 3.1 Summary of Arsenic Concentrations by Aquifer

Aquifer	Total number of wells	Arsenic > 10 µg/L	
		Number of wells	Percentage
Ogallala-South	215	96	45%
Ogallala-North	222	17	8%
Edwards-Trinity (High Plains)	11	2	18%
Dockum	28	0	0%
Other	2	0	0%

In the Ogallala-South area where many wells have arsenic concentrations >10 µg/L, there is a stratification of arsenic concentrations with depth, particularly at the higher percentiles (Figure 3.5). Arsenic concentrations decrease with depth, which may suggest that tapping deeper water by deepening shallow wells or screening off shallower parts of certain wells may decrease arsenic concentrations and might provide a solution for wells where arsenic exceeds the MCL.

Figure 3.5 Stratification of Arsenic Concentrations with Depth in the Ogallala-South

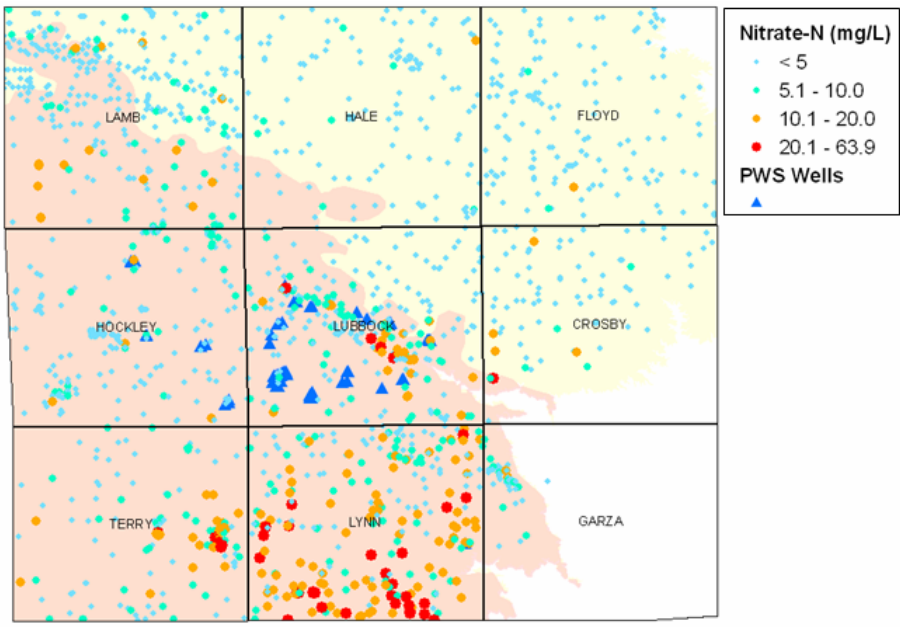


Arsenic concentrations are plotted as the 10th, 25th, 50th, 75th, and 90th percentiles and depths represent the median of 20th percentiles

Nitrate

Nitrate concentrations >10 mg/L nitrate-N (USEPA MCL) are abundant within the study area, especially in the Ogallala-South aquifer where 20 percent of the wells exceed the MCL (Figure 3.6). There is very little nitrate contamination in the Ogallala-North aquifer where only about 2 percent of the wells have nitrate concentrations exceeding the MCL.

Figure 3.6 Nitrate Concentrations in the Ogallala Aquifer within the Study Area



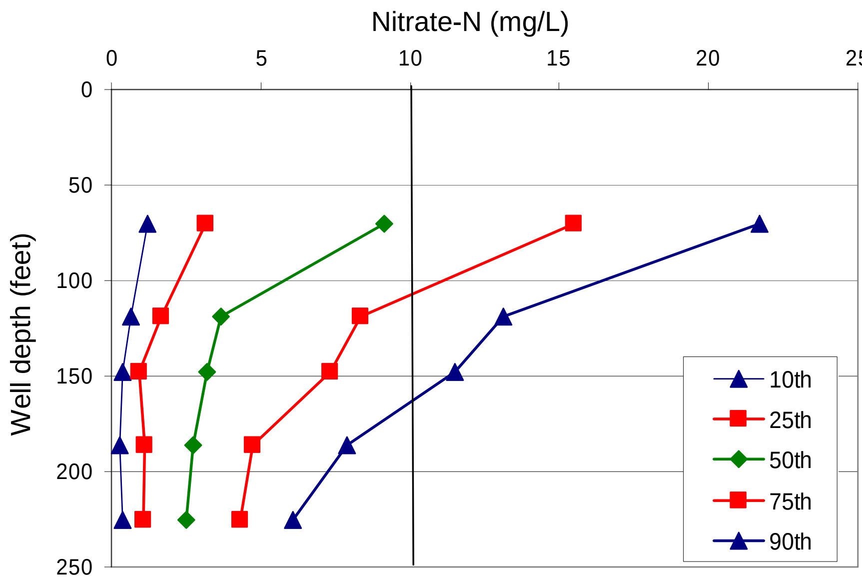
Data are from the TWDB database. The most recent sample for each well in the Ogallala aquifer is shown. Table 3.2 shows the percentage of wells with nitrate-N exceeding the MCL (10 mg/L).

Table 3.2 Summary of Nitrate Concentrations by Aquifer

Aquifer	Total number of wells	Nitrate > 10 mg/L	
		Number of wells	Percentage
Ogallala-South	1026	201	20%
Ogallala-North	580	12	2%
Edwards-Trinity (High Plains)	30	0	0%
Dockum	59	2	3%
Other	23	2	9%

In the Ogallala-South area where many wells have nitrate concentrations >10 mg/L, there is a clear stratification of nitrate-N concentrations with depth, particularly at the higher percentiles (Figure 3.7). Nitrate concentrations decrease with depth. This suggests that tapping deeper water by deepening shallow wells or screening off shallower parts of certain wells may decrease nitrate concentrations and might provide a solution for wells where nitrate exceeds the MCL.

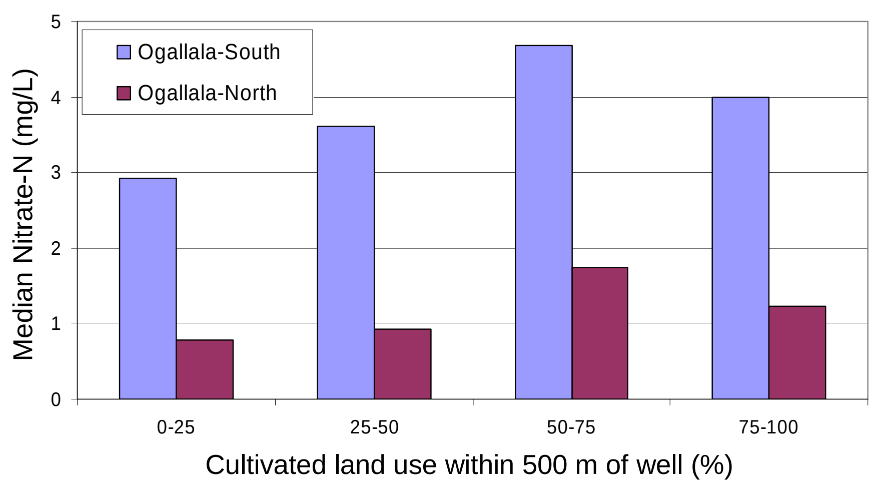
Figure 3.7 Stratification of Nitrate-N Concentrations with Depth in the Ogallala-South



Nitrate concentrations are plotted as the 10th, 25th, 50th, 75th, and 90th percentiles and depths represent the median of 20th percentiles.

Nitrate concentrations are correlated with land use in the study area (Figure 3.8). Median nitrate concentrations were compared with percentage of cultivated land within a 500 m radius around wells. Results indicate that nitrate-N concentrations generally increase with increasing cultivation.

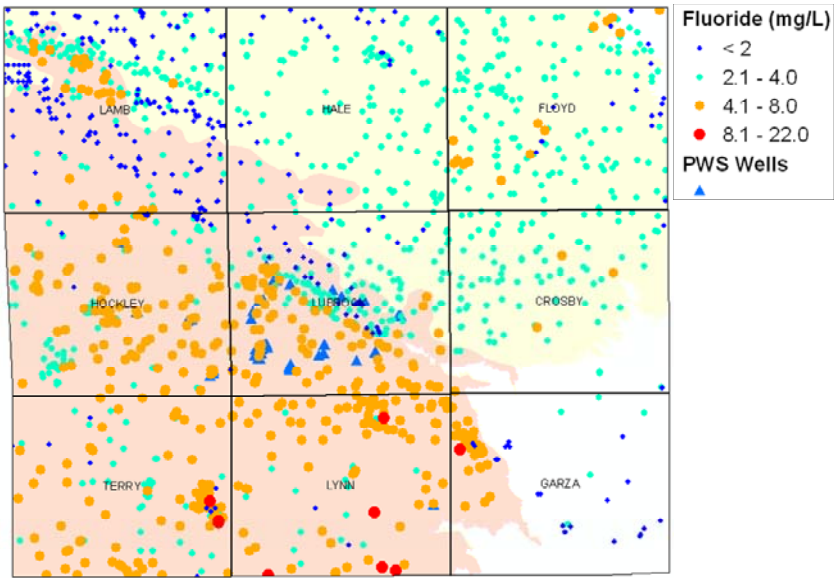
Figure 3.8 Relationship between Nitrate Concentrations and Cultivated Land



Fluoride

Fluoride concentrations exceeding the fluoride MCL (4 mg/L) are widespread in the Ogallala-South area (Figure 3.9, 51% of wells) and are low in the Ogallala-North area (3% of wells).

Figure 3.9 Spatial Distribution of Fluoride Concentrations in the Study Area



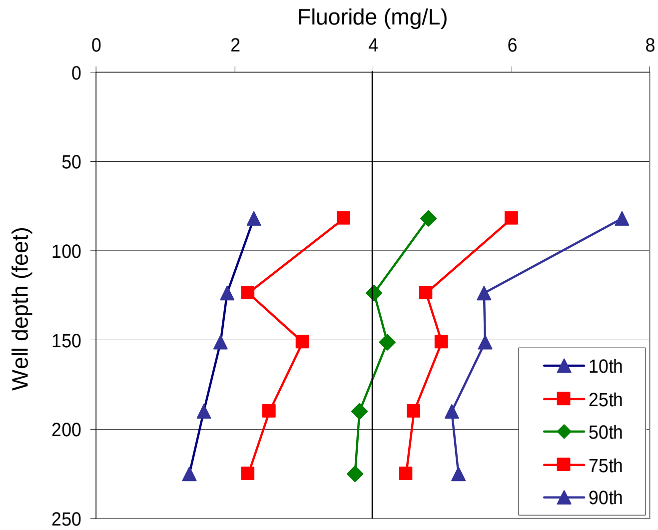
Data are from the TWDB database. The most recent sample for each well is shown. Table 3.3 shows the percentage of wells with fluoride exceeding the MCL (4 mg/L)) by aquifer.

Table 3.3 Summary of Fluoride Concentrations by Aquifer

Aquifer	Total number of wells	Fluoride ≥ 4 mg/L	
		Number of wells	Percentage
Ogallala-South	848	429	51%
Ogallala-North	576	17	3%
Edwards-Trinity (High Plains)	28	9	32%
Dockum	54	2	3%
Other	12	3	25%

In the Ogallala-South area where there are high rate of fluoride concentrations >4 mg/L, there is some stratification of fluoride concentrations with depth. Fluoride concentrations decrease with depth, particularly up to a depth of 125 feet (Figure 3.10). This suggests that tapping deeper water by deepening shallow wells or screening off the shallower parts of certain wells may decrease fluoride concentrations and might provide a solution for wells where fluoride concentrations exceed the MCL.

Figure 3.10 Stratification of Fluoride Concentrations with Depth in the Ogallala-South Area

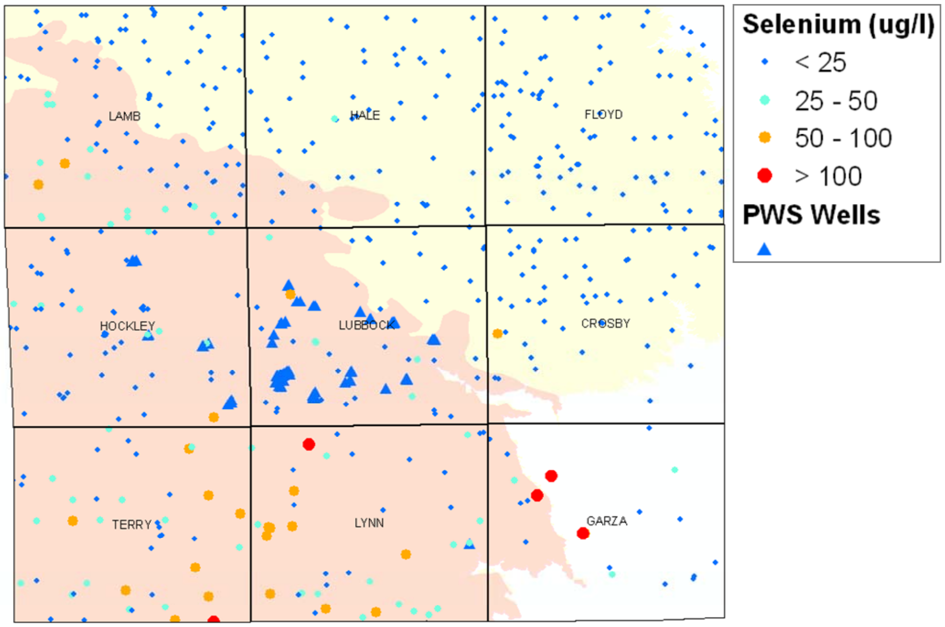


Fluoride concentrations are plotted as the 10th, 25th, 50th, 75th, and 90th percentiles and depths represent the median of 20th percentiles

Selenium

Selenium concentrations in the study area are generally below the MCL (50 µg/L). Concentrations of selenium are higher in the Ogallala-South area with 10 percent of wells exceeding the MCL, and in the Dockum aquifer where 15 percent of wells exceed the MCL. In the Ogallala-North and Edwards-Trinity (High Plains) aquifers, less than 1 percent of wells exceed the MCL for selenium. Figure 3.11 shows the distribution of selenium concentrations within the study area.

Figure 3.11 Spatial Distribution of Selenium Concentrations in the Study Area



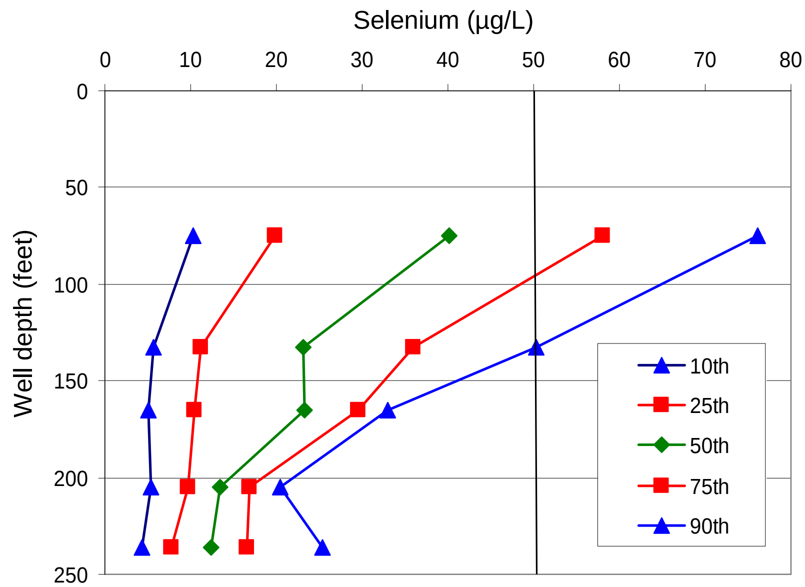
Data are from the TWDB database. The most recent sample for each well is shown. Table 3.4 shows the percentage of wells with selenium concentrations exceeding the selenium MCL (50 µg/L).

Table 3.4 Summary of Selenium Concentrations by Aquifer

Aquifer	Total number of wells	Selenium > 50 µg/L	
		Number of wells	Percentage
Ogallala-South	225	22	10%
Ogallala-North	227	1	0.5%
Edwards-Trinity (High Plains)	11	0	0%
Dockum	33	5	15%
Other	2	0	0%

In the Ogallala-South area, where many wells have selenium concentrations >50 µg/L, there is a stratification of selenium concentrations with depth, particularly in the upper percentiles (Figure 3.12). Stratification of selenium is similar to that of nitrate and fluoride, with a decrease in selenium levels in the upper 200 feet (Figure 3.12). This suggests that tapping deeper water by deepening shallow wells or screening off the shallower parts of certain wells may decrease selenium concentrations and might provide a solution for wells where selenium exceeds the MCL.

Figure 3.12 Stratification of Selenium Concentrations with Depth in the Ogallala-South Area

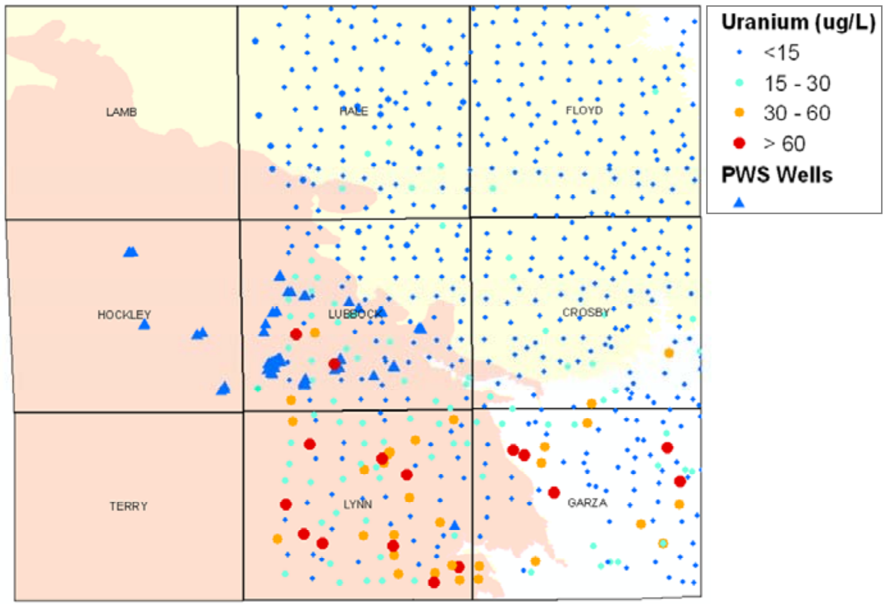


Selenium concentrations are plotted as the 10th, 25th, 50th, 75th, and 90th percentiles and depths represent the median of 20th percentiles

Uranium

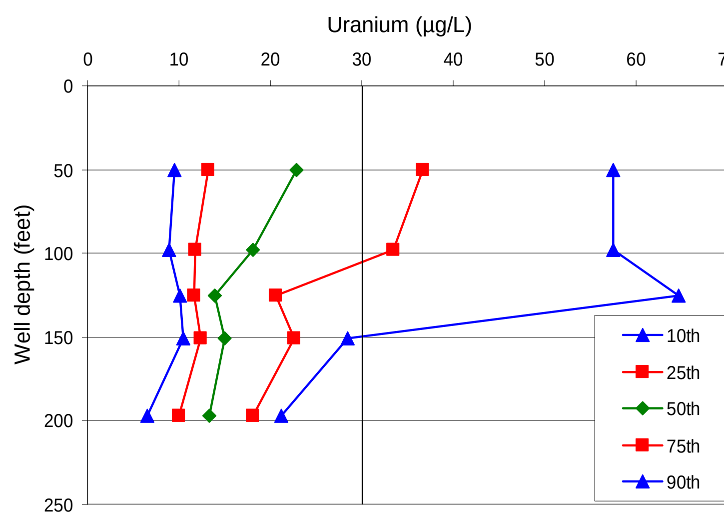
Uranium concentrations in the study area show distinct variation between the Ogallala-North and Ogallala-South areas. Concentrations of uranium are higher in the Ogallala-South area with 19 percent of wells exceeding the MCL (30 µg/L). In the Ogallala-North area there are no measurements that exceed the MCL for uranium (Figure 3.13). Data in the map are from the NURE database.

Figure 3.13 Spatial Distribution of Uranium Concentrations in the Study Area



In the Ogallala-South area where some wells show uranium concentrations greater than 30 µg/L, there is some stratification of uranium concentrations with depth, particularly in the upper percentiles (Figure 3.14). Depth stratification of uranium is similar to that of nitrate, fluoride, and selenium, with a decrease in uranium levels in the upper 150-200 feet. This suggests that tapping deeper water by deepening shallow wells or screening off the shallower parts of certain wells may decrease uranium concentrations and might provide a solution for wells where uranium exceeds the MCL.

Figure 3.14 Stratification of Uranium Concentrations with Depth in the Ogallala-South Area



Uranium concentrations are plotted as the 10th, 25th, 50th, 75th, and 90th percentiles and depths represent the median of 20th percentiles

3.3 REGIONAL GEOLOGY

The major aquifer in the study area is the High Plains or Ogallala aquifer. The main geologic unit that makes up the High Plains aquifer is the Ogallala Formation, which is late Tertiary (Miocene-Pliocene, about 4-12 million years) in age (Nativ 1988). The Ogallala Formation consists of coarse fluvial sandstones and conglomerates that were deposited in paleovalleys in a mid-Tertiary erosional surface with eolian sand in intervening upland areas (Gustavson and Holliday 1985). The Ogallala-North area generally corresponds to a paleovalley where the saturated thickness of the aquifer is greater and the water table is deeper. In contrast, the Ogallala-South area generally corresponds to a paleoupland where the Ogallala Formation is thin, the aquifer thickness is low, and the water table is shallower. The top of the Ogallala Formation is marked by a resistant calcite layer termed the "caprock" caliche.

The Ogallala Formation is overlain by Quarternary-age (Pleistocene-Holocene) eolian, fluvial, and lacustrine sediments called the Blackwater Draw Formation (Holliday 1989). The texture of the formation ranges from sand and gravel along riverbeds and mostly clay in playa floors.

The Ogallala Formation is underlain by lower Cretaceous (Comanchean) strata in the southern High Plains. The top of the Cretaceous sediments is marked by an erosional surface that represents the end of the Laramide orogeny. Nonuniform erosion resulted in topographic relief on the Cretaceous beneath the Ogallala Formation. Cretaceous strata are absent beneath the thick Ogallala paleovalley fill deposits because they were removed by erosion. The Cretaceous sediments were deposited in a subsiding shelf environment and consist of (1) the Trinity Group (basal sandy, permeable Antlers Formation), (2) Fredericksburg Group (limy to shaly formations, including the Walnut, Comanche Peak, and Edwards Formation, as well as the Kiamichi Formation), and (3) the Washita Group (low-permeability, shaly sediments of Duck Creek Formation) (Nativ 1988). The sequence results in two main aquifer units: the Antlers Sandstone (also termed the Trinity or Paluxy sandstone, ~ 15 m thick) and the Edwards Limestone (~ 30 m thick). The term Edwards Trinity (High Plains) aquifer is generally used to describe these units (Ashworth 1991). The limestone decreases in thickness to the northwest and transitions into the Kiamichi Formation and Duck Creek Formation (predominantly shale).

The Ogallala Formation is underlain by the Triassic Dockum Group in much of the southern High Plains. The Dockum Group is exposed along the margins of the High Plains (~150 m thick). The uppermost sediments consist of red mudstones (termed red beds) that generally form an aquitard. Underlying units (Trujillo Sandstone [Upper Dockum] and Santa Rosa Sandstone [Lower Dockum]) are aquifers. Water quality in the Dockum is generally poor (Dutton and Simpkins 1986). The sediment of the Dockum was deposited in a continental fluvio-lacustrine environment that included streams, deltas, lakes, and mud flats (McGowen, *et al.* 1977) and included alternating arid and humid climatic conditions. The Triassic rocks are thickest in the Midland Basin (≤600 m).

3.4 DETAILED ASSESSMENT

The Southwest Gardens Water PWS has 18 wells: G1520217A–R. Well depths range from 110 to 160 feet. All these wells are designated as being within the Ogallala aquifer (121OGLL). Wells G1520217D, G1520217E, and G1520217F each have their own entry point, allowing contaminants to be traced back specifically to these wells; the other wells all share a single entry point, making it difficult to narrow down the source of contaminants in these wells. Table 3.5 summarizes fluoride and arsenic concentrations measured at the Southwest Gardens Water PWS.

All 23 fluoride measurements and all but the most recent of 16 arsenic measurements, taken between 1998 and 2007, exceed the MCLs for fluoride (4 mg/L) and arsenic (10 µg/L). The spatial distributions of fluoride and arsenic concentrations measured within 5- and 10-km buffers of the supply wells are shown in Figures 3.15 and 3.16, respectively.

Table 3.5 Fluoride and Arsenic Concentrations in the Southwest Gardens Water PWS

Date	Fluoride (mg/L)	Arsenic (µg/L)	Well or wells sampled
4/6/1998	5.5	11.9	-
5/18/1998	5.7	-	unknown
8/3/1998	5.4	11.3	G1520217A, B, C, and G-R
4/26/1999	5.2	10.7	unknown
3/13/2001	5.2	11.4	G1520217A, B, C, and G-R
8/27/2002	5.6	-	G1520217A, B, C, and G-R
3/20/2003	5.3	-	G1520217A, B, C, and G-R
7/23/2003	5.9	-	G1520217A, B, C, and G-R
12/1/2003	5.3	-	G1520217A, B, C, and G-R
2/23/2004	5.3	10.9	G1520217A, B, C, and G-R
4/14/2004	5.9	-	G1520217A, B, C, and G-R
9/22/2004	5.5	-	G1520217A, B, C, and G-R
12/12/2004	5.8	-	G1520217A, B, C, and G-R
1/17/2005	5.8	11.2	G1520217A, B, C, and G-R
4/19/2005	5.3	10.4	G1520217A, B, C, and G-R
7/12/2005	5.8	10.8	G1520217A, B, C, and G-R
12/1/2005	5.7	10.3	G1520217A, B, C, and G-R
2/23/2006	5.8	11.6	G1520217A, B, C, and G-R
4/6/2006	5.5	-	G1520217A, B, C, and G-R
6/21/2006	-	11.3	G1520217A, B, C, and G-R
7/28/2006	5.7	10.9	G1520217A, B, C, and G-R
10/19/2006	5.7	10.8	G1520217A, B, C, and G-R
1/18/2007	5.6	11.6	G1520217A, B, C, and G-R
4/11/2007	5.9	7.2	G1520217A, B, C, and G-R

(data from the TCEQ PWS database)

Figure 3.15 Fluoride Concentrations within 5- and 10-Km Buffers of the Southwest Gardens Water PWS Wells

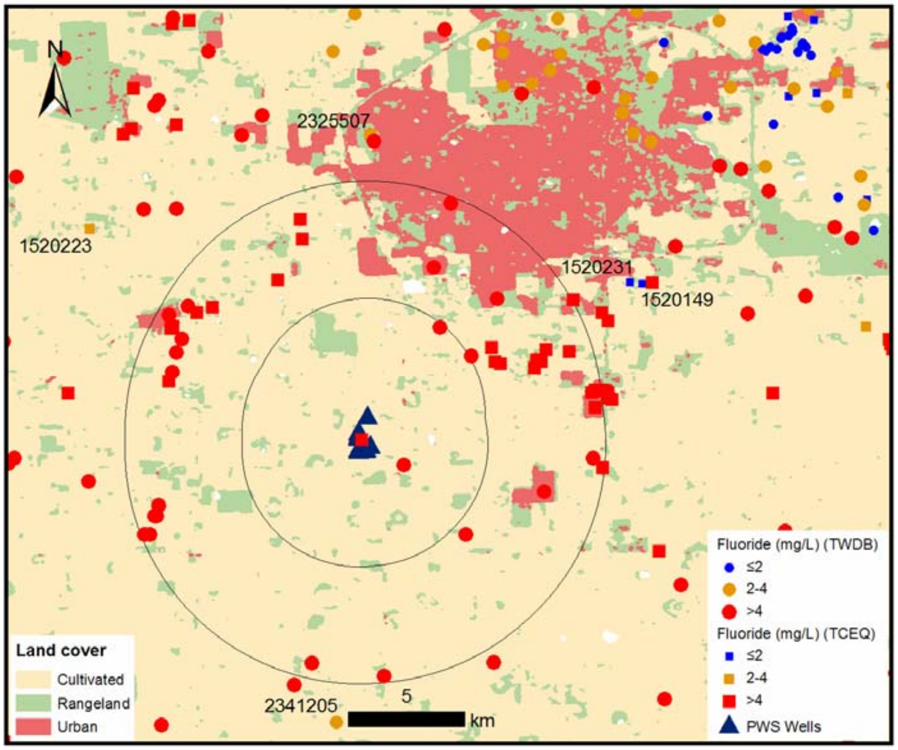
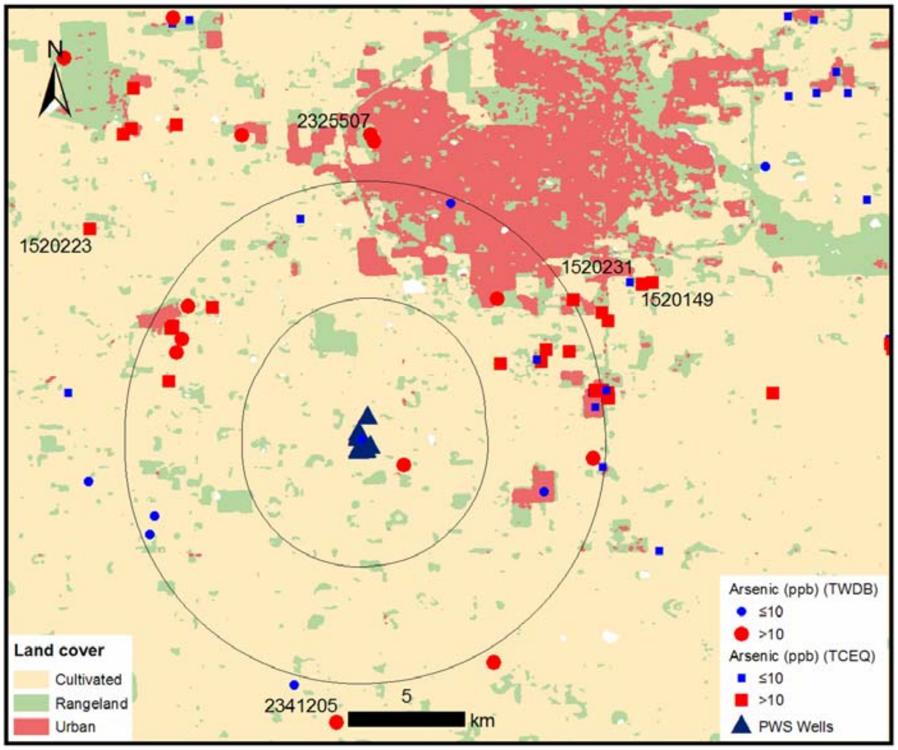


Figure 3.16 Arsenic Concentrations within 5- and 10-Km Buffers of the Southwest Gardens Water PWS Wells



Data are from the TCEQ and TWDB databases. Two types of samples were included in the analysis. Samples from the TCEQ database (shown as squares on the map) represent the most recent sample taken at a PWS, which can be raw samples from a single well or entry point samples that may combine water from multiple sources. Samples from the TWDB database are taken from single wells (shown as circles in the map). Where more than one measurement has been made in a well, the most recent concentration is shown.

All the samples taken within 10 km of the PWS wells have fluoride concentrations that exceed the MCL (4 mg/L). Most samples in the vicinity have arsenic concentrations below the MCL (10 µg/L). Slightly beyond this area, there are several wells with measured fluoride concentrations below the MCL. However, most of these exceed the MCL for arsenic. Well 1520231, about 12 km to the northeast, is the nearest well that meets the MCLs for both fluoride and arsenic. Farther to the northeast, there is a clear drop in fluoride levels. This coincides with a regional decrease in fluoride content in the northern part of the Ogallala aquifer.

3.4.1 Summary of Alternative Groundwater Sources

There are no obvious groundwater sources in the vicinity (10 km) of the PWS that can serve as alternative sources. Because no wells in the vicinity of the PWS wells show fluoride levels under the MCL (4 mg/L), it may be necessary to look for new supplies in or near wells farther from the PWS. Acceptable fluoride levels are also present to the northeast, coinciding with a regional change in water quality in the Ogallala aquifer. Although this area is a significant distance away, the consistent low levels indicate that chances of finding fluoride concentrations below the MCL are good.

In addition, regional analyses show that fluoride and arsenic levels tend to decrease with depth. This suggests that tapping deeper water by deepening one or more wells and screening only the deeper portion may decrease concentrations of these constituents in drinking water. However, there are not enough local data available to evaluate this option.

SECTION 4
ANALYSIS OF THE SOUTHWEST GARDENS WATER PWS

4.1 DESCRIPTION OF EXISTING SYSTEM

4.1.1 Existing System

The location of Southwest Gardens Mobile Home Park is shown in Figure 4.1. The Southwest Gardens PWS is located at 154th Street and S. Frankford Avenue, south of Lubbock, Texas and is owned by RBTQ, Inc. of Lubbock, Texas. Mr. Charles "Quiz" Quizenberry is the system Managing Partner and has a "D" groundwater license, and Duane Damron is the operator and is not licensed. The system is a mobile home community with 125 metered connections and a population of approximately 375 and was completed in 1997.

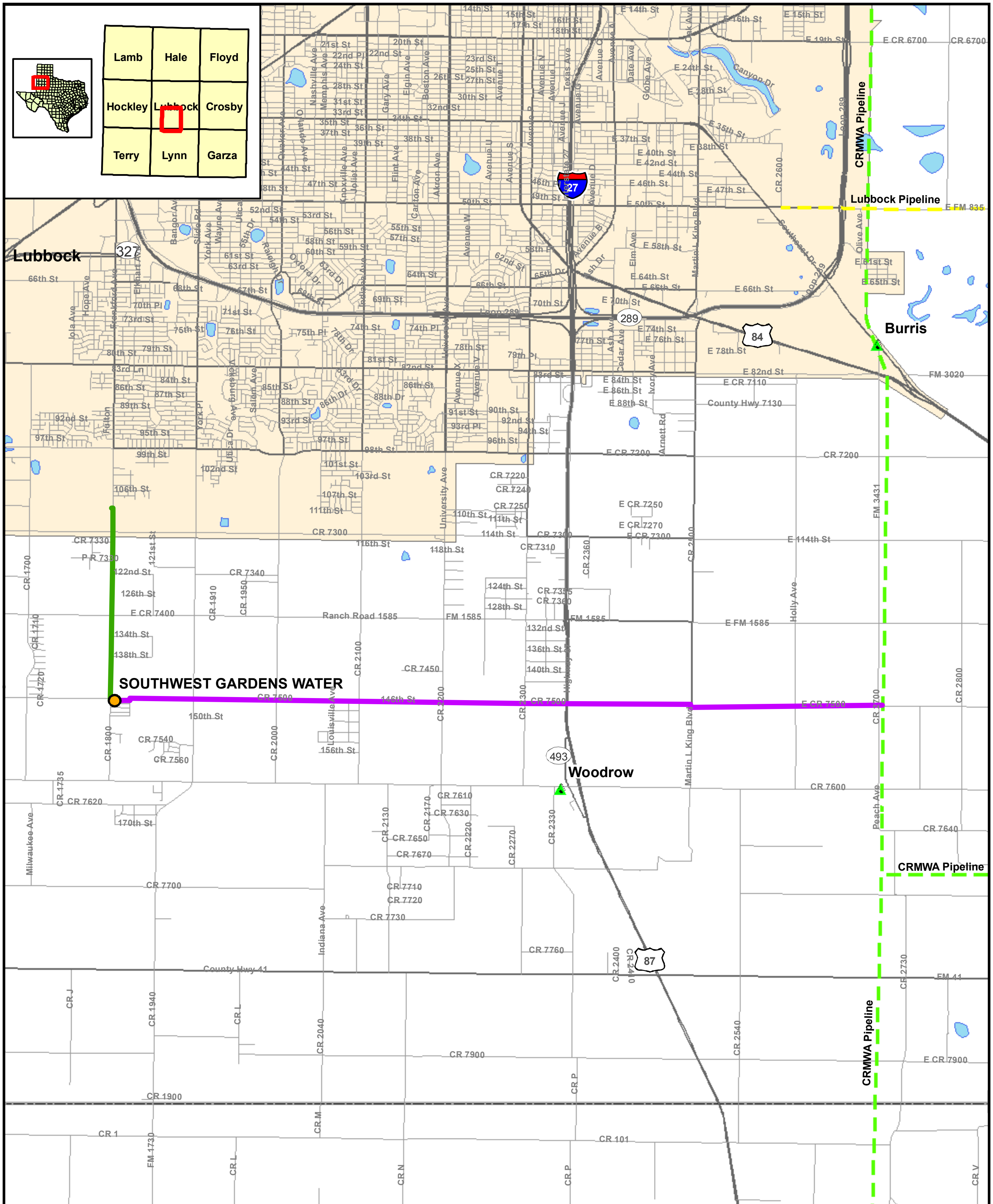
Water is supplied by four wells pulling water from the Ogallala aquifer: Well G1520217B is 152 feet deep and is rated at 40 gallons per minute (gpm). Well G1520217C is 156 feet deep and is rated at 45 gpm. Well G1520217O is 168 feet deep and is rated at 50 gpm. Well G1520217P is 151 feet deep and is rated at 40 gpm. All four wells discharge to a 25,000-gallon ground storage tank. Two service pumps take suction from the ground storage tank and discharge through one 50-gallon pressure tank to the distribution system. Two additional service pumps serve as a backup system and take suction from the ground storage tank and discharge through three 1,000-gallon pressure tanks to the distribution system. The four wells are individually housed in insulated Quonset huts in good repair.

The Southwest Gardens PWS recorded fluoride concentrations that range between 5.2 mg/L and 5.9 mg/L during the period April 1998 to April 2005 and exceeding the fluoride MCL of 4.0 mg/L. Arsenic concentrations of 0.0104 mg/L and 0.0114 mg/L were recorded between April 1998 and April 2005, which exceed the 0.010 mg/L MCL for arsenic that went into effect on January 23, 2006 (USEPA 2005; TCEQ 2004). Therefore, Southwest Gardens PWS faces compliance issues under these water quality standards.

The distribution system is made of 6- and 2-inch polyvinyl chloride (PVC) pipe and is in good condition. Annual loss is approximately 1.5 percent. The nearest pipeline is from the City of Lubbock and is 3.5 - 4 miles to the north. Disinfection with bleach occurs at each well head prior to storage.

Basic system information is as follows:

- Population served: 375
- Connections: 125
- Average daily flow: 0.028 mgd
- Total production capacity: 0.200 mgd



Legend

- Study System
- PWS's
- Cities
- City Limits
- Counties
- Major Road
- Minor Road
- CRMWA Pipeline
- Lubbock Pipeline
- SW-1 Lubbock Public Water System
- SW-2 CRMWA Line Lubbock to Tahoka

N

Miles

0 0.75 1.5

Figure 4.1

SOUTHWEST GARDENS WATER

Pipeline Alternatives

Basic system raw water quality data are as follows:

- Typical arsenic range: 0.0104-0.0114 mg/L
- Typical fluoride range: 5.2-5.9 mg/L
- Typical total dissolved solids range: 792-1030 mg/L
- Typical pH range: 7.4-7.7
- Typical calcium range: 58.2-71 mg/L
- Typical magnesium range: 59-86.3 mg/L
- Typical sodium range: 131-161 mg/L
- Typical chloride range: 177-252 mg/L
- Typical bicarbonate (HCO3) range: 322-344 mg/L
- Typical iron range: 0.01-0.056 mg/L
- Typical bicarbonate range: 322-344 mg/L

4.1.2 Capacity Assessment

The project team conducted a capacity assessment of the Southwest Gardens PWS on April 25, 2007. Results of this evaluation are separated into four categories: general assessment of capacity, positive aspects of capacity, capacity deficiencies, and capacity concerns. The general assessment of capacity describes the overall impression of FMT capability of the water system. The positive aspects of capacity describe the strengths of the system. These factors can provide the building blocks for the system to improve capacity deficiencies. The capacity deficiencies noted are those aspects that are creating a particular problem for the system related to long-term sustainability. Primarily, these problems are related to the system's ability to meet current or future compliance, ensure proper revenue to pay the expenses of running the system, and to ensure the proper operation of the system. The last category, capacity concerns, includes items that are not causing significant problems for the system at this time. However, the system may want to address them before they become problematic.

Because of the challenges facing very small water systems, it is increasingly important for them to develop the internal capacity to comply with all state and federal requirements for public drinking water systems. For example, it is especially important for very small water systems to develop long-term plans, set aside money in reserve accounts, and track system expenses and revenues because they cannot rely on increased growth and economies of scale to offset their costs. In addition, it is crucial for the owner, manager, and operator of a very small water system to understand the regulations and participate in appropriate trainings. Providing safe drinking water is the responsibility of every public water system, including those very small water systems that face increased challenges with compliance.

The project team interviewed the following individuals:

- Charles Quisenberry –Managing Partner and Certified Operator
- Duane Damron – Contract Certified Operator

4.1.2.1 General Structure

The Southwest Gardens Public Water System is located approximately 3 miles south of the City of Lubbock. The water system supplies water to the 125 service connections of the Southwest Gardens Mobile Home Park (MHP). The water system is a separate operation from the mobile home park. The initial water system was built in 1987 and then upgraded to its current size in 1995-1997. The water system was in receivership in 1993 when it was purchased by the present owners.

4.1.2.2 General Assessment of Capacity

Based on the team's assessment, this system has a good level of capacity. There are several positive FMT aspects of the water system, but there are also some areas that need improvement. The deficiencies noted could prevent the water system from being able to meet compliance now or in the future and may also impact the water system's long-term sustainability.

4.1.2.3 Positive Aspects of Capacity

In assessing a system's overall capacity, it is important to look at all aspects – positive and negative. It is important for systems to understand those characteristics that are working well, so that those activities can be continued or strengthened. In addition, these positive aspects can assist the system in addressing the capacity deficiencies or concerns. The factors that were particularly important for Southwest Gardens Water are listed below.

- **Knowledgeable and Dedicated Staff –** The staff is very familiar with the regulations, knows the customers personally, and generally receives no complaints from the customers. The current staff has greatly improved the system from its days in receivership. The staff members are members of the Texas Water Utility Group and attend regular meetings.
- **Written Plant Operations Manual –** The system has a plant operations manual.
- **Written Water Conservation Plan –** The system has a water conservation plan.
- **Housekeeping and General Appearance –** The system facilities and property were in good condition and well maintained. The system received an outstanding achievement award from TCEQ.
- **Low Level of Water Loss –** The system reported losses of 1.9 percent, which is an extremely low rate of loss.

4.1.2.4 Capacity Deficiencies

The following capacity deficiencies were noted in conducting the assessment and seriously impact the ability of the water system to meet compliance with current and future regulations and to ensure long-term sustainability.

- **Lack of Long Term Capital Planning for Compliance and Sustainability –** There appears to be no long term plan in place to achieve and maintain compliance and to ensure the long-term sustainability of the water system. System needs appear to be assessed on a daily basis, rather than a multi-year basis. Without some type of planning process, the owner is not able to plan for the revenue needed to make system improvements or add treatment processes. The system can also use the long-term planning process to help identify financing strategies to pay for the long-term needs.

- **Lack of Compliance with Water Quality Standards –** The water system is not in compliance with water quality standards.

4.1.2.5 Potential Capacity Concerns

The following items were concerns regarding capacity but no specific operational, managerial, or financial problems can be attributed to these items at this time. The system should address the items listed below to further improve FMT capabilities and to improve the system's long-term sustainability.

- **Inadequate Emergency Preparedness –** The water system has not undertaken the necessary planning to address emergencies typical for this type of system. The system does not have a written emergency plan, nor does it have or have access to an emergency generator. In the event of an emergency, it is recommended that the water system, at a minimum, have an emergency contact list that includes the name, title, and phone number of the people who should be contacted in the event of an emergency. It is also important to have an emergency plan that outlines what actions will be taken and by whom. The plan should address emergency conditions such as storms, floods, major line breaks, electrical failure, drought, and system contamination or equipment failure.

- **Lack of a Source Water and Wellhead Protection Plan -** Although participation in the source water protection program through TCEQ is voluntary, it is recommended the water system participate in the program to better protect its water source. In addition, the water system should develop a wellhead protection plan. Although not required, wellhead protection plans provide a valuable resource to the water system in the maintenance and protection of the water wells the system relies on for safe drinking water. As a first step, the system should contact TCEQ to inquire about participating in the source water protection plan. Although the system does not have a source water or wellhead protection plan, the subdivision has restrictive covenants prohibiting certain uses of the land that may have the potential to negatively impact source water.

- **Lack of Reserve Fund –** The system does not maintain a reserve account for paying for emergency or future infrastructure needs. They have not raised rates since 1998 and there currently no plans to increase rates. The lack of rate increases for the past 9 years will make it difficult to establish a reserve fund.

4.2 ALTERNATIVE WATER SOURCE DEVELOPMENT

4.2.1 Identification of Alternative Existing Public Water Supply Sources

Using data drawn from the TCEQ drinking water and TWDB groundwater well databases, the PWSs surrounding the Southwest Gardens Water PWS were reviewed with regard to their reported drinking water quality and production capacity. PWSs that appeared to have water supplies with water quality issues were ruled out from evaluation as alternative sources, while those without identified water quality issues were investigated further. Owing to the large number of small (<1 mgd) water systems in the vicinity, small systems were only considered if they were established residential or non residential systems within 10 miles of the Southwest Gardens PWS. Large systems or systems capable of producing greater than four times the daily volume produced by the study system were considered if they were within 15 miles of the study system. A distance of 15 miles was considered to be the upper limit of economic feasibility for constructing a new water line. Table 4.1 is a list of the selected PWSs based on these criteria for large and small PWSs within 15 miles of Southwest Gardens PWS. If it was determined that these PWSs had excess supply capacity and might be willing to sell the excess, or might be a suitable location for a new groundwater well, the system was taken forward for further consideration and identified with “EVALUATE FURTHER” in the comments column of Table 4.1.

Table 4.1 Selected Public Water Systems within 15 Miles of the Southwest Gardens Water

PWS ID	PWS Name	Distance from Southwest Gardens Water (miles)	Comments/Other Issues
1520002	LUBBOCK PWS	2.38	Large SW/GW system. No WQ issues. EVALUATE FURTHER
1520243	TALENT PLUS	3.51	Small NonRes GW system. WQ issues: Fl, Nitrate
1520222	COOPER DRIVE IN	3.62	Small GW system. WQ issues: As, Fl
1520239	STONEGATE GOLF COURSE	3.82	Small NonRes GW system. WQ issues: Fl
1520242	LUBBOCK STOCKYARD	4.2	Small NonRes GW system. WQ issues: Fl
1520064	FORT JACKSON MOBILE ESTATES	4.33	Small GW system. WQ issues: As, Fl, Combined Uranium, Nitrate
1520036	GREEN MOBILE HOME PARK	4.42	Small GW system. WQ issues: As, Fl
1520184	PETES DRIVE IN 4	4.44	Small NonRes GW system. WQ issues: Fl
1520188	CASEY ESTATES WATER	4.45	Small GW system. WQ issues: As, Fl
1520227	SOUTHWEST SPORTS PLEX	4.52	Small GW system. WQ issues: Fl
1520236	PRATERS FOODS INC	4.63	Small NonRes GW system. WQ issues: As, Fl
1520155	COUNTRY SQUIRE MHP 2	4.7	Small GW system. WQ issues: As, Fl
1520199	WOLFFORTH PLACE	4.7	Small GW system. WQ issues: As, Fl, Se
1520182	HORKEY LP GAS CO INC	4.8	Small NonRes GW system. WQ issues: Fl
1520067	114TH STREET MOBILE HOME PARK	5	Small GW system. WQ issues: As, Fl
1520142	COUNTRY SQUIRE MHP 1	5.04	Small GW system. WQ issues: As, Fl, Nitrate
1520005	WOLFFORTH CITY OF	5.29	Large GW system. WQ issues: As, Fl
1520103	RUDD COUNTRY INC	5.33	Small GW system. WQ issues: As, Fl

PWS ID	PWS Name	Distance from Southwest Gardens Water (miles)	Comments/Other Issues
1520180	RIVER SMITHS OUTPOST	5.33	Small GW system. WQ issues: As, Fl
1520163	ADVENTURES USA	5.38	Small NonRes GW system. WQ issues: Fl
1520122	LUBBOCK COOPER ISD	5.44	Small NonRes GW system. WQ issues: As, Fl
1520047	WESTERN TERRACE MOBILE HOME PARK	5.45	Small GW system. WQ issues: As, Fl, Nitrate, Combined Uranium
1520179	TOWN AND COUNTRY INC	5.57	Small NonRes GW system. WQ issues: Fl
1520009	BIG Q MOBILE HOME ESTATES	5.88	Small GW system. WQ issues: As, Fl, Combined Uranium
1520147	BECKER PUMP & PIPE WATER SUPPLY	6.2	Small NonRes GW system. WQ issues: As, Fl
1520130	MCLAIN OIL CO STATION 39	6.21	Small NonRes GW system. WQ issues: As, Fl
1520157	TEXAS WATER RAMPAGE INC	6.25	Small GW system. WQ issues: As, Fl
1520231	CENTRAL FREIGHT LINES	7.13	Small NonRes GW system. WQ issues: As, Fl
1520192	TERRELLS MOBILE HOME PARK	7.29	Small GW system. WQ issues: As, Fl
1520149	WHORTON MOBILE HOME PARK	7.34	Small GW system. WQ issues: As, Fl
1520208	BERNARDS LIQUOR STORE	7.35	Small NonRes GW system. WQ issues: As, Fl
1520223	PAUL COBB WATER SYSTEM	8.24	Small GW system. WQ issues: As, Fl, Se
1520177	FOUR CORNERS GROCERY	9.05	Small NonRes GW system. WQ issues: As, Fl
1520025	BUSTERS MOBILE HOME PARK	9.16	Small GW system. WQ issues: As, Fl
1520156	ELM GROVE MOBILE HOME PARK	9.27	Small GW system. WQ issues: As, Fl, Se
1970003	CRMWA WATER LINE from Lubbock to Tahoka	9.38	Large SW/GW system. No WQ issues. EVALUATE FURTHER
1520039	PECAN GROVE MOBILE HOME PARK	9.46	Small GW system. WQ issues: As, Fl, Se, Nitrate
1520118	WESTGATE VILLAGE MHP	9.46	Small GW system. WQ issues: As, Fl
1530004	NEW HOME CITY OF	9.49	Small GW system. WQ issues: As, Fl
1520020	REESE CENTER	10.84	Large SW system. No WQ issues, however limited data. Purchase water

After the PWSs in Table 4.1 with water quality problems were eliminated from further consideration, the remaining PWSs were screened by proximity to Southwest Gardens PWS and sufficient total production capacity for selling or sharing water. Based on the initial screening summarized in Table 4.1 above, two alternatives were selected for further evaluation. The closest alternative is a connection to the Lubbock PWS and the second alternative is a connection directly to the CRMWA pipeline between Lubbock and Tahoka. As described in Table 4.2, the primary source of water for the distribution system on the east and south sides of the City of Lubbock is the CRMWA. Descriptions of both the City of Lubbock and the CRMWA follow Table 4.2.

Table 4.2 Public Water Systems Within the Vicinity of the Southwest Gardens Water PWS Selected for Further Evaluation

PWS ID	PWS Name	Pop	Conn	Total Production (mgd)	Ave Daily Usage (mgd)	Approx. Dist. from Southwest Gardens Water	Comments/Other Issues
1520002	Lubbock PWS	222,473	81,059	136.077	40.263	2.4 miles	Large SW/GW system that does have excess capacity. The primary source of water for the City of Lubbock in the eastern and southern portions of their distribution system is CRMWA.
1970003	CRMWA Water Line from Lubbock to Tahoka	199,144	72,520	57.94	35.67	9.3 miles	Large SW/GW system that has limited excess capacity. Option involves connecting to pipeline located between Lubbock and Tahoka. Would require CRMWA approval before considering.

4.2.1.1 City of Lubbock Water System

The City of Lubbock PWS produces an average of 38 to 40 mgd for the City of Lubbock and five surrounding small municipalities. The system is capable of meeting a peak demand of over 90 mgd. In addition to treating water for the City of Lubbock distribution system, the Lubbock water treatment plant treats about 6 mgd on average for the six Canadian River Municipal Water Authority (CRMWA) member cities receiving treated water from the City of Lubbock.

The City of Lubbock receives water from two sources, the CRMWA and from the Bailey County well field. Additional details on the CRMWA are provided in a separate description. As a member of the 11-City agreement with the CRMWA, the City of Lubbock is responsible for treating raw water from the Lake Meredith/Roberts County well field located 160 miles north of Lubbock. A CRMWA aqueduct distributes the treated water to six other PWSs: Levelland, Brownfield, Slaton, Tahoka, O'Donnell, and Lamesa. In 2006, the water from CRMWA constituted about 76 percent of the water used by the City of Lubbock. The other 24 percent comes from a well field in Bailey County located 60 miles northwest of Lubbock. The city has water rights to 82,000 surface acres at the Bailey County well field. The water produced by the Bailey County well field is chlorinated before it enters the pipeline leading to Lubbock. As the water reaches Lubbock, it enters directly into the distribution system predominantly in the northwest section of Lubbock. It should be noted that the City of Lubbock normally utilizes their total annual water allocation from CRMWA and if Lubbock needs additional water, their supply is supplemented with water from the Bailey County well field which consists of 150 wells capable of producing 50 mgd total (pipeline is limited to 40 mgd). In 2006, the City of Lubbock pumped an average of 9.3 mgd from the Bailey County well field. However, most of this water was pumped during the summer months with the pipeline near peak capacity at various times.

In addition to the population of Lubbock, five cities are connected to the City of Lubbock distribution system. Shallowater and Reese Redevelopment are located northwest and west of Lubbock and receive water predominantly originating in Bailey County. Buffalo Springs and Ransom Canyon are located east of Lubbock and receive water mostly originating from Lake Meredith/Roberts County well field. A fifth city, Littlefield, located northwest of the City has an emergency water line connected to the Bailey County pipeline. The decision to add these five cities to the City of Lubbock water supply was made by the Lubbock City Council.

Future plans for the City of Lubbock water supply system call for the construction of infrastructure to obtain water from Lake Alan Henry located 65 miles southeast of Lubbock. The project is still in the preliminary engineering phase. The amount of water available from this system will be staged into the existing Lubbock system over several years to match Lubbock's needs. The system is estimated to be operating in 2012.

4.2.1.2 Canadian River Municipal Water Authority

The CRMWA has contracts to provide water to 11 member cities in west Texas, including Amarillo, Borger, Brownfield, Lamesa, Levelland, Lubbock, O'Donnell, Pampa, Plainview, Slaton, and Tahoka. A pipeline ranging in size from 8 feet to 1.5 feet is used to convey untreated water approximately 160 miles from Lake Meredith and a well field in Roberts County (40 miles northeast of Lake Meredith) to the Lubbock water treatment plant. Along the pipeline route, four cities (Amarillo, Borger, Pampa, and Plainview) receive their allocated water supply and each of these four cities treats their own water. The rest of the raw water for the other seven member cities of the CRMWA is treated at the City of Lubbock water treatment plant. The treated water is pumped into the City of Lubbock distribution system and to the other six member cities. The raw water line flows by gravity from Amarillo to the Lubbock treatment plant. The treated water leaving the City of Lubbock water treatment plant flows by gravity in the east leg pipeline to Lamesa; however, the water in the west leg to Levelland and Brownfield is pumped.

The current volume of water delivered annually by the CRMWA to the member cities is 85,000 acre-feet (35,000 acre-feet from Lake Meredith and 50,000 acre-feet from the well field in Roberts County). The available water volume is set by the CRMWA and may fluctuate during the year, but the volume is based on the water levels in the well field and in the lake. The allocation for each member city is based on a contracted percentage of the available volume. The City of Lubbock is under contract to receive 41.6 mgd from the CRMWA, and the City of Lubbock water treatment plant treats an additional 5.4 mgd for the other six member cities. When the CRMWA program was established in the 1960s, the system was designed to accommodate the 11 member cities at the time and there were no plans to add additional member cities.

If a member city has excess water, that particular city can decide to sell that water to a non-member PWS. If the non-member city would receive the water directly from a member city's distribution system, then the CRMWA would not be involved. However, if a non-member is requesting to receive the water (essentially a portion of a member city's allocation) via a direct line from the CRMWA line, then the non-member city must get approval from the

CRMWA and the 11 member cities. The non-member PWS would be responsible for financing the installation of the pipeline to connect to the CRMWA treated water line from Lubbock. The CRMWA would be involved throughout the process of a non-member PWS applying for, securing access to, and eventually receiving water through the CRMWA system.

4.2.2 Potential for New Groundwater Sources

4.2.2.1 Installing New Compliant Wells

Developing new wells or well fields is recommended, provided good quality groundwater available in sufficient quantity can be identified. Since a number of water systems in the area have water quality problems with fluoride and arsenic, it should be possible to share in the cost and effort of identifying compliant groundwater and constructing well fields.

Installation of a new well in the vicinity of the system intake point is likely to be an attractive option provided compliant groundwater can be found, since the PWS is already familiar with the operation of a water well. As a result, existing nearby wells with good water quality should be investigated. Re-sampling and test pumping would be required to verify and determine the quality and quantity of water at those wells.

The use of existing wells should probably be limited to use as indicators of groundwater quality and availability. If a new groundwater source is to be developed, it is recommended that a new well or wells be installed instead of using existing wells. This would ensure well characteristics are known and meet standards for drinking water wells.

Some of the alternatives suggest new wells be drilled in areas where existing wells have acceptable water quality. In developing the cost estimates, Parsons assumed that the aquifer in these areas would produce the required amount of water with only one well. Site investigations and geological research, which are beyond the scope of this study, could indicate whether the aquifer at a particular site and depth would provide the amount of water needed or if more than one well would need to be drilled in separate areas.

4.2.2.2 Results of Groundwater Availability Modeling

Regional groundwater withdrawal in the Texas High Plains region is extensive and likely to remain near current levels over the next decades. In Lubbock County, where the PWS is located, groundwater is available from two sources, the relatively shallow Ogallala aquifer, and the underlying Edwards-Trinity (High Plains) aquifer. The Ogallala provides drinking water to most of the communities in the Texas panhandle, as well as irrigation water. The Edwards-Trinity (High Plains) aquifer has a relatively low-yield, typically in the 50 to 200 gpm range, and is used almost exclusively as an irrigation water source. Supply wells for the Southwest Gardens Water System and its vicinity withdraw groundwater from the southern Ogallala aquifer. No active Edwards-Trinity (High Plains) wells are found within a 10-mile radius of the system.

The Ogallala is the largest aquifer in the United States. The aquifer outcrop underlies much of the Texas High Plains region and eastern New Mexico, and extends eastward beyond Lubbock. The Ogallala provides significantly more water for users than any other aquifer in the state, and is used primarily for irrigation. The aquifer saturated thickness ranges up to an approximate depth of 600 feet; supply wells have an average yield of approximately 500 gpm, but higher yields, up to 2,000 gpm, are found in previously eroded drainage channels filled with coarse-grained sediments (TWDB 2007). Water level declines in excess of 300 feet have occurred in several aquifer areas over the last 50 to 60 years; the rate of decline, however, has slowed in recent years and water levels have risen in a few areas (TWDB 2007). The Texas Water Plan anticipates 24 percent depletion in the Ogallala supply over the next decades, from 5,000,097 acre-feet per year estimated in 2000 to 3,785,409 acre-feet per year in 2050.

A GAM developed for the Ogallala aquifer simulated historical conditions and provided long-term groundwater projections (Blandford, *et al.* 2003). Predictive simulations using the GAM model indicated that, if estimated future withdrawals are realized, aquifer water levels could decline to a point at which significant regions currently practicing irrigated agriculture could be essentially dewatered by 2050. The model predicted the most critical conditions for Cochran, Hockley, Lubbock, Yoakum, Terry, and Gaines Counties where the simulated drawdown could exceed 100 feet. For Lubbock County, the simulated drawdown by the year 2050 would be within a typical 50 to 100 feet range (Blandford, *et al.* 2003). The Ogallala aquifer GAM was not run for the PWS because anticipated use would represent a minor addition to regional withdrawal conditions, beyond the spatial resolution of the GAM model.

4.2.3 Potential for New Surface Water Sources

There is a low potential for development of new surface water sources for the PWS system as indicated by limited water availability within the river basin. The Southwest Gardens Water System is located in the upper Brazos Basin where current surface water availability is expected to decrease up to 17 percent over the next 50 years according to the 2002 Texas Water Plan (from approximately from 1,423,071 acre-feet per year to 1,177,277 acre-feet per year during drought conditions).

In the vicinity of the Southwest Gardens Water System, there is no availability of surface water for new uses. The TCEQ availability map for the Brazos Basin indicates that in the site vicinity, and within the entire Lubbock County, unappropriated flows for new uses are typically available up to 50 percent of the time. This supply is inadequate as the TCEQ requires 100 percent supply availability for a PWS.

4.2.4 Options for Detailed Consideration

The initial review of alternative sources of water results in the following options for more-detailed consideration:

1. Lubbock Public Water System. A pipeline would be constructed from the City of Lubbock distribution system to Southwest Gardens Water (Alternative SW-1).

2. CRMWA Water Line from Lubbock to Tahoka. A pipeline would be constructed from the CRMWA main pipeline that conveys treated water from the Lubbock treatment plant to the City of Tahoka and the water would be piped to Southwest Gardens Water (Alternative SW-2).

3. New Wells at 10, 5, and 1 mile. Installing a new well within 10, 5, or 1 mile of the Southwest Gardens Water PWS would produce compliant water in place of the water produced by the existing active well. This assumes compliant water can be found. A pipeline and pump station would be constructed to transfer the water to the Southwest Gardens Water PWS (Alternatives SW-3, SW-4, and SW-5).

4.3 TREATMENT OPTIONS

4.3.1 Centralized Treatment Systems

Centralized treatment of the well water is identified as a potential option. Reverse osmosis and EDR treatment could all be potentially applicable. The central RO treatment alternative is SW-6 and the central EDR treatment alternative is SW-7.

4.3.2 Point-of-Use Systems

POU treatment using RO is valid for fluoride and arsenic removal. The POU treatment alternative is SW-8.

4.3.3 Point-of-Entry Systems

POE treatment using RO is valid for fluoride and arsenic removal. The POE treatment alternative is SW-9.

4.4 BOTTLED WATER

Providing bottled water is considered an interim measure to be used until a compliance alternative is implemented. Even though the community is small and people know each other; it would be reasonable to require a quarterly communication advising customers of the need to take advantage of the bottled water program. An alternative to providing delivered bottled water is to provide a central, publicly accessible dispenser for treated drinking water. Alternatives addressing bottled water are SW-10, SW-11, and SW-12.

4.5 ALTERNATIVE DEVELOPMENT AND ANALYSIS

A number of potential alternatives for compliance with the MCL for fluoride and arsenic have been identified. Each of the potential alternatives is described in the following subsections. It should be noted that the cost information given is the capital cost and change in O&M costs associated with implementing the particular alternative. Appendix C contains cost estimates for the compliance alternatives. These compliance alternatives represent a range of possibilities, and a number of them are likely not feasible. However, all have been presented to provide a complete picture of the range of alternatives considered. It is anticipated that a PWS will be able to use the information contained herein to select the most attractive alternative(s) for more detailed evaluation and possible subsequent implementation.

4.5.1 Alternative SW-1: Purchase Treated Water from the City of Lubbock

This alternative involves purchasing treated water from the City of Lubbock, which will be used to supply the Southwest Gardens Water PWS. The City of Lubbock currently has sufficient excess capacity for this alternative to be feasible, although current City policy only allows drinking water to be provided to areas annexed by the City and to governmental entities beyond the city limits. For purposes of this report, in order to allow direct and straightforward comparison with other alternatives, this alternative assumes that water would be purchased from the City. Also, it is assumed that Southwest Gardens Water would obtain all its water from the City of Lubbock.

This alternative would require constructing a pipeline from the City of Lubbock water main to the existing storage tank for the Southwest Gardens Water system. A 20,000-gallon storage tank would be placed near the connection to the City's pipeline to receive water. A pump station would also be required to overcome pipe friction and the elevation differences between the City of Lubbock and Southwest Gardens Water. The required 4-inch pipeline would be approximately 2.39 miles long. See Figure 4.1 for pipeline route. It is assumed the piping would be installed with capacity to meet all water demand for the Southwest Gardens Mobile Home Park, since the incremental cost would be relatively small, and would provide operational flexibility.

By definition this alternative involves regionalization, since Southwest Gardens Water would be obtaining drinking water from an existing larger supplier. Also, other PWSs near Southwest Gardens Water are in need of compliant drinking water and could share in implementation of this alternative.

The estimated capital cost for this alternative includes constructing the pipeline, storage tank, building, and pump station. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost related to current operation of the Southwest Gardens Water's wells, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $702,500, and the alternatives' estimated annual O&M cost is $36,000.

The reliability of adequate amounts of compliant water under this alternative should be good. City of Lubbock provides treated surface water on a large scale, facilitating adequate O&M resources. From the perspective of Southwest Gardens Water, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pumps are well understood. If the decision were made to perform blending then the operational complexity would increase.

The feasibility of this alternative is dependent on an agreement being reached with the City of Lubbock to purchase treated drinking water

4.5.2 Alternative SW-2: Purchase Treated Water from the CRMWA Water Line from Lubbock to Tahoka

This alternative involves purchasing compliant water from the CRMWA, which would be used to supply Southwest Gardens Water. As previously stated, Southwest Gardens Water must get approval from the CRMWA and 11 member cities to construct a direct water line from the CRMWA main distribution line to the city's water supply.

This alternative would require construction of a pump station, a 20,000-gallon feed tank at a point adjacent to CRMWA's main distribution line, and a 4-inch pipeline from the pump station to Southwest Gardens Water. Using the pipeline route shown on Figure 4.1, the length of pipe required would be approximately 9.32 miles.

The pump station would include two pumps, including one standby, and would be housed in a building. It is assumed the pumps and piping would be installed with capacity to meet all water demand for Southwest Gardens Water, since the incremental cost would be relatively small, and it would provide operational flexibility.

The estimated capital cost for this alternative includes constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost that Southwest Gardens Water currently pays to operate its well field, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $2.35 million, and the alternative's estimated annual O&M cost is $25,100. If the purchased water was used for blending rather than for the full water supply, the annual O&M cost for this alternative could be reduced because of reduced pumping costs and reduced water purchase costs. However, additional costs would be incurred for equipment to ensure proper blending, and additional monitoring to ensure the finished water is compliant.

The reliability of adequate amounts of compliant water under this alternative should be good. The CRMWA has adequate O&M resources. From the perspective of Southwest Gardens Water, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood, and Southwest Gardens Water personnel currently operate pipelines and pump stations. If the decision were made to perform blending then the operational complexity would increase.

The feasibility of this alternative is dependent on an agreement being reached between Southwest Gardens Water, the CRMWA, and 11-member cities to purchase compliant drinking water.

4.5.3 Alternative SW-3: New Well at 10 miles

This alternative consists of installing one new well within 10 miles of the Southwest Gardens Water that would produce compliant water in place of the water produced by the existing wells. At this level of study, it is not possible to positively identify an existing well or the location where a new well could be installed.

This alternative would require constructing one new 300-foot well, two new pump stations with storage tanks near each pump station, and a pipeline from the new well to the existing intake point for the Southwest Gardens Water system. For this alternative, the 4-inch pipeline is assumed to be approximately 10 miles long. Each pump station would include two transfer pumps, including one standby, and would be housed in a building. The new storage tank would include two service pumps, including one standby, and would be housed in a building.

Depending on well location and capacity, this alternative could present some options for a more regional solution. It may be possible to share water and costs with another nearby system.

The estimated capital cost for this alternative includes installing the well, constructing the pipeline, the pump stations, the storage tank, service pumps, and pump house. The estimated O&M cost for this alternative includes O&M for the pipeline and pump stations, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing Southwest Gardens Water wells. The estimated capital cost for this alternative is $2.74 million, and the estimated annual O&M cost for this alternative is $38,700.

The reliability of adequate amounts of compliant water under this alternative should be good, since water wells, pump stations and pipelines are commonly employed. From the perspective of Southwest Gardens Water, this alternative would be similar to operate as the existing system. Southwest Gardens Water personnel have experience with O&M of wells, pipelines and pump stations.

The feasibility of this alternative is dependent on the ability to find an adequate existing well or success in installing a well that produces an adequate supply of compliant water. It is likely that an alternate groundwater source would not be found on land owned by Southwest Gardens Water, so landowner cooperation would likely be required.

4.5.4 Alternative SW-4: New Well at 5 miles

This alternative consists of installing one new well within 5 miles of the Southwest Gardens Water that would produce compliant water in place of the water produced by the existing wells. At this level of study, it is not possible to positively identify an existing well or the location where a new well could be installed.

This alternative would require constructing one new 300-foot well, a new pump station with feed tank near the new well, a pipeline from the new well/feed tank to a new 20,000-gallon storage tank with a service pump installed within the pumphouse near the existing intake point for the Southwest Gardens Water system. The pump station and feed tank would be necessary to overcome pipe friction and changes in land elevation. For this alternative, the pipeline is assumed to be approximately 5 miles long, and would be a 4-inch water line that discharges to a new storage tank at the Southwest Gardens Water PWS. The pump station near the well would include two transfer pumps, including one standby, and would be housed in a building.

Depending on well location and capacity, this alternative could present some options for a more regional solution. It may be possible to share water and costs with another nearby system.

The estimated capital cost for this alternative includes installing the well, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes O&M for the pipeline and pump station, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing Southwest Gardens Water wells. The estimated capital cost for this alternative is $1.46 million, and the estimated annual O&M cost saving for this alternative is $19,500.

The reliability of adequate amounts of compliant water under this alternative should be good, since water wells, pump stations and pipelines are commonly employed. From the perspective of Southwest Gardens Water, this alternative would be similar to operate as the existing system. Southwest Gardens Water personnel have experience with O&M of wells, pipelines and pump stations.

The feasibility of this alternative is dependent on the ability to find an adequate existing well or success in installing a well that produces an adequate supply of compliant water. It is likely an alternate groundwater source would not be found on land owned by Southwest Gardens Water, so landowner cooperation would likely be required.

4.5.5 Alternative SW-5: New Well at 1 mile

This alternative consists of installing one new well within 1 mile of the Southwest Gardens Water that would produce compliant water in place of the water produced by the existing wells. At this level of study, it is not possible to positively identify an existing well or the location where a new well could be installed.

This alternative would require constructing one new 300-foot well and a pipeline from the new well to the existing intake point for the Southwest Gardens Water system. For this alternative, the pipeline is assumed to be approximately 1 mile long, and would be a 4-inch water line that discharges to an existing storage tank at the Southwest Gardens Water PWS.

The estimated capital cost for this alternative includes installing the well, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes O&M for the pipeline and pump station, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing Southwest Gardens Water wells. The estimated capital cost for this alternative is $333,100, and the estimated annual O&M cost savings for this alternative is $600.

The reliability of adequate amounts of compliant water under this alternative should be good, since water wells, pump stations and pipelines are commonly employed. From the perspective of Southwest Gardens Water, this alternative would be similar to operate as the existing system. Southwest Gardens Water personnel have experience with O&M of wells, pipelines and pump stations.

The feasibility of this alternative is dependent on the ability to find an adequate existing well or success in installing a well that produces an adequate supply of compliant water. It is possible an alternate groundwater source would not be found on land owned by Southwest Gardens Water, so landowner cooperation may be required.

4.5.6 Alternative SW-6: Central RO Treatment

This system would continue to pump water from the existing wells, and would treat the water through an RO system prior to distribution. For this option, 100 percent of the raw water would be treated to obtain compliant water. The RO process concentrates impurities in the reject stream which would require disposal. It is estimated the RO reject generation would be approximately 50,000 gallons per day (gpd) when the system is operated at full flow.

This alternative consists of constructing the RO treatment plant near the existing wells. The plant is composed of a 500 square foot building with a paved driveway; a skid with the pre-constructed RO plant; and a 200,000-gallon pond for storing reject water. The treated water would be chlorinated and stored in the existing water storage tank prior to being pumped into the distribution system. The entire facility is fenced.

The estimated capital cost for this alternative is $605,100, and the estimated annual O&M cost is $84,700.

The reliability of adequate amount of compliant water under this alternative is good, since RO treatment is a common and well-understood treatment technology. However, O&M efforts required for the central RO treatment plant may be significant, and O&M personnel would require training with RO. The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

4.5.7 Alternative SW-7: Central EDR Treatment

The system would continue to pump water from the existing wells, and would treat the water through an EDR system prior to distribution. For this option the EDR would treat the full flow without bypass as the EDR operation can be tailored for desired removal efficiency. It is estimated the EDR reject generation would be approximately 22,200 gpd when the system is operated at full flow.

This alternative consists of constructing the EDR treatment plant near the existing wells. The plant is composed of a 500 square foot building with a paved driveway; a skid with the pre-constructed EDR system; and a 200,000-gallon pond for storing concentrated water. The treated water would be chlorinated and stored in the existing water storage tank prior to being pumped into the distribution system. The entire facility is fenced.

The estimated capital cost for this alternative is $764,600 and the estimated annual O&M cost is $67,700.

The reliability of adequate amounts of compliant water under this alternative is good, since EDR treatment is a common and well-understood treatment technology. However, O&M efforts required for the central EDR treatment plant may be significant, and O&M personnel would require training with EDR. The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

4.5.8 Alternative SW-8: Point-of-Use Treatment

This alternative consists of the continued operation of the Southwest Gardens Water well fields, plus treatment of water to be used for drinking or food preparation at the point of use to remove fluoride and arsenic. The purchase, installation, and maintenance of POU treatment systems to be installed "under the sink" would be necessary for this alternative. Blending is not an option in this case. According to TCEQ, when PWSs use POU treatment systems for compliance, they must provide programs for long-term operation, maintenance, and monitoring to ensure proper performance.

This alternative would require installing the POU treatment units in residences and other buildings that provide drinking or cooking water. Southwest Gardens Water staff would be responsible for purchase and maintenance of the treatment units, including membrane and filter replacement, periodic sampling, and necessary repairs. In houses, the most convenient point for installation of the treatment units is typically under the kitchen sink, with a separate tap installed for dispensing treated water. Installation of the treatment units in kitchens will require the entry of Southwest Gardens Water or contract personnel into the houses of customers. As a result, cooperation of customers would be important for success implementing this alternative. The treatment units could be installed so they could be accessed without house entry, but that would complicate the installation and increase costs.

POU treatment processes would involve RO. RO treatment processes produce a reject waste stream. The reject waste streams result in a slight increase in the overall volume of water used. POU systems have the advantage that only a minimum volume of water is treated (only that for human consumption). This minimizes the size of the treatment units, the increase in water required, and the waste for disposal. For this alternative, it is assumed the increase in water consumption is insignificant in terms of supply cost, and that the reject waste stream can be discharged to the house septic or sewer system.

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing and installing the POU treatment systems. The estimated O&M cost for this alternative includes the purchase and replacement of filters and membranes, as well as periodic sampling and record keeping as required by the Texas Administrative Code (Title 30, Part I, Chapter 290, Subchapter F, Rule 290.106). The estimated capital cost for this alternative is $154,700, and the estimated annual O&M cost for this alternative is $115,600. For the cost estimate, it is assumed that one POU treatment unit will be required for each of the 125 existing connections in the Southwest Gardens Water system. It should be noted that the POU treatment units would need to be more complex than units typically found in commercial retail outlets in order to meet regulatory requirements, making purchase and installation more expensive. Additionally, capital cost would increase if POU treatment units are placed at other taps within a home, such as refrigerator water dispensers, ice makers, and bathroom sinks.

The reliability of adequate amounts of compliant water under this alternative is fair, since it relies on the active cooperation of the customers for system installation, use, and maintenance, and only provides compliant water to single tap within a house. Additionally, the O&M efforts (including monitoring of the devices to ensure adequate performance) required for the POU systems will be significant, and the current personnel are inexperienced in this type of work. From the perspective of Southwest Gardens Water, this alternative would be characterized as more difficult to operate owing to the in-home requirements and the large number of individual units.

The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

4.5.9 Alternative SW-9: Point-of-Entry Treatment

This alternative consists of the continued operation of the Southwest Gardens Water well fields, plus treatment of water as it enters residences to remove fluoride and arsenic. The purchase, installation, and maintenance of the treatment systems at the point of entry to a household would be necessary for this alternative. Blending is not an option in this case.

This alternative would require the installation of the POE treatment units at houses and other buildings that provide drinking or cooking water. Every building connected to the system must have a POE device installed, maintained, and adequately monitored. TCEQ must be assured that the system has 100 percent participation of all property and or building owners. A way to achieve 100 percent participation is through a public announcement and education program. Example public programs are provided in the document "*Point-of-Use or Point-of-Entry" Treatment Options for Small Drinking Water Systems*" published by USEPA. The property owner's responsibilities for the POE device must also be contained in the title to the property and "run with the land" so subsequent property owners understand their responsibilities (USEPA 2006).

Southwest Gardens would be responsible for purchase, operation, and maintenance of the treatment units, including membrane and filter replacement, periodic sampling, and necessary repairs. It may also be desirable to modify piping so water for non-consumptive uses can be withdrawn upstream of the treatment unit. The POE treatment units would be installed outside the residences, so entry would not be necessary for O&M. Some cooperation from customers would be necessary for installation and maintenance of the treatment systems.

Point-of-Entry treatment for arsenic and fluoride would involve RO. Treatment processes produce a reject stream that requires disposal. The reject stream results in a slight increase in the overall volume of water used. POE systems treat a greater volume of water than POU systems. For this alternative, it is assumed the increase in water consumption is insignificant in terms of supply cost, and that the reject waste stream can be discharged to the house septic or sewer system.

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing and installing the POE treatment systems. The estimated O&M cost for this alternative includes the purchase and replacement of filters and membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $1.86 million, and the estimated annual O&M cost for this alternative is $275,000. For the cost estimate, it is assumed that one POE treatment unit will be required for each of the 125 existing connections in the Southwest Gardens Water system.

The reliability of adequate amounts of compliant water under this alternative are fair, but better than POU systems since it relies less on the active cooperation of the customers for system installation, use, and maintenance, and compliant water is supplied to all taps within a house. Additionally, the O&M efforts required for the POE systems will be significant, and the current personnel are inexperienced in this type of work. From the perspective of Southwest Gardens Water, this alternative would be characterized as more difficult to operate owing to the on-property requirements and the large number of individual units.

The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

4.5.10 Alternative SW-10: Public Dispenser for Treated Drinking Water

This alternative consists of the continued operation of the Southwest Gardens Water wells, plus dispensing treated water for drinking and cooking at a publicly accessible location. Implementing this alternative would require purchasing and installing a treatment unit where customers would be able to come and fill their own containers. This alternative also includes notifying customers of the importance of obtaining drinking water from the dispenser. In this way, only a relatively small volume of water requires treatment, but customers would be required to pick up and deliver their own water. Blending is not an option in this case. It should be noted that this alternative would be considered an interim measure until a compliance alternative is implemented.

Southwest Gardens Water personnel would be responsible for maintenance of the treatment unit, including membrane replacement, periodic sampling, and necessary repairs. The spent membranes will require disposal. This alternative relies on a great deal of cooperation and action from the customers in order to be effective.

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing and installing the treatment system to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes purchasing and replacing filters and membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $17,400, and the estimated annual O&M cost for this alternative is $37,200.

The reliability of adequate amounts of compliant water under this alternative is fair, because of the large amount of effort required from the customers and the associated inconvenience. Southwest Gardens Water PWS has not provided this type of service in the past. From the perspective of Southwest Gardens Water, this alternative would be characterized as relatively easy to operate, since these types of treatment units are highly automated, and there is only one dispensing unit.

The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

4.5.11 Alternative SW-11: 100 Percent Bottled Water Delivery

This alternative consists of the continued operation of the Southwest Gardens Water wells, but compliant drinking water will be delivered to customers in containers. This alternative involves setting up and operating a bottled water delivery program to serve all the customers in the system. It is expected that Southwest Gardens Water would find it most convenient and economical to contract a bottled water service. The bottle delivery program would have to be flexible enough to allow the delivery of smaller containers should customers be incapable of lifting and manipulating 5-gallon bottles. Blending is not an option in this case. It should be noted that this alternative would be considered an interim measure until a compliance alternative is implemented.

This alternative does not involve capital cost for construction, but would require some initial costs for system setup, and then ongoing costs to have the bottled water furnished. It is assumed for this alternative that bottled water is provided to 100 percent of the Southwest Gardens Water PWS customers.

This alternative does not present options for a regional solution.

The estimated initial capital cost is for setting up the program. The estimated O&M cost for this alternative includes program administration and purchase of the bottled water. The estimated capital cost for this alternative is $24,000, and the estimated annual O&M cost for this alternative is $160,600. For the cost estimate, it is assumed that each person requires 1 gallon of bottled water per day.

The reliability of adequate amounts of compliant water under this alternative is fair, since it relies on the active cooperation of customers to order and utilize the water. Management and administration of the bottled water delivery program will require attention from Southwest Gardens Water.

The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

4.5.12 Alternative FW-12: Public Dispenser for Trucked Drinking Water

This alternative consists of continued operation of the Southwest Gardens Water wells, plus dispensing compliant water for drinking and cooking at a publicly accessible location. The compliant water would be purchased from the City of Lubbock, and delivered by truck to a tank at a central location where customers would be able to fill their own containers. This alternative also includes notifying customers of the importance of obtaining drinking water from the dispenser. In this way, only a relatively small volume of water requires treatment, but customers are required to pick up and deliver their own water. Blending is not an option in this case. It should be noted that this alternative would be considered an interim measure until a compliance alternative is implemented.

Southwest Gardens Water would purchase a truck that would be suitable for hauling potable water, and install a storage tank. It is assumed the storage tank would be filled once a week, and that the chlorine residual would be tested for each truckload. The truck would have to meet requirements for potable water, and each load would be treated with bleach. This alternative relies on a great deal of cooperation and action from the customers for it to be effective.

This alternative presents limited options for a regional solution if two or more systems share the purchase and operation of the water truck.

The estimated capital cost for this alternative includes purchasing a water truck and construction of the storage tank to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes O&M for the truck, maintenance for the tank, water quality testing, record keeping, and water purchase, The estimated capital cost for this alternative is $134,900, and the estimated annual O&M cost for this alternative is 33,400.

The reliability of adequate amounts of compliant water under this alternative is fair because of the large amount of effort required from the customers and the associated inconvenience. Current personnel have not provided this type of service in the past. From the perspective of Southwest Gardens Water, this alternative would be characterized as relatively easy to operate, but the water hauling and storage would have to be done with care to ensure sanitary conditions.

The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

4.5.13 Summary of Alternatives

Table 4.3 provides a summary of the key features of each alternative for Southwest Gardens Water PWS.

1 **Table 4.3 Summary of Compliance Alternatives for Southwest Gardens Water PWS**

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
SW-1	Purchase water from the City of Lubbock	- Pump station - 2.39-mile pipeline	$702,500	$36,000	$97,200	Good	N	Agreement must be successfully negotiated with City of Lubbock and easements must be acquired. Blending may be possible. .
SW-2	Purchase water from CRMWA water line from Lubbock to Tahoka	- Pump station - 9.32-mile pipeline	$2,354,400	$25,000	$230,400	Good	N	Agreement must be successfully negotiated with the 11 member cities of the CRMWA. Costs could possibly be shared with small systems along pipeline route.
SW-3	Install new compliant well at 10 miles	- New well - Storage tank - 2 Pump stations - 10-mile pipeline	$2,741,500	$38,700	$277,700	Good	N	May be difficult to find well with good water quality. Costs could possibly be shared with small systems along pipeline route.
SW-4	Install new compliant well at 5 miles	- New well - Storage tank - Pump station - 5-mile pipeline	$1,455,900	$19,500	$146,500	Good	N	May be difficult to find well with good water quality. Costs could possibly be shared with small systems along pipeline route.
SW-5	Install new compliant well at 1 mile	- New well - 1-mile pipeline	$333,100	$600	$29,600	Good	N	May be difficult to find well with good water quality.
SW-6	Continue operation of Southwest Gardens Water well field with central RO treatment	- Central RO treatment plant	$605,100	$84,700	$137,500	Good	T	Costs could possibly be shared with nearby small systems.
SW-7	Continue operation of Southwest Gardens Water well field with central EDR treatment	- Central EDR treatment plant	$764,600	$67,700	$134,400	Good	T	Costs could possibly be shared with nearby small systems.
SW-8	Continue operation of Southwest Gardens Water well field, and POU treatment	- POU treatment units.	$154,700	$115,600	$129,100	Fair	T, M	Only one compliant tap in home. Cooperation of residents required for installation, maintenance, and testing.
SW-9	Continue operation of Southwest Gardens Water well field, and POE treatment	- POE treatment units.	$1,856,300	$275,000	$436,800	Fair (*better than POU*)	T, M	All home taps compliant and less resident cooperation required.
SW-10	Continue operation of Southwest Gardens Water well field, but furnish public dispenser for treated drinking water	- Water treatment and dispenser unit	$17,400	$37,200	$38,700	Fair/interim measure	T	Does not provide compliant water to all taps, and requires a lot of effort by customers.
SW-11	Continue operation of Southwest Gardens Water well field, but furnish bottled drinking	- Set up bottled water system	$24,000	$160,600	$162,700	Fair/interim measure	M	Does not provide compliant water to all taps, and requires customers to order and use. Management of program may be significant.

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
	water for all customers							
SW-12	Continue operation of Southwest Gardens Water well field, but furnish public dispenser for trucked drinking water.	- Construct storage tank and dispenser - Purchase potable water truck	$134,900	$33,400	$45,200	Fair/interim measure	M	Does not provide compliant water to all taps, and requires a lot of effort by customers.

Notes: *N – No significant increase required in technical or management capability*
T – Implementation of alternative will require increase in technical capability
M – Implementation of alternative will require increase in management capability
1 – See cost breakdown in Appendix C
2 – 20-year return period and 6 percent interest

4.6 MAJOR REGIONAL SOLUTIONS

A concept for a regional solution to provide compliant drinking water to PWSs near Lubbock and surrounding counties was developed and evaluated to investigate whether a large-scale regional approach might be more cost-effective than each PWS seeking its own solution. The development and evaluation of the Lubbock Area Regional Solutions is described in Appendix E. It was found that a regional solution to serving non-compliant PWSs in the Lubbock area presents a potentially viable solution to an existing problem. A regional system could be implemented within a cost-per-connection range of $59/month ($711/year) to $189/month ($2,266/year), with the actual cost depending on the source and costs of capital funds needed to build a regional system.

4.7 COST OF SERVICE AND FUNDING ANALYSIS

To evaluate the financial impact of implementing the compliance alternatives, a 30-year financial planning model was developed. This model can be found in Appendix D. The financial model is based on estimated cash flows, with and without implementation of the compliance alternatives. Data for such models are typically derived from established budgets, audited financial reports, published water tariffs, and consumption data. Southwest Gardens Water is a small facility, having 125 connections, which serves a population of 375. Information that was available to complete the financial analysis included 2006 revenues and the current water rates which were obtained from the owner of the facility. The sole tracked expense for the facility was the cost of contract labor for operating the system. Southwest Gardens water usage for 2006 was calculated using the revenue and water rate data provided by the owner. System expenditures for Southwest Gardens were provided as $24,000 per year.

This analysis will need to be performed in a more detailed fashion and applied to alternatives that are deemed attractive and worthy of more detailed evaluation. A more detailed analysis should include additional factors such as:

- Cost escalation,
- Price elasticity effects where increased rates may result in lower water consumption,
- Costs for other system upgrades and rehabilitation needed to maintain compliant operation.

4.7.1 Financial Plan Development

Financial records for Southwest Gardens Water were limited to revenues and current water rates. Tracked expenses were limited to contract labor for operating the PWS system. As a result additional expenses, typical for a PWS with 125 connections were estimated. Annual revenue for the PWS was $43,861. The current base rate of $24.50 per month per connection, an actual usage at a rate of $2.10 per 1,000 gallons, and a 1.5 percent water loss factor were used to calculate the annual water usage of 10,000,000 gallons. These values were entered into the financial model. Expenses other than for contract labor which amounted to $24,000 were estimated for the Southwest Gardens Water PWS, and are shown in Table 4.4.

4.7.2 Current Financial Condition

4.7.2.1 Cash Flow Needs

Based on estimates provided by the system operator, the current average annual water bill for residential customers of Country Village Mobile Home Estates is estimated to be $390, or 1.1 percent of the annual household income of $35,189. Because of the lack of separate financial data exclusively for the water system, it is difficult to determine exact cash flow needs. However, it appears that water usage revenues are sufficient to fund water system expenses.

4.7.2.2 Ratio Analysis

Current Ratio

The Current Ratio for the Country Village Mobile Home Estates water system could not be determined due to lack of financial data.

Debt to Net Worth Ratio

A Debt-to-Net-Worth Ratio also could not be determined owing to lack of financial data.

Operating Ratio = 2.0

Because of the lack of complete separate financial data on expenses specifically related to the Southwest Gardens water system, an accurate Operating Ratio could not be accurately determined. The system's estimated operating expenditures of approximately $24,000 are less than the operating revenues, with a resulting operating ratio of 2.0. An operating ratio of 2.0 indicates that the system revenues are adequate to cover the system's operating expenses. Water rates may need to be raised to meet the costs of implementing any of the water treatment alternatives.

4.7.3 Financial Plan Results

Each compliance alternative for Southwest Gardens Water was evaluated, with emphasis on the impact on affordability (expressed as a percentage of household income), and the overall increase in water rates necessary to pay for the improvements. Each alternative was examined under the various funding options described in Section 2.4.

For State Revolving Fund (SRF) funding options, customer MHI compared to the state average determines the availability of subsidized loans. The MHI for customers of Southwest Gardens is $35,189, compared to a statewide average of $41,000, or 86 percent of the statewide average. Since the MHI for Southwest Gardens is greater than 75 percent of the statewide average, the Southwest Gardens Water PWS does not qualify for any discounted interest rates or principal forgiveness. Non-discounted SFR interest rates for Drinking Water projects range from 2.95 percent to 3.85 percent.

Results of the financial impact analysis are provided in Table 4.4 and Figure 4.2. Table 4.4 presents rate impacts assuming that any deficiencies in reserve accounts are funded immediately in the year following the occurrence of the deficiency, which would cause the first few years' water rates to be higher than they would be if the reserve account was built-up over a longer period of time. Figure 4.2 provides a bar chart that, in terms of the yearly billing to an average customer (28,125 gallons/day consumption), shows the following:

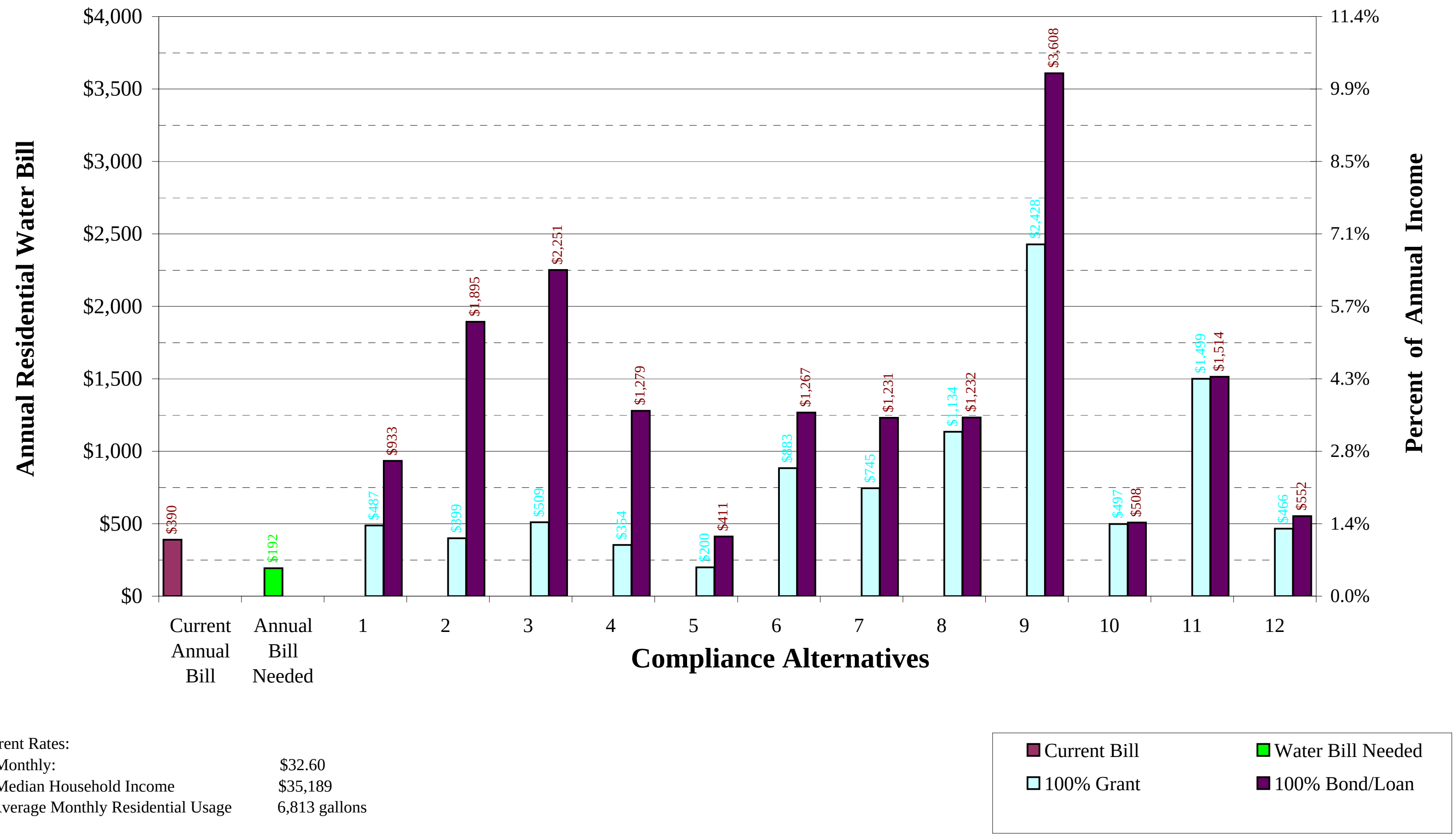
- Current annual average bill,
- Projected annual average bill including rate increase, if needed, to match existing expenditures, and
- Projected annual bill including rate increases needed to fund implementation of a compliance alternative (this does not include funding for reserve accounts).

The two bars shown for each compliance alternative represent the rate changes necessary for revenues to match total expenditures assuming 100 percent grant funding and 100 percent loan/bond funding. Most funding options will fall between 100 percent grant and 100 percent loan/bond funding, with the exception of 100 percent revenue financing. Establishing or increasing reserve accounts would require an increase in rates. If existing reserves are insufficient to fund a compliance alternative, rates would need to be raised before implementing the compliance alternative. This would allow for accumulation of sufficient reserves to avoid larger but temporary rate increases during the years the compliance alternative was being implemented.

Table 4.4 Southwest Gardens - Financial Impact on Households

Alternative	Description		All Revenue	100% Grant	75% Grant	50% Grant	SRF	Bond
1	Purchase Water from Lubbock PWS	Max % of HH Income	16%	2%	2%	3%	4%	4%
		Max % Rate Increase Compared to Current	1337%	50%	107%	164%	251%	279%
		Average Water Bill Required by Alternative	$ 5,099.36	$ 517.93	$ 715.91	$ 913.89	$ 1,214.21	$ 1,309.85
2	Purchase Water from CRA Lubbock-Tahoka	Max % of HH Income	54%	1%	3%	5%	9%	10%
		Max % Rate Increase Compared to Current	4754%	0%	196%	388%	679%	771%
		Average Water Bill Required by Alternative	$ 17,140.51	$ 390.10	$ 1,030.43	$ 1,693.93	$ 2,700.38	$ 3,020.92
3	New Well at 10 Miles	Max % of HH Income	63%	2%	4%	7%	10%	12%
		Max % Rate Increase Compared to Current	5588%	61%	284%	508%	846%	954%
		Average Water Bill Required by Alternative	$ 20,076.53	$ 556.38	$ 1,328.95	$ 2,101.53	$ 3,273.45	$ 3,646.68
4	New Well at 5 Miles	Max % of HH Income	33%	1%	2%	4%	6%	6%
		Max % Rate Increase Compared to Current	2881%	0%	100%	218%	398%	456%
		Average Water Bill Required by Alternative	$ 10,541.83	$ 390.10	$ 700.16	$ 1,110.46	$ 1,732.83	$ 1,931.04
5	New Well at 1 Mile	Max % of HH Income	7%	1%	1%	1%	1%	1%
		Max % Rate Increase Compared to Current	543%	0%	0%	0%	0%	11%
		Average Water Bill Required by Alternative	$ 2,305.05	$ 390.10	$ 390.10	$ 390.10	$ 390.10	$ 402.33
6	Central Treatment - Reverse Osmosis	Max % of HH Income	15%	4%	4%	5%	6%	6%
		Max % Rate Increase Compared to Current	1236%	253%	302%	351%	426%	450%
		Average Water Bill Required by Alternative	$ 4,729.62	$ 1,194.70	$ 1,365.24	$ 1,535.77	$ 1,794.45	$ 1,876.84
7	Central Treatment - Electro-dialysis Reversal	Max % of HH Income	18%	3%	4%	5%	6%	6%
		Max % Rate Increase Compared to Current	1533%	182%	244%	306%	401%	431%
		Average Water Bill Required by Alternative	$ 5,779.66	$ 959.09	$ 1,174.57	$ 1,390.05	$ 1,716.92	$ 1,821.01
8	Point-of-Use Treatment	Max % of HH Income	5%	5%	5%	6%	6%	6%
		Max % Rate Increase Compared to Current	381%	381%	394%	407%	426%	432%
		Average Water Bill Required by Alternative	$ 1,705.23	$ 1,624.17	$ 1,667.77	$ 1,711.36	$ 1,777.48	$ 1,798.54
9	Point-of-Entry Treatment	Max % of HH Income	48%	13%	14%	16%	19%	19%
		Max % Rate Increase Compared to Current	4237%	1045%	1196%	1347%	1577%	1650%
		Average Water Bill Required by Alternative	$ 15,253.72	$ 3,837.21	$ 4,360.31	$ 4,883.41	$ 5,676.91	$ 5,929.62
10	Public Dispenser for Treated Drinking Water	Max % of HH Income	2%	2%	2%	2%	2%	2%
		Max % Rate Increase Compared to Current	55%	55%	56%	58%	60%	61%
		Average Water Bill Required by Alternative	$ 544.58	$ 535.47	$ 540.37	$ 545.27	$ 552.71	$ 555.08
11	Supply Bottled Water to 100% of Population	Max % of HH Income	7%	7%	7%	7%	7%	7%
		Max % Rate Increase Compared to Current	569%	569%	571%	573%	576%	576%
		Average Water Bill Required by Alternative	$ 2,261.19	$ 2,248.61	$ 2,255.38	$ 2,262.14	$ 2,272.40	$ 2,275.67
12	Central Trucked Drinking Water	Max % of HH Income	3%	2%	2%	2%	2%	2%
		Max % Rate Increase Compared to Current	150%	39%	50%	61%	78%	83%
		Average Water Bill Required by Alternative	$ 916.96	$ 482.82	$ 520.83	$ 558.83	$ 616.47	$ 634.83

Figure 4-2 Southwest Gardens - Alternative Cost Summary



Current Rates:

Monthly:	$32.60
Median Household Income	$35,189
Average Monthly Residential Usage	6,813 gallons

SECTION 5
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APPENDIX A
PWS INTERVIEW FORM

CAPACITY DEVELOPMENT ASSESSMENT FORM

*Prepared By*___________________________________ *Date*___________________________

Section 1. Public Water System Information

1. PWS ID #
2. Water System Name
3. County
4. Owner
   Address
   Tele.
   E-mail
   Fax
   Message
5. Admin
   Address
   Tele.
   E-mail
   Fax
   Message
6. Operator
   Address
   Tele.
   E-mail
   Fax
   Message
7. Population Served
8. No. of Service Connections
9. Ownership Type
10. Metered (Yes or No)
11. Source Type
12. Total PWS Annual Water Used
13. Number of Water Quality Violations (Prior 36 months)

    Total Coliform

    Chemical/Radiological

    Monitoring (CCR, Public Notification, etc.)

    Treatment Technique, D/DBP

A. Basic Information

1. Name of Water System:

2. Name of Person Interviewed:

3. Position:

4. Number of years at job:

5. Number of years experience with drinking water systems:

6. Percent of time (day or week) on drinking water system activities, with current position (how much time is dedicated exclusively to the water system, not wastewater, solid waste or other activities):

7. Certified Water Operator (Yes or No):

   If Yes,
   7a. Certification Level (water):

   7b. How long have you been certified?

8. Describe your water system related duties on a typical day.

B. Organization and Structure

1. Describe the organizational structure of the Utility. Please provide an organizational chart. (Looking to find out the governance structure (who reports to whom), whether or not there is a utility board, if the water system answers to public works or city council, etc.)

2. If not already covered in Question 1, to whom do you report?

3. Do all of the positions have a written job description?

   3a. If yes, is it available to employees?

   3b. May we see a copy?

C. Personnel

1. What is the current staffing level (include all personnel who spend more than 10% of their time working on the water system)?

2. Are there any vacant positions? How long have the positions been vacant?

3. In your opinion, is the current staffing level adequate? If not adequate, what are the issues or staffing needs (how many and what positions)?

4. What is the rate of employee turnover for management and operators? What are the major issues involved in the turnover (e.g., operator pay, working conditions, hours)?

5. Is the system staffed 24 hours a day? How is this handled (on-site or on-call)? Is there an alarm system to call an operator if an emergency occurs after hours?

D. Communication

1. Does the utility have a mission statement? If yes, what is it?

2. Does the utility have water quality goals? What are they?

3. How are your work priorities set?

4. How are work tasks delegated to staff?

5. Does the utility have regular staff meetings? How often? Who attends?

6. Are there separate management meetings? If so, describe.

7. Do management personnel ever visit the treatment facility? If yes, how often?

8. Is there effective communication between utility management and state regulators (e.g., NMED)?

9. Describe communication between utility and customers.

E. Planning and Funding

1. Describe the rate structure for the utility.

2. Is there a written rate structure, such as a rate ordinance? May we see it?

    2a. What is the average rate for 6,000 gallons of water?

3. How often are the rates reviewed?

4. What process is used to set or revise the rates?

5. In general, how often are the new rates set?

6. Is there an operating budget for the water utility? Is it separate from other activities, such as wastewater, other utilities, or general city funds?

7. Who develops the budget, how is it developed and how often is a new budget created or the old budget updated?

8. How is the budget approved or adopted?

9. In the last 5 years, how many budget shortfalls have there been (i.e., didn't collect enough money to cover expenses)? What caused the shortfall (e.g., unpaid bills, an emergency repair, weather conditions)?

    9a. How are budget shortfalls handled?

10. In the last 5 years how many years have there been budget surpluses (i.e., collected revenues exceeded expenses?

    10a. How are budget surpluses handled (i.e., what is done with the money)?

11. Does the utility have a line-item in the budget for emergencies or some kind of emergency reserve account?

12. How do you plan and pay for short-term system needs?

13. How do you plan and pay for long- term system needs?

14. How are major water system capital improvements funded? Does the utility have a written capital improvements plan?

15. How is the facility planning for future growth (either new hook-ups or expansion into new areas)?

16. Does the utility have and maintain an annual financial report? Is it presented to policy makers?

17. Has an independent financial audit been conducted of the utility finances? If so, how often? When was the last one?

18. Will the system consider any type of regionalization with any other PWS, such as system interconnection, purchasing water, sharing operator, emergency water connection, sharing bookkeeper/billing or other?

F. Policies, Procedures, and Programs

1. Are there written operational procedures? Do the employees use them?

2. Who in the utility department has spending authorization? What is the process for obtaining needed equipment or supplies, including who approves expenditures?

3. Does the utility have a source water protection program? What are the major components of the program?

4. Are managers and operators familiar with current SDWA regulations?

5. How do the managers and operators hear about new or proposed regulations, such as arsenic, DBP, Groundwater Rule? Are there any new regulations that will be of particular concern to the utility?

6. What are the typical customer complaints that the utility receives?

7. Approximately how many complaints are there per month?

8. How are customer complaints handled? Are they recorded?

9. (If not specifically addressed in Question 7) If the complaint is of a water quality nature, how are these types of complaints handled?

10. Does the utility maintain an updated list of critical customers?

11. Is there a cross-connection control plan for the utility? Is it written? Who enforces the plan's requirements?

12. Does the utility have a written water conservation plan?

13. Has there been a water audit of the system? If yes, what were the results?

14. (If not specifically answered in 11 above) What is the estimated percentage for loss to leakage for the system?

15. Are you, or is the utility itself, a member of any trade organizations, such as AWWA or Rural Water Association? Are you an active member (i.e., attend regular meetings or participate in a leadership role)? Do you find this membership helpful? If yes, in what ways does it help you?

G. Operations and Maintenance

1. How is decision-making authority split between operations and management for the following items:

    a. Process Control

    b. Purchases of supplies or small equipment

    c. Compliance sampling/reporting

    d. Staff scheduling

2. Describe your utility's preventative maintenance program.

3. Do the operators have the ability to make changes or modify the preventative maintenance program?

4. How does management prioritize the repair or replacement of utility assets? Do the operators play a role in this prioritization process?

5. Does the utility keep an inventory of spare parts?

6. Where does staff have to go to buy supplies/minor equipment? How often?

    6a. How do you handle supplies that are critical, but not in close proximity (for example if chlorine is not available in the immediate area or if the components for a critical pump are not in the area)

7. Describe the system's disinfection process. Have you had any problems in the last few years with the disinfection system?

    7a. Who has the ability to adjust the disinfection process?

8. How often is the disinfectant residual checked and where is it checked?

    8a. Is there an official policy on checking residuals or is it up to the operators?

9. Does the utility have an O & M manual? Does the staff use it?

10. Are the operators trained on safety issues? How are they trained and how often?

11. Describe how on-going training is handled for operators and other staff. How do you hear about appropriate trainings? Who suggests the trainings – the managers or the operators? How often do operators, managers, or other staff go to training? Who are the typical trainers used and where are the trainings usually held?

12. In your opinion is the level of your on-going training adequate?

13. In your opinion is the level of on-going training for other staff members, particularly the operators, adequate?

14. Does the facility have mapping of the water utility components? Is it used on any routine basis by the operators or management? If so, how is it used? If not, what is the process used for locating utility components?

15. In the last sanitary survey, were any deficiencies noted? If yes, were they corrected?

16. How often are storage tanks inspected? Who does the inspection?

    16a. Have you experienced any problems with the storage tanks?

H. SDWA Compliance

1. Has the system had any violations (monitoring or MCL) in the past 3 years? If so, describe.

2. How were the violations handled?

3. Does the system properly publish public notifications when notified of a violation?

4. Is the system currently in violation of any SDWA or state regulatory requirements, including failure to pay fees, fines, or other administrative type requirements?

5. Does the utility prepare and distribute a Consumer Confidence Report (CCR)? Is it done every year? What type of response does the utility get to the CCR from customers?

I. Emergency Planning

1. Does the system have a written emergency plan to handle emergencies such as water outages, weather issues, loss of power, loss of major equipment, etc?

2. When was the last time the plan was updated?

3. Do all employees know where the plan is? Do they follow it?

4. Describe the last emergency the facility faced and how it was handled.

Attachment A

A. Technical Capacity Assessment Questions

1. Based on available information of water rights on record and water pumped has the system exceeded its water rights in the past year? YES ☐ NO ☐

   In any of the past 5 years? YES ☐ NO ☐ How many times? _____

2. Does the system have the proper level of certified operator? *(Use questions a – c to answer.)*
   YES ☐ NO ☐

   a. What is the Classification Level of the system by NMED? _____

   b. Does the system have one or more certified operator(s)? [20 NMAC 7.4.20]

   YES ☐ NO ☐

   c. If YES, provide the number of operators at each New Mexico Certification Level. [20 NMAC 7.4.12]

   _____NM Small System _____Class 2

   _____NM Small System Advanced _____Class 3

   _____Class 1 _____Class 4

3. Did the system correct any sanitary deficiency noted on the most recent sanitary survey within 6 months of receiving that information? [20 NMAC 7.20.504]

   YES ☐ NO ☐ No Deficiencies ☐

   What was the type of deficiency? *(Check all that are applicable.)*

   Source ☐ Storage ☐

   Treatment ☐ Distribution ☐

   Other _____

   From the system's perspective, were there any other deficiencies that were not noted on the sanitary survey? Please describe.

4. Will the system's current treatment process meet known future regulations?

   Radionuclides YES ☐ NO ☐ Doesn't Apply ☐

   Arsenic YES ☐ NO ☐ Doesn't Apply ☐

   Stage 1 Disinfectants and Disinfection By-Product (DBP)

   YES ☐ NO ☐ Doesn't Apply ☐

   Surface Water Treatment Rule YES ☐ NO ☐ Doesn't Apply ☐

5. Does the system have a current site plan/map? [20 NMAC 7.10.302 A.1.]

   YES ☐ NO ☐

6. Has the system had a water supply outage in the prior 24 months?

YES ☐ NO ☐

What were the causes of the outage(s)? *(Include number of outages for each cause.)*

Drought _____ Limited Supply _____

System Failure _____ Other _____

7. Has the system ever had a water audit or a leak evaluation?

YES ☐ NO ☐ Don't Know ☐

If YES, please complete the following table.

Type of Investigation	Date Done	Water Loss (%)	What approach or technology was used to complete the investigation?	Was any follow-up done? If so, describe

8. Have all drinking water projects received NMED review and approval? [20 NMAC 7.10.201]

YES ☐ NO ☐

If NO, what types of projects have not received NMED review and approval.

Source ☐ Storage ☐

Treatment ☐ Distribution ☐

Other ☐ _____

9. What are the typical customer complaints that the utility receives?

10. Approximately how many complaints are there per month? _____

11. How are customer complaints handled? Are they recorded?

12. What is the age and composition of the distribution system? ***(Collect this information from the Sanitary Survey)***

Pipe Material	Approximate Age	Percentage of the system	Comments
			Sanitary Survey Distribution System Records Attached

13. Are there any dead end lines in the system?
YES ☐ NO ☐

14. Does the system have a flushing program?
YES ☐ NO ☐
If YES, please describe.

15. Are there any pressure problems within the system?
YES ☐ NO ☐
If YES, please describe.

16. Does the system disinfect the finished water?
YES ☐ NO ☐
If yes, which disinfectant product is used? ______

Interviewer Comments on Technical Capacity:

B. Managerial Capacity Assessment Questions

17. Has the system completed a 5-year Infrastructure Capital Improvement Plan (ICIP) plan?
YES ☐ NO ☐
If YES, has the plan been submitted to Local Government Division?
YES ☐ NO ☐

18. Does the system have written operating procedures?
YES ☐ NO ☐

19. Does the system have written job descriptions for all staff?
YES ☐ NO ☐

20. Does the system have:

A preventative maintenance plan?
YES ☐ NO ☐
A source water protection plan?
YES ☐ NO ☐ N/A ☐
An emergency plan?
YES ☐ NO ☐
A cross-connection control program?
YES ☐ NO ☐
An emergency source?
YES ☐ NO ☐
System security measures?
YES ☐ NO ☐

21. Does the system report and maintain records in accordance with the drinking water regulations concerning:

Water quality violations
YES ☐ NO ☐

Public notification
YES ☐ NO ☐

Sampling exemptions
YES ☐ NO ☐

22. Please describe how the above records are maintained:

23. Describe the management structure for the water system, including board and operations staff. Please include examples of duties, if possible.

24. Please describe type and quantity of training or continuing education for staff identified above.

25. Describe last major project undertaken by the water system, including the following: project in detail, positive aspects, negative aspects, the way in which the project was funded, any necessary rate increases, the public response to the project, whether the project is complete or not, and any other pertinent information.

26. Does the system have any debt? YES ☐ NO ☐

If yes, is the system current with all debt payments?
YES ☐ NO ☐

If no, describe the applicable funding agency and the default.

27. Is the system currently contemplating or actively seeking funding for any project?
YES ☐ NO ☐

If yes, from which agency and how much?

Describe the project?

Is the system receiving assistance from any agency or organization in its efforts?

28. Will the system consider any type of regionalization with other PWS? *(Check YES if the system has already regionalized.)*

YES ☐ NO ☐

If YES, what type of regionalization has been implemented/considered/discussed? *(Check all that apply.)*

System interconnection ☐
Sharing operator ☐
Sharing bookkeeper ☐
Purchasing water ☐
Emergency water connection ☐
Other: _____

29. Does the system have any of the following? *(Check all that apply.)*

Water Conservation Policy/Ordinance ☐ Current Drought Plan ☐
Water Use Restrictions ☐ Water Supply Emergency Plan ☐

Interviewer Comments on Managerial Capacity:

C. Financial Capacity Assessment

30. Does the system have a budget?

YES ☐ NO ☐

If YES, what type of budget?

Operating Budget ☐

Capital Budget ☐

31. Have the system revenues covered expenses and debt service for the past 5 years?

YES ☐ NO ☐

If NO, how many years has the system had a shortfall? _____

32. Does the system have a written/adopted rate structure?

YES ☐ NO ☐

33. What was the date of the last rate increase? _____

34. Are rates reviewed annually?

YES ☐ NO ☐

IF YES, what was the date of the last review? _____

35. Did the rate review show that the rates covered the following expenses? *(Check all that apply.)*

Operation & Maintenance ☐

Infrastructure Repair & replacement ☐

Staffing ☐

Emergency/Reserve fund ☐

Debt payment ☐

36. Is the rate collection above 90% of the customers?

YES ☐ NO ☐

37. Is there a cut-off policy for customers who are in arrears with their bill or for illegal connections?

YES ☐ NO ☐

If yes, is this policy implemented?

38. What is the residential water rate for 6,000 gallons of usage in one month. _____

39. In the past 12 months, how many customers have had accounts frozen or dropped for non-payment? _____

[Convert to % of active connections

Less than 1% ☐ 1% - 3% ☐ 4% - 5% ☐ 6% - 10% ☐

11% - 20% ☐ 21% - 50% ☐ Greater than 50% ☐]

40. The following questions refer to the process of obtaining needed equipment and supplies.

a. Can the water system operator buy or obtain supplies or equipment when they are needed?

YES ☐ NO ☐

b. Is the process simple or burdensome to the employees?

c. Can supplies or equipment be obtained quickly during an emergency?

YES ☐ NO ☐

d. Has the water system operator ever experienced a situation in which he/she couldn't purchase the needed supplies?

YES ☐ NO ☐

e. Does the system maintain some type of spare parts inventory?

YES ☐ NO ☐

If yes, please describe.

41. Has the system ever had a financial audit?

YES ☐ NO ☐

If YES, what is the date of the most recent audit? ______

42. Has the system ever had its electricity or phone turned off due to non-payment? Please describe.

Interviewer Comments on Financial Assessment:

43. What do you think the system capabilities are now and what are the issues you feel your system will be facing in the future? In addition, are there any specific needs, such as types of training that you would like to see addressed by NMED or its contractors?

APPENDIX B
COST BASIS

This section presents the basis for unit costs used to develop the conceptual cost estimates for the compliance alternatives. Cost estimates are conceptual in nature (+50%/-30%), and are intended to make comparisons between compliance options and to provide a preliminary indication of possible rate impacts. Consequently, these costs are pre-planning level and should not be viewed as final estimated costs for alternative implementation. Capital cost includes an allowance for engineering and construction management. It is assumed that adequate electrical power is available near the site. The cost estimates specifically do not include costs for the following:

- Obtaining land or easements.
- Surveying.
- Mobilization/demobilization for construction.
- Insurance and bonds

In general, unit costs are based on recent construction bids for similar work in the area when possible, consultations with vendors or other suppliers, published construction and O&M cost data, and USEPA cost guidance. Unit costs used for the cost estimates are summarized in Table B.1.

Unit costs for pipeline components are based on 2007 RS Means Site Work & Landscape Cost Data. The number of borings and encasements and open cuts and encasements is estimated by counting the road, highway, railroad, stream, and river crossings for a conceptual routing of the pipeline. The number of air release valves is estimated by examining the land surface profile along the conceptual pipeline route. It is assumed that gate valves and flush valves would be installed, on average, every 5,000 feet along the pipeline. Pipeline cost estimates are based on the use of C-900 PVC pipe. Other pipe materials could be considered for more detailed development of attractive alternatives.

Pump station unit costs are based on experience with similar installations. The cost estimate for the pump stations include two pumps, station piping and valves, station electrical and instrumentation, minor site improvement, installation of a concrete pad, fence and building, and tools. The number of pump stations is based on calculations of pressure losses in the proposed pipeline for each alternative. Back-flow prevention is required in cases where pressure losses are negligible, and pump stations are not needed. Construction cost of a storage tank is based on consultations with vendors and 2007 RS Means Site Work & Landscape Cost Data.

Labor costs are estimated based on 2007 RS Means Site Work & Landscape Cost Data specific to the Lubbock County region.

Electrical power cost is estimated to be $0.043 per kWH, as supplied by Xcel Energy. The annual cost for power to a pump station is calculated based on the pumping head and volume, and includes 11,800 kWH for pump building heating, cooling, and lighting, as recommended in USEPA publication, *Standardized Costs for Water Supply Distribution Systems* (1992).

In addition to the cost of electricity, pump stations have other maintenance costs. These costs cover: materials for minor repairs to keep the pumps operating; purchase of a maintenance vehicle, fuel costs, and vehicle maintenance costs; utilities; office supplies, small tools and equipment; and miscellaneous materials such as safety, clothing, chemicals, and paint. The non-power O&M costs are estimated based on the USEPA publication, *Standardized Costs for Water Supply Distribution Systems* (1992), which provides cost curves for O&M components. Costs from the 1992 report are adjusted to 2007 dollars based on the ENR construction cost index.

Pipeline maintenance costs include routine cleaning and flushing, as well as minor repairs to lines. The unit rate for pipeline maintenance is calculated based on the USEPA technical report, *Innovative and Alternate Technology Assessment Manual MCD 53* (1980). Costs from the 1980 report are adjusted to 2007 dollars based on the ENR construction cost index.

Storage tank maintenance costs include cleaning and renewal of interior lining and exterior coating. Unit costs for storage tank O&M are based on USEPA publication *Standardized Costs for Water Supply Distribution Systems* (1992). Costs from the 1992 report are adjusted to 2007 dollars based on the ENR construction cost index.

The purchase price for point-of-use (POU) water treatment units is based on vendor price lists for treatment units, plus installation. O&M costs for POU treatment units are also based on vendor price lists. It is assumed that a yearly water sample would be analyzed for the contaminant of concern.

The purchase price for point-of-entry (POE) water treatment units is based on vendor price lists for treatment units, plus an allowance for installation, including a concrete pad and shed, piping modifications, and electrical connection. O&M costs for POE treatment units are also based on vendor price lists. It is assumed that a yearly water sample would be analyzed for the contaminant of concern.

Central treatment plant costs, for both adsorption and coagulation/filtration, include pricing for buildings, utilities, and site work. Costs are based on pricing given in the various 2007 RS Means Cost Data references, as well as prices obtained from similar work on other projects. Pricing for treatment equipment was obtained from vendors.

Well installation costs are based on quotations from drillers for installation of similar depth wells in the area. Well installation costs include drilling, a well pump, electrical and instrumentation installation, well finishing, piping, and water quality testing. O&M costs for water wells include power, materials, and labor.

Purchase price for the treatment unit dispenser is based on vendor price lists, plus an allowance for installation at a centralized public location. The O&M costs are also based on vendor price lists. It is assumed that weekly water samples would be analyzed for the contaminant of concern.

Costs for bottled water delivery alternatives are based on consultation with vendors that deliver residential bottled water. The cost estimate includes an initial allowance for set-up of the program, and a yearly allowance for program administration.

The cost estimate for a public dispenser for trucked water includes the purchase price for a water truck and construction of a storage tank. Annual costs include labor for purchasing the water, picking up and delivering the water, truck maintenance, and water sampling and testing. It is assumed the water truck would be required to make one trip per dispenser each week, and that chlorine residual would be determined for each truck load.

Table B.1
Summary of General Data
Southwest Gardens
1520217
General PWS Information

Service Population	375		**Number of Connections**	125
Total PWS Daily Water Usage	0.028 (mgd)		**Source**	Site visit list

Unit Cost Data

General Items	**Unit**	**Unit Cost**
Treated water purchase cost	*See alternative*	
Water purchase cost (trucked)	$/1,000 gals	$ 2.61
Contingency	20%	n/a
Engineering & Constr. Management	25%	n/a
Procurement/admin (POU/POE)	20%	n/a
Pipeline Unit Costs	**Unit**	**Unit Cost**
PVC water line, Class 200, 04"	LF	$ 26
Bore and encasement, 10"	LF	$ 240
Open cut and encasement, 10"	LF	$ 105
Gate valve and box, 04"	EA	$ 805
Air valve	EA	$ 2,000
Flush valve	EA	$ 1,000
Metal detectable tape	LF	$ 2
Bore and encasement, length	Feet	200
Open cut and encasement, length	Feet	50
Pump Station Unit Costs	**Unit**	**Unit Cost**
Pump	EA	$ 8,000
Pump Station Piping, 04"	EA	$ 540
Gate valve, 04"	EA	$ 805
Check valve, 04"	EA	$ 805
Electrical/Instrumentation	EA	$ 10,000
Site work	EA	$ 2,500
Building pad	EA	$ 5,000
Pump Building	EA	$ 10,000
Fence	EA	$ 6,000
Tools	EA	$ 1,000
Well Installation Unit Costs	**Unit**	**Unit Cost**
Well installation	*See alternative*	
Water quality testing	EA	$ 1,250
Well pump	EA	$ 10,000
Well electrical/instrumentation	EA	$ 5,500
Well cover and base	EA	$ 3,000
Piping	EA	$ 3,000
20,000 gal storage / feed tank	EA	$ 30,000
Electrical Power	$/kWH	$ 0.043
Building Power	kWH	11,800
Labor	$/hr	$ 68
Materials	EA	$ 1,500
Transmission main O&M	$/mile	$ 250
Tank O&M	EA	$ 1,000
POU/POE Unit Costs		
POU treatment unit purchase	EA	$ 600
POU treatment unit installation	EA	$ 150
POE treatment unit purchase	EA	$ 5,000
POE - pad and shed, per unit	EA	$ 2,000
POE - piping connection, per unit	EA	$ 1,000
POE - electrical hook-up, per unit	EA	$ 1,000
POU Treatment O&M, per unit	$/year	$ 225
POE Treatment O&M, per unit	$/year	$ 1,500
Treatment analysis	$/year	$ 200
POU/POE labor support	$/hr	$ 50
Dispenser/Bottled Water Unit Costs		
POE-Treatment unit purchase	EA	$ 7,000
POE-Treatment unit installation	EA	$ 5,000
Treatment unit O&M	EA	$ 2,000
Administrative labor	hr	$ 40
Bottled water cost (inc. delivery)	gallon	$ 1
Water use, per capita per day	gpcd	1
Bottled water program materials	EA	$ 5,000
5,000 gal storage / feed tank	EA	$ 15,000
Site improvements	EA	$ 3,000
Potable water truck	EA	$ 75,000
Water analysis, per sample	EA	$ 200
Potable water truck O&M costs	$/mile	$ 2

Central Treatment Unit Costs	**Unit**	**Unit Cost**
General		
Site preparation	acre	$ 4,000
Slab	CY	$ 1,000
Building	SF	$ 60
Building electrical	SF	$ 8
Building plumbing	SF	$ 8
Heating and ventilation	SF	$ 7
Fence	LF	$ 15
Paving	SF	$ 2
Reject pond, excavation	CYD	$ 3
Reject pond, compacted fill	CYD	$ 7
Reject pond, lining	SF	$ 0.5
Reject pond, vegetation	SY	$ 1
Reject pond, access road	LF	$ 30
Reject water haulage truck	EA	$ 100,000
Chlorination point	EA	$ 2,000
Building power	$/kWH	$ 0.043
Equipment power	$/kWH	$ 0.043
Labor, O&M	hr	$ 40
Analyses	test	$ 200
Reverse Osmosis		
Electrical	JOB	$ 50,000
Piping	JOB	$ 20,000
RO package plant	UNIT	$ 160,000
RO materials	year	$ 5,000
RO chemicals	year	$ 2,500
Backwash disposal mileage cost	miles	$ 1
Backwash disposal fee	1,000 gal/yr	$ 5
EDR		
Electrical	JOB	$ 50,000
Piping	JOB	$ 20,000
EDR package plant	UNIT	$ 260,000
Transfer pumps (5 hp)	EA	$ 5,000
EDR materials	year	$ 5,000
EDR chemicals	year	$ 2,500
Backwash disposal mileage cost	miles	$ 1
Backwash disposal fee	1,000 gal/yr	$ 5

APPENDIX C
COMPLIANCE ALTERNATIVE CONCEPTUAL COST ESTIMATES

This appendix presents the conceptual cost estimates developed for the compliance alternatives. The conceptual cost estimates are given in Tables C.1 through C.12. The cost estimates are conceptual in nature (+50%/-30%), and are intended for making comparisons between compliance options and to provide a preliminary indication of possible water rate impacts. Consequently, these costs are pre-planning level and should not be viewed as final estimated costs for alternative implementation.

Table C.1

PWS Name	***Southwest Gardens***
Alternative Name	***Purchase Water from Lubbock PWS***
Alternative Number	***SW-1***

Distance from Alternative to PWS (along pipe)		2.39	miles
Total PWS annual water usage		10.22	MG
Treated water purchase cost	$	2.61	per 1,000 gals
Pump Stations needed w/ 1 feed tank each		1	
On site storage tanks / pump sets needed		0	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	7	n/a	n/a	n/a
PVC water line, Class 200, 04"	12,619	LF	$ 26	$ 328,099
Bore and encasement, 10"	-	LF	$ 240	$ -
Open cut and encasement, 10"	350	LF	$ 105	$ 36,750
Gate valve and box, 04"	3	EA	$ 805	$ 2,032
Air valve	2	EA	$ 2,000	$ 4,000
Flush valve	3	EA	$ 1,000	$ 2,524
Metal detectable tape	12,619	LF	$ 2	$ 25,238
Subtotal				**$ 398,643**
Pump Station(s) Installation				
Pump	2	EA	$ 8,000	$ 16,000
Pump Station Piping, 04"	1	EA	$ 540	$ 540
Gate valve, 04"	4	EA	$ 805	$ 3,220
Check valve, 04"	2	EA	$ 805	$ 1,610
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,500	$ 2,500
Building pad	1	EA	$ 5,000	$ 5,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 6,000	$ 6,000
Tools	1	EA	$ 1,000	$ 1,000
20,000 gal storage / feed tank	1	EA	$ 30,000	$ 30,000
Subtotal				**$ 85,870**

Subtotal of Component Costs		**$ 484,513**
Contingency	20%	$ 96,903
Design & Constr Management	25%	$ 121,128
TOTAL CAPITAL COSTS		**$ 702,544**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	2.39	mile	$ 250	$ 598
Subtotal				**$ 598**
Water Purchase Cost				
From PWS	10,220	1,000 gal	$ 2.61	$ 26,674
Subtotal				**$ 26,674**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.043	$ 507
Pump Power	3,847	kWH	$ 0.043	$ 165
Materials	1	EA	$ 1,500	$ 1,500
Labor	365	Hrs	$ 40	$ 14,600
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 17,773**
O&M Credit for Existing Well Closure				
Pump power	9,015	kWH	$ 0.043	$ (388)
Well O&M matl	1	EA	$ 1,500	$ (1,500)
Well O&M labor	180	Hrs	$ 40	$ (7,200)
Subtotal				**$ (9,088)**
TOTAL ANNUAL O&M COSTS				**$ 35,957**

Table C.2

PWS Name *Southwest Gardens*
Alternative Name *Purchase Water from CRA Lubbock-Tahoka*
Alternative Number *SW-2*

Distance from Alternative to PWS (along pipe)		9.32	miles
Total PWS annual water usage		10.22	MG
Treated water purchase cost	$	1.32	per 1,000 gals
Pump Stations needed w/ 1 feed tank each		1	
On site storage tanks / pump sets needed		0	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	1	n/a	n/a	n/a
Number of Crossings, open cut	13	n/a	n/a	n/a
PVC water line, Class 200, 04"	49,210	LF	$ 26	$ 1,279,450
Bore and encasement, 10"	200	LF	$ 240	$ 48,000
Open cut and encasement, 10"	650	LF	$ 105	$ 68,250
Gate valve and box, 04"	10	EA	$ 805	$ 7,923
Air valve	13	EA	$ 2,000	$ 26,000
Flush valve	10	EA	$ 1,000	$ 9,842
Metal detectable tape	49,210	LF	$ 2	$ 98,419
Subtotal				**$ 1,537,883**
Pump Station(s) Installation				
Pump	2	EA	$ 8,000	$ 16,000
Pump Station Piping, 04"	1	EA	$ 540	$ 540
Gate valve, 04"	4	EA	$ 805	$ 3,220
Check valve, 04"	2	EA	$ 805	$ 1,610
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,500	$ 2,500
Building pad	1	EA	$ 5,000	$ 5,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 6,000	$ 6,000
Tools	1	EA	$ 1,000	$ 1,000
20,000 gal storage / feed tank	1	EA	$ 30,000	$ 30,000
Subtotal				**$ 85,870**
Subtotal of Component Costs				**$ 1,623,753**
Contingency	20%			$ 324,751
Design & Constr Management	25%			$ 405,938
TOTAL CAPITAL COSTS				**$ 2,354,443**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	9.32	mile	$ 250	$ 2,330
Subtotal				**$ 2,330**
Water Purchase Cost				
From PWS	10,220	1,000 gal	$ 1.32	$ 13,490
Subtotal				**$ 13,490**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.043	$ 507
Pump Power	17,287	kWH	$ 0.043	$ 743
Materials	1	EA	$ 1,500	$ 1,500
Labor	365	Hrs	$ 40	$ 14,600
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 18,351**
O&M Credit for Existing Well Closure				
Pump power	9,015	kWH	$ 0.043	$ (388)
Well O&M matl	1	EA	$ 1,500	$ (1,500)
Well O&M labor	180	Hrs	$ 40	$ (7,200)
Subtotal				**$ (9,088)**
TOTAL ANNUAL O&M COSTS				**$ 25,083**

Table C.3

PWS Name	***Southwest Gardens***
Alternative Name	***New Well at 10 Miles***
Alternative Number	***SW-3***

Distance from PWS to new well location	10	miles
Estimated well depth	300	feet
Number of wells required	1	
Well installation cost (location specific)	$145	per foot
Pump Stations needed w/ 1 feed tank each	2	
On site storage tanks / pump sets needed	0	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	1	n/a	n/a	n/a
Number of Crossings, open cut	16	n/a	n/a	n/a
PVC water line, Class 200, 04"	52,800	LF	$ 26	$ 1,372,800
Bore and encasement, 10"	200	LF	$ 240	$ 48,000
Open cut and encasement, 10"	800	LF	$ 105	$ 84,000
Gate valve and box, 04"	11	EA	$ 805	$ 8,501
Air valve	11	EA	$ 2,000	$ 22,000
Flush valve	11	EA	$ 1,000	$ 10,560
Metal detectable tape	52,800	LF	$ 2	$ 105,600
Subtotal				**$ 1,651,461**
Pump Station(s) Installation				
Pump	4	EA	$ 8,000	$ 32,000
Pump Station Piping, 04"	2	EA	$ 540	$ 1,080
Gate valve, 04"	8	EA	$ 805	$ 6,440
Check valve, 04"	4	EA	$ 805	$ 3,220
Electrical/Instrumentation	2	EA	$ 10,000	$ 20,000
Site work	2	EA	$ 2,500	$ 5,000
Building pad	2	EA	$ 5,000	$ 10,000
Pump Building	2	EA	$ 10,000	$ 20,000
Fence	2	EA	$ 6,000	$ 12,000
Tools	2	EA	$ 1,000	$ 2,000
20,000 gal storage / feed tank	2	EA	$ 30,000	$ 60,000
Subtotal				**$ 171,740**
Well Installation				
Well installation	300	LF	$ 145	$ 43,500
Water quality testing	2	EA	$ 1,250	$ 2,500
Well pump	1	EA	$ 10,000	$ 10,000
Well electrical/instrumentation	1	EA	$ 5,500	$ 5,500
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 3,000	$ 3,000
Subtotal				**$ 67,500**
Subtotal of Component Costs				**$ 1,890,701**
Contingency	20%			$ 378,140
Design & Constr Management	25%			$ 472,675
TOTAL CAPITAL COSTS				**$ 2,741,516**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	10	mile	$ 250	$ 2,500
Subtotal				**$ 2,500**
Pump Station(s) O&M				
Building Power	23,600	kWH	$ 0.043	$ 1,015
Pump Power	15,647	kWH	$ 0.043	$ 673
Materials	2	EA	$ 1,500	$ 3,000
Labor	730	Hrs	$ 40	$ 29,200
Tank O&M	2	EA	$ 1,000	$ 2,000
Subtotal				**$ 35,888**
Well O&M				
Pump power	16,894	kWH	$ 0.043	$ 726
Well O&M matl	1	EA	$ 1,500	$ 1,500
Well O&M labor	180	Hrs	$ 40	$ 7,200
Subtotal				**$ 9,426**
O&M Credit for Existing Well Closure				
Pump power	9,015	kWH	$ 0.043	$ (388)
Well O&M matl	1	EA	$ 1,500	$ (1,500)
Well O&M labor	180	Hrs	$ 40	$ (7,200)
Subtotal				**$ (9,088)**
TOTAL ANNUAL O&M COSTS				**$ 38,726**

Table C.4

PWS Name *Southwest Gardens*
Alternative Name *New Well at 5 Miles*
Alternative Number *SW-4*

Distance from PWS to new well location	5 miles
Estimated well depth	300 feet
Number of wells required	1
Well installation cost (location specific)	$145 per foot
Pump Stations needed w/ 1 feed tank each	1
On site storage tanks / pump sets needed	0

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	1	n/a	n/a	n/a
Number of Crossings, open cut	8	n/a	n/a	n/a
PVC water line, Class 200, 04"	26,400	LF	$ 26	$ 686,400
Bore and encasement, 10"	200	LF	$ 240	$ 48,000
Open cut and encasement, 10"	400	LF	$ 105	$ 42,000
Gate valve and box, 04"	5	EA	$ 805	$ 4,250
Air valve	6	EA	$ 2,000	$ 12,000
Flush valve	5	EA	$ 1,000	$ 5,280
Metal detectable tape	26,400	LF	$ 2	$ 52,800
Subtotal				**$ 850,730**
Pump Station(s) Installation				
Pump	2	EA	$ 8,000	$ 16,000
Pump Station Piping, 04"	1	EA	$ 540	$ 540
Gate valve, 04"	4	EA	$ 805	$ 3,220
Check valve, 04"	2	EA	$ 805	$ 1,610
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,500	$ 2,500
Building pad	1	EA	$ 5,000	$ 5,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 6,000	$ 6,000
Tools	1	EA	$ 1,000	$ 1,000
20,000 gal storage / feed tank	1	EA	$ 30,000	$ 30,000
Subtotal				**$ 85,870**
Well Installation				
Well installation	300	LF	$ 145	$ 43,500
Water quality testing	2	EA	$ 1,250	$ 2,500
Well pump	1	EA	$ 10,000	$ 10,000
Well electrical/instrumentation	1	EA	$ 5,500	$ 5,500
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 3,000	$ 3,000
Subtotal				**$ 67,500**

Subtotal of Component Costs		**$ 1,004,100**
Contingency	20%	$ 200,820
Design & Constr Management	25%	$ 251,025
TOTAL CAPITAL COSTS		**$ 1,455,946**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	5	mile	$ 250	$ 1,250
Subtotal				**$ 1,250**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.043	$ 507
Pump Power	7,824	kWH	$ 0.043	$ 336
Materials	1	EA	$ 1,500	$ 1,500
Labor	365	Hrs	$ 40	$ 14,600
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 17,944**
Well O&M				
Pump power	16,894	kWH	$ 0.043	$ 726
Well O&M matl	1	EA	$ 1,500	$ 1,500
Well O&M labor	180	Hrs	$ 40	$ 7,200
Subtotal				**$ 9,426**
O&M Credit for Existing Well Closure				
Pump power	9,015	kWH	$ 0.043	$ (388)
Well O&M matl	1	EA	$ 1,500	$ (1,500)
Well O&M labor	180	Hrs	$ 40	$ (7,200)
Subtotal				**$ (9,088)**

TOTAL ANNUAL O&M COSTS	**$ 19,533**

Table C.5

PWS Name *Southwest Gardens*
Alternative Name *New Well at 1 Mile*
Alternative Number *SW-5*

Distance from PWS to new well location	1	miles
Estimated well depth	300	feet
Number of wells required	1	
Well installation cost (location specific)	$145	per foot
Pump Stations needed w/ 1 feed tank each	0	
On site storage tanks / pump sets needed	0	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	2	n/a	n/a	n/a
PVC water line, Class 200, 04"	5,280	LF	$ 26	$ 137,280
Bore and encasement, 10"	-	LF	$ 240	$ -
Open cut and encasement, 10"	100	LF	$ 105	$ 10,500
Gate valve and box, 04"	1	EA	$ 805	$ 850
Air valve	1	EA	$ 2,000	$ 2,000
Flush valve	1	EA	$ 1,000	$ 1,056
Metal detectable tape	5,280	LF	$ 2	$ 10,560
Subtotal				**$ 162,246**
Pump Station(s) Installation				
Pump	-	EA	$ 8,000	$ -
Pump Station Piping, 04"	-	EA	$ 540	$ -
Gate valve, 04"	-	EA	$ 805	$ -
Check valve, 04"	-	EA	$ 805	$ -
Electrical/Instrumentation	-	EA	$ 10,000	$ -
Site work	-	EA	$ 2,500	$ -
Building pad	-	EA	$ 5,000	$ -
Pump Building	-	EA	$ 10,000	$ -
Fence	-	EA	$ 6,000	$ -
Tools	-	EA	$ 1,000	$ -
20,000 gal storage / feed tank	-	EA	$ 30,000	$ -
Subtotal				**$ -**
Well Installation				
Well installation	300	LF	$ 145	$ 43,500
Water quality testing	2	EA	$ 1,250	$ 2,500
Well pump	1	EA	$ 10,000	$ 10,000
Well electrical/instrumentation	1	EA	$ 5,500	$ 5,500
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 3,000	$ 3,000
Subtotal				**$ 67,500**
Subtotal of Component Costs				**$ 229,746**
Contingency	20%			$ 45,949
Design & Constr Management	25%			$ 57,437
TOTAL CAPITAL COSTS				**$ 333,132**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	1	mile	$ 250	$ 250
Subtotal				**$ 250**
Pump Station(s) O&M				
Building Power	-	kWH	$ 0.043	$ -
Pump Power	-	kWH	$ 0.043	$ -
Materials	-	EA	$ 1,500	$ -
Labor	-	Hrs	$ 40.00	$ -
Tank O&M	-	EA	$ 1,000	$ -
Subtotal				**$ -**
Well O&M				
Pump power	16,894	kWH	$ 0.043	$ 726
Well O&M matl	1	EA	$ 1,500	$ 1,500
Well O&M labor	180	Hrs	$ 40	$ 7,200
Subtotal				**$ 9,426**
O&M Credit for Existing Well Closure				
Pump power	9,015	kWH	$ 0.043	$ (388)
Well O&M matl	1	EA	$ 1,500	$ (1,500)
Well O&M labor	180	Hrs	$ 40	$ (7,200)
Subtotal				**$ (9,088)**
TOTAL ANNUAL O&M COSTS				**$ 589**

Table C.6

PWS Name ***Southwest Gardens***
Alternative Name ***Central Treatment - Reverse Osmosis***
Alternative Number ***SW-6***

Capital Costs

Cost Item	Quantity	Unit	Unit Cost		Total Cost	
Reverse Osmosis Unit Purchase/Installation						
Site preparation	0.5	acre	$	4,000	$	2,000
Slab	15	CY	$	1,000	$	15,000
Building	500	SF	$	60	$	30,000
Building electrical	500	SF	$	8	$	4,000
Building plumbing	500	SF	$	8	$	4,000
Heating and ventilation	500	SF	$	7	$	3,500
Fence	700	LF	$	15	$	10,500
Paving	2,000	SF	$	2	$	4,000
Electrical	1	JOB	$	50,000	$	50,000
Piping	1	JOB	$	20,000	$	20,000
Reverse osmosis package including:						
High pressure pumps - 15hp						
Cartridge filters and vessels						
RO membranes and vessels						
Control system						
Chemical feed systems						
Freight cost						
Vendor start-up services	1	UNIT	$	160,000	$	160,000
Reject pond:						
Excavation	1,500	CYD	$	3	$	4,500
Compacted fill	1,250	CYD	$	7	$	8,750
Lining	21,750	SF	$	1	$	10,875
Vegetation	2,500	SY	$	1	$	2,500
Access road	625	LF	$	30	$	18,750
Subtotal of Design/Construction Costs					**$**	**348,375**
Contingency	20%				$	69,675
Design & Constr Management	25%				$	87,094
Reject water haulage truck	1	EA	$	100,000	$	100,000
TOTAL CAPITAL COSTS					**$**	**605,144**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost		Total Cost	
Reverse Osmosis Unit O&M						
Building Power	9,000	kwh/yr	$	0.043	$	387
Equipment power	30,000	kwh/yr	$	0.043	$	1,290
Labor	1,000	hrs/yr	$	40	$	40,000
Materials	1	year	$	5,000	$	5,000
Chemicals	1	year	$	2,500	$	2,500
Analyses	24	test	$	200	$	4,800
Subtotal					**$**	**53,977**
Backwash Disposal						
Disposal truck mileage	17,934	miles	$	1	$	17,934
Backwash disposal fee	2,557	kgal/yr	$	5	$	12,785
Subtotal					**$**	**30,719**
TOTAL ANNUAL O&M COSTS					**$**	**84,696**

Table C.7

PWS Name *Southwest Gardens*
Alternative Name *Central Treatment - Electro-dialysis Reversal*
Alternative Number *SW-7*

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
EDR Unit Purchase/Installation				
Site preparation	0.5	acre	$ 4,000	$ 2,000
Slab	15	CY	$ 1,000	$ 15,000
Building	500	SF	$ 60	$ 30,000
Building electrical	500	SF	$ 8	$ 4,000
Building plumbing	500	SF	$ 8	$ 4,000
Heating and ventilation	500	SF	$ 7	$ 3,500
Fence	700	LF	$ 15	$ 10,500
Paving	2,000	SF	$ 2	$ 4,000
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 20,000	$ 20,000
Transfer pump	2	EA	$ 5,000.00	$ 10,000
EDR package including:				
Feed and concentrate pumps				
Cartridge filters and vessels				
EDR membrane stacks				
Electrical module				
Chemical feed systems				
Freight cost				
Vendor start-up services	1	UNIT	$ 260,000	$ 260,000
Reject pond:				
Excavation	1,500	CYD	$ 3	$ 4,500
Compacted fill	1,250	CYD	$ 7	$ 8,750
Lining	21,750	SF	$ 1	$ 10,875
Vegetation	2,500	SY	$ 1	$ 2,500
Access road	625	LF	$ 30	$ 18,750
Subtotal of Design/Construction Costs				**$ 458,375**
Contingency	20%			$ 91,675
Design & Constr Management	25%			$ 114,594
Reject water haulage truck	1	EA	$ 100,000	$ 100,000
TOTAL CAPITAL COSTS				**$ 764,644**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
EDR Unit O&M				
Building Power	9,000	kwh/yr	$ 0.043	$ 387
Equipment power	32,000	kwh/yr	$ 0.043	$ 1,376
Labor	1,000	hrs/yr	$ 40	$ 40,000
Materials	1	year	$ 5,000	$ 5,000
Chemicals	1	year	$ 2,500	$ 2,500
Analyses	24	test	$ 200	$ 4,800
Subtotal				**$ 54,063**
Backwash Disposal				
Disposal truck mileage	7,980	miles	$ 1	$ 7,980
Backwash disposal fee	1,137	kgal/yr	$ 5	$ 5,685
Subtotal				**$ 13,665**
TOTAL ANNUAL O&M COSTS				**$ 67,728**

Table C.8

PWS Name ***Southwest Gardens***
Alternative Name ***Point-of-Use Treatment***
Alternative Number ***SW-8***

Number of Connections for POU Unit Installation 125 connections

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POU-Treatment - Purchase/Installation				
POU treatment unit purchase	125	EA	$ 600	$ 75,000
POU treatment unit installation	125	EA	$ 150	$ 18,750
Subtotal				**$ 93,750**
Subtotal of Component Costs				**$ 93,750**
Contingency	20%			$ 18,750
Design & Constr Management	25%			$ 23,438
Procurement & Administration	20%			$ 18,750
TOTAL CAPITAL COSTS				**$ 154,688**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POU materials, per unit	125	EA	$ 225	$ 28,125
Contaminant analysis, 1/yr per unit	125	EA	$ 200	$ 25,000
Program labor, 10 hrs/unit	1,250	hrs	$ 50	$ 62,500
Subtotal				**$ 115,625**
TOTAL ANNUAL O&M COSTS				**$ 115,625**

Table C.9

PWS Name ***Southwest Gardens***
Alternative Name ***Point-of-Entry Treatment***
Alternative Number ***SW-9***

Number of Connections for POE Unit Installation 125 connections

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POE-Treatment - Purchase/Installat				
POE treatment unit purchase	125	EA	$ 5,000	$ 625,000
Pad and shed, per unit	125	EA	$ 2,000	$ 250,000
Piping connection, per unit	125	EA	$ 1,000	$ 125,000
Electrical hook-up, per unit	125	EA	$ 1,000	$ 125,000
Subtotal				**$ 1,125,000**
Subtotal of Component Costs				**$ 1,125,000**
Contingency	20%			$ 225,000
Design & Constr Management	25%			$ 281,250
Procurement & Administration	20%			$ 225,000
TOTAL CAPITAL COSTS				**$ 1,856,250**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POE materials, per unit	125	EA	$ 1,500	$ 187,500
Contaminant analysis, 1/yr per unit	125	EA	$ 200	$ 25,000
Program labor, 10 hrs/unit	1,250	hrs	$ 50	$ 62,500
Subtotal				**$ 275,000**
TOTAL ANNUAL O&M COSTS				**$ 275,000**

Table C.10

PWS Name ***Southwest Gardens***
Alternative Name ***Public Dispenser for Treated Drinking Water***
Alternative Number ***SW-10***

Number of Treatment Units Recommended 1

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Public Dispenser Unit Installation				
POE-Treatment unit(s)	1	EA	$ 7,000	$ 7,000
Unit installation costs	1	EA	$ 5,000	$ 5,000
Subtotal				**$ 12,000**
Subtotal of Component Costs				**$ 12,000**
Contingency	20%			$ 2,400
Design & Constr Management	25%			$ 3,000
TOTAL CAPITAL COSTS				**17,400**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Treatment unit O&M, 1 per unit	1	EA	$ 2,000	$ 2,000
Contaminant analysis, 1/wk per u	52	EA	$ 200	$ 10,400
Sampling/reporting, 1 hr/day	365	HRS	$ 68	$ 24,820
Subtotal				**$ 37,220**
TOTAL ANNUAL O&M COSTS				**$ 37,220**

Table C.11

PWS Name ***Southwest Gardens***
Alternative Name ***Supply Bottled Water to 100% of Population***
Alternative Number ***SW-11***

Service Population	375	
Percentage of population requiring supply	100%	
Water consumption per person	1	gpcd
Calculated annual potable water needs	136,875	gallons

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Implementation				
Initial program set-up	500	hours	$ 40	$ 20,000
Subtotal				**$ 20,000**
Subtotal of Component Costs				**$ 20,000**
Contingency	20%			$ 4,000
TOTAL CAPITAL COSTS				**$ 24,000**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water purchase costs	136,875	gals	$ 1	$ 136,875
Program admin, 9 hrs/wk	468	hours	$ 40	$ 18,720
Program materials	1	EA	$ 5,000	$ 5,000
Subtotal				**$ 160,595**
TOTAL ANNUAL O&M COSTS				**$ 160,595**

Table C.12

PWS Name ***Southwest Gardens***
Alternative Name ***Central Trucked Drinking Water***
Alternative Number ***SW-12***

Service Population	375	
Percentage of population requiring supply	100%	
Water consumption per person	1	gpcd
Calculated annual potable water needs	136,875	gallons
Travel distance to compliant water source	7	miles

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Storage Tank Installation				
5,000 gal storage / feed tank	1	EA	$ 15,000	$ 15,000
Site improvements	1	EA	$ 3,000	$ 3,000
Potable water truck	1	EA	$ 75,000	$ 75,000
Subtotal				**$ 93,000**
Subtotal of Component Costs				**$ 93,000**
Contingency	20%			$ 18,600
Design & Constr Management	25%			$ 23,250
TOTAL CAPITAL COSTS				**$ 134,850**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water delivery labor, 4 hrs/wk	208	hrs	$ 68	$ 14,144
Truck operation, 1 round trip/wk	728	miles	$ 2	$ 1,456
Water purchase	137	1,000 gals	$ 2.61	$ 357
Water testing, 1 test/wk	52	EA	$ 200	$ 10,400
Sampling/reporting, 2 hrs/wk	104	hrs	$ 68	$ 7,072
Subtotal				**$ 33,429**
TOTAL ANNUAL O&M COSTS				**$ 33,429**

APPENDIX D
EXAMPLE FINANCIAL MODEL

Table D.1 Example Financial Model

Step 1

Water System: SW Gardens

Step 2

Click Here to Update

Water System	SW Gardens
Alternative Description	New Well at 1 Mile

Sum of Amount — Year / Funding Alternative

Group	Type	2008 100% Grant	2008 Bond	2009 100% Grant	2009 Bond	2010 100% Grant	2010 Bond	2011 100% Grant	2011 Bond	2012 100% Grant	2012 Bond
Capital Expenditures	Capital Expenditures-Funded from	$ -	$ 333,132	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from	$ 333,132	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Expenditures Sum		$ 333,132	$ 333,132	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt Service	Revenue Bonds	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060
	State Revolving Funds	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt Service Sum		$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060
Operating Expenditures	Contract Labor	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000
	O&M Associated with Alternative			$ 589	$ 589	$ 589	$ 589	$ 589	$ 589	$ 589	$ 589
Operating Expenditures Sum		$ 24,000	$ 24,000	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589
Residential Operating Revenu	Residential Tier2 Annual Rate	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier3 Annual Rate	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier4 Annual Rate	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Unmetered Annual Rate	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier 1 Annual Rate	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832
	Residential Base Annual Rate	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199
Residential Operating Revenues Sum		$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031

Group	Type	2013 100% Grant	2013 Bond	2014 100% Grant	2014 Bond	2015 100% Grant	2015 Bond	2016 100% Grant	2016 Bond	2017 100% Grant	2017 Bond
Capital Expenditures	Capital Expenditures-Funded from	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Expenditures Sum		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt Service	Revenue Bonds	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060
	State Revolving Funds	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt Service Sum		$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060
Operating Expenditures	Contract Labor	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000
	O&M Associated with Alternative	$ 589	$ 589	$ 589	$ 589	$ 589	$ 589	$ 589	$ 589	$ 589	$ 589
Operating Expenditures Sum		$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589
Residential Operating Revenu	Residential Tier2 Annual Rate	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier3 Annual Rate	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier4 Annual Rate	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Unmetered Annual Rate	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier 1 Annual Rate	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832
	Residential Base Annual Rate	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199
Residential Operating Revenues Sum		$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031

Group	Type	2018 100% Grant	2018 Bond	2019 100% Grant	2019 Bond	2020 100% Grant	2020 Bond	2021 100% Grant	2021 Bond	2022 100% Grant	2022 Bond	2023 100% Grant	2023 Bond
Capital Expenditures	Capital Expenditures-Funded from	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Expenditures Sum		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt Service	Revenue Bonds	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060
	State Revolving Funds	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt Service Sum		$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060	$ -	$ 26,060
Operating Expenditures	Contract Labor	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000
	O&M Associated with Alternative	$ 589	$ 589	$ 589	$ 589	$ 589	$ 589	$ 589	$ 589	$ 589	$ 589	$ 589	$ 589
Operating Expenditures Sum		$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589	$ 24,589
Residential Operating Revenu	Residential Tier2 Annual Rate	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier3 Annual Rate	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier4 Annual Rate	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Unmetered Annual Rate	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier 1 Annual Rate	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832	$ 11,832
	Residential Base Annual Rate	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199	$ 36,199
Residential Operating Revenues Sum		$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031

Location_Name	SW Gardens
Alt_Desc	New Well at 1 Mile

Current_Year Funding_Alt

Data	2008 100% Grant	2008 Bond	2009 100% Grant	2009 Bond	2010 100% Grant	2010 Bond	2011 100% Grant	2011 Bond	2012 100% Grant	2012 Bond
Sum of Beginning_Cash_Bal	$ 48,061	$ 48,061	$ 72,092	$ 46,032	$ 95,533	$ 43,414	$ 118,975	$ 40,795	$ 142,416	$ 38,177
Sum of Total_Expenditures	$ 357,132	$ 383,192	$ 24,589	$ 50,649	$ 24,589	$ 50,649	$ 24,589	$ 50,649	$ 24,589	$ 50,649
Sum of Total_Receipts	$ 381,163	$ 381,163	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031
Sum of Net_Cash_Flow	$ 24,031	$ (2,029)	$ 23,442	$ (2,618)	$ 23,442	$ (2,618)	$ 23,442	$ (2,618)	$ 23,442	$ (2,618)
Sum of Ending_Cash_Bal	$ 72,092	$ 46,032	$ 95,533	$ 43,414	$ 118,975	$ 40,795	$ 142,416	$ 38,177	$ 165,858	$ 35,559
Sum of Working_Cap	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sum of Repl_Resv	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sum of Total_Reqd_Resv	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sum of Net_Avail_Bal	$ 72,092	$ 46,032	$ 95,533	$ 43,414	$ 118,975	$ 40,795	$ 142,416	$ 38,177	$ 165,858	$ 35,559
Sum of Add_Resv_Needed	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sum of Rate_Inc_Needed	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sum of Percent_Rate_Increase	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Data	2013 100% Grant	2013 Bond	2014 100% Grant	2014 Bond	2015 100% Grant	2015 Bond	2016 100% Grant	2016 Bond	2017 100% Grant	2017 Bond
Sum of Beginning_Cash_Bal	$ 165,858	$ 35,559	$ 189,300	$ 32,941	$ 212,741	$ 30,322	$ 236,183	$ 27,704	$ 259,624	$ 25,086
Sum of Total_Expenditures	$ 24,589	$ 50,649	$ 24,589	$ 50,649	$ 24,589	$ 50,649	$ 24,589	$ 50,649	$ 24,589	$ 50,649
Sum of Total_Receipts	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031
Sum of Net_Cash_Flow	$ 23,442	$ (2,618)	$ 23,442	$ (2,618)	$ 23,442	$ (2,618)	$ 23,442	$ (2,618)	$ 23,442	$ (2,618)
Sum of Ending_Cash_Bal	$ 189,300	$ 32,941	$ 212,741	$ 30,322	$ 236,183	$ 27,704	$ 259,624	$ 25,086	$ 283,066	$ 22,468
Sum of Working_Cap	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sum of Repl_Resv	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sum of Total_Reqd_Resv	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sum of Net_Avail_Bal	$ 189,300	$ 32,941	$ 212,741	$ 30,322	$ 236,183	$ 27,704	$ 259,624	$ 25,086	$ 283,066	$ 22,468
Sum of Add_Resv_Needed	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sum of Rate_Inc_Needed	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sum of Percent_Rate_Increase	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Data	2018 100% Grant	2018 Bond	2019 100% Grant	2019 Bond	2020 100% Grant	2020 Bond	2021 100% Grant	2021 Bond	2022 100% Grant	2022 Bond	2023 100% Grant	2023 Bond
Sum of Beginning_Cash_Bal	$ 283,066	$ 22,468	$ 306,507	$ 19,849	$ 329,949	$ 17,231	$ 353,391	$ 14,613	$ 376,832	$ 11,995	$ 400,274	$ 9,376
Sum of Total_Expenditures	$ 24,589	$ 50,649	$ 24,589	$ 50,649	$ 24,589	$ 50,649	$ 24,589	$ 50,649	$ 24,589	$ 50,649	$ 24,589	$ 50,649
Sum of Total_Receipts	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031	$ 48,031
Sum of Net_Cash_Flow	$ 23,442	$ (2,618)	$ 23,442	$ (2,618)	$ 23,442	$ (2,618)	$ 23,442	$ (2,618)	$ 23,442	$ (2,618)	$ 23,442	$ (2,618)
Sum of Ending_Cash_Bal	$ 306,507	$ 19,849	$ 329,949	$ 17,231	$ 353,391	$ 14,613	$ 376,832	$ 11,995	$ 400,274	$ 9,376	$ 423,715	$ 6,758
Sum of Working_Cap	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sum of Repl_Resv	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sum of Total_Reqd_Resv	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sum of Net_Avail_Bal	$ 306,507	$ 19,849	$ 329,949	$ 17,231	$ 353,391	$ 14,613	$ 376,832	$ 11,995	$ 400,274	$ 9,376	$ 423,715	$ 6,758
Sum of Add_Resv_Needed	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sum of Rate_Inc_Needed	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sum of Percent_Rate_Increase	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

APPENDIX E
CONCEPTUAL ANALYSIS OF INCREASING COMPLIANT DRINKING WATER

E.1 INTRODUCTION

E.1.1 OVERVIEW OF DRINKING WATER QUALITY IN REGION

There are many PWSs in the Lubbock area that do not have compliant drinking water due to elevated concentrations of naturally occurring contaminants in the area groundwater. Largely, this is a result of the generally poor water quality associated with the Ogallala-South Formation that is the water source for most of these systems (see Chapter 3 of the report to which this is appended). The common groundwater contaminants in the Ogallala-South Formation include arsenic, selenium, fluoride, nitrate, and uranium.

According to the TCEQ Water Utility Database, there are nearly 24,000 people in the Lubbock area who are served by active residential PWSs that do not currently have compliant drinking water. The majority of this population can be found in the area just outside the City of Lubbock, and also to the south of the city. The total area population with noncompliant drinking water is likely greater than 24,000, since only populations served by active PWSs are included in this estimate. There is additional populations that currently obtain drinking water from private wells or are served by PWSs that have too few connections to be considered active PWSs in the TCEQ Water Utility Database. Additionally, while the issue of noncompliant drinking water affects these area residents directly, the lack of good quality drinking water may restrict growth in the entire Lubbock area.

This appendix presents a conceptual analysis of a possible regional solution to the drinking water compliance issue in the Lubbock area. The purpose of this analysis is to investigate whether a large-scale regional approach to provide compliant drinking water might be more cost-effective than each PWS seeking its own solution. The objective of the analysis is to provide an indication of whether there is sufficient potential benefit to a regional approach to warrant further study. The conceptual analysis presented here is based on a single scenario and does not attempt to evaluate or rank a range of different solutions. For purposes of this report, this single scenario is referred to as the Lubbock Area Regional Solution (LARS).

To improve readability, the tables and figures for this appendix appear in Section E.6.

E.1.2 EVALUATION OF PWS DRINKING WATER QUALITY

Drinking water quality for the PWSs in the eight counties included in and around Lubbock was evaluated using TCEQ PWS drinking water quality data to identify PWSs that had potential water quality compliance issues. There are a number of PWSs that do not serve residential populations, such as restaurants, businesses, *etc*. Since this analysis is focused on residential systems, these commercial systems were excluded from the analysis. Additionally, systems listed as "inactive" were also excluded because it was not easy to determine whether they were listed as inactive because of small size, or are truly inactive.

Once the active residential PWSs were identified, they were screened for the common contaminants in the area: arsenic, selenium, fluoride, nitrate, and uranium. Systems with concentrations of the identified contaminants greater than MCLs were deemed to have noncompliant water. It is important to note that this screening was not an official compliance determination, and a system's compliance status determined from the screening may not coincide with a system's actual compliance status. Discrepancies may result from the data available not being current, the use of simplified algorithms to give an indication of compliance, *etc*.

The PWSs identified with potential water quality compliance issues are shown in Table E.1, along with numbers of connections, the population served, and average daily consumption. For the LARS, the area has been divided into three separate subareas named LARS–Lubbock, LARS-Lamesa, and LARS-Brownfield. The PWSs, population, connections, and average daily consumptions for these subareas are shown in Tables E.2, E.3, and E.4. These systems are also shown in Figure E.1. As can be seen on the figure, these systems are generally located near Lubbock and south of Lubbock.

E.1.3 EXISTING DRINKING WATER SUPPLIES AND INFRASTRUCTURE

PWSs in the area typically obtain drinking water from wells, purchase water from the City of Lubbock, or obtain water from the Canadian River Municipal Water Authority (CRMWA), either as one of the 11 member cities or as customers of a member city. The City of Lubbock is a member city of the CRMWA and has the largest water system in the area. As well as getting water from the CRMWA, Lubbock obtains water from its own well field in Bailey County. The CRMWA provides surface water and groundwater via a pipeline from the north to a water treatment plant located at and operated by Lubbock, from which point the treated water is distributed via transmission mains to the seven member cities west and south of Lubbock. There are existing CRMWA pipelines that extend to the southeast and west and southwest from Lubbock. The approximate location and extent of these lines are shown in Figure E.1.

The CRMWA production is fully committed to the 11 member cities. In addition, the transmission mains from Lubbock to the other seven member cities are at capacity during the summer months. Therefore, the LARS scenario proposed here uses new wells for the water source and if existing pipeline infrastructure is used for water transmission, allowances are made to account for any pipeline capacity used.

E.2 DESCRIPTION OF THE LARS

Since existing water supplies and infrastructure do not have sufficient capacity available, and the existing infrastructure does not cover the entire area projected to be served by the LARS, the LARS needs to provide both a water source and a means of conveyance. To accomplish this, the LARS includes several groundwater treatment plants located near clusters of PWSs with water quality problems. The locations of these treatment plants include one near the existing water treatment plant in Lubbock, one at Lamesa, and one at Brownfield (Figure E.2).

In addition to the groundwater treatment plants, new well fields would also be required to feed the groundwater treatment plants. The assumed water quality used to design each groundwater treatment plant is based on water quality data for PWSs near the proposed plant location. Groundwater treatment will be achieved using RO technology because, of the two technologies best suited for treating contaminants generally found in the water of the Ogallala-South aquifer (RO and EDR), RO is typically the most economical option.

The plant at Lubbock would tie into the Lubbock distribution system. The water would be passed through the Lubbock distribution system, and pipelines would be run from the Lubbock distribution system to the noncompliant PWSs around Lubbock. The location of the treatment plant, required new pipelines, and potential customers for the Lubbock component of the LARS are shown on Figure E.3.

The plant at Lamesa could tie into the Lubbock distribution system at Lamesa or could be independent. If tied into the Lamesa system, it could supplement Lamesa's system to allow the non-compliant PWSs upstream of Lamesa to withdraw water without impacting existing customers between Lamesa and Lubbock. If not tied in, the system could serve PWSs outside the Lamesa area. The location of the treatment plant, required new pipelines, and potential customers for the Lamesa component of the LARS are shown on Figure E.4.

The plant at Brownfield could tie into the Brownfield distribution system at Brownfield or could be independent. If tied into the Brownfield system, it could supplement Lubbock's system to allow the non-compliant PWSs upstream of Brownfield to withdraw water without impacting existing customers between Brownfield and Lubbock. If not tied in, the system could serve PWSs outside the Brownfield area. The location of the treatment plant, required new pipelines, and potential customers for the Brownfield component of the LARS are shown on Figure E.5.

Pipelines could be built to connect the CRMWA lines to the other noncompliant PWSs. In this way, the Lamesa and Brownfield groundwater treatment plants could provide enough drinking water to meet the demands of the systems at the ends of the CRMWA lines to offset water that would be taken out by noncompliant PWSs along the existing CRMWA lines. Connecting pipelines for the groundwater treatment plants and noncompliant PWSs to the existing City of Lubbock and CRMWA pipe systems reduces the need for added infrastructure to implement the regional solution, and would provide operational flexibility.

E.3 ESTIMATED COSTS

Costs to implement the LARS were estimated. This includes costs for new wells, pipelines, pump stations, and treatment plants. A conceptual design was developed for the main infrastructure components, and was used as the basis for estimating capital and O&M costs. The estimated capital and O&M costs for the major infrastructure components are summarized in Table E.5. The annualized costs of these components are also shown in

Table E.5, using a 6 percent discount rate and a 20-year period. Details of the capital costs for the three subareas are included in Tables E.6, E.7, and E.8.

Table E-9 presents an estimate of the cost of service to the LARS customers. If the customers were to bear the total capital and operating costs of the systems for their subarea or the system as a whole, the approximate monthly cost per connection would be as follows:

LARS-Lubbock:	$111/month	$1,336/year	4% of MHI
LARS-Lamesa:	$277/month	$3,327/year	9% of MHI
LARS-Brownfield:	$226/month	$2,716/year	8% of MHI
Combined:	$189/month	$2,266/year	6% of MHI

If the systems would be able to get 100 percent grant funding for the capital costs of constructing the system, the approximate monthly cost per connection would be as follows:

LARS-Lubbock:	$42/month	$509/year	1% of MHI
LARS-Lamesa:	$53/month	$630/year	2% of MHI
LARS-Brownfield:	$72/month	$866/year	2% of MHI
Combined:	$59/month	$711/year	2% of MHI

This then forms the approximate range of the cost of service for the customers (per connection) of a regional solution.

Increasing the coverage of the regional solution to include populations served by inactive PWSs or those that have private wells could have the effect of reducing treatment costs on a per gallon basis, but increasing the cost for distribution piping. Likewise, other sources of water with associated quality aspects would affect the cost, including surface water sources, better groundwater sources, and the use of reclaimed water, either for supplemental potable or non-potable uses. A more detailed assessment would be required to determine whether the overall effect would be an increase or decrease on the cost to the customers.

E.5 CONCLUSION

A regional solution to serving non-compliant PWSs in the Lubbock area presents a potentially viable solution to an existing problem. If suitable groundwater can be found, a regional system could be implemented within a cost per connection range of $59/month to $189/month, with the actual cost depending on the source and costs of capital funds needed to build a regional system.

A Community Development Block Grant is one possible source of funding the capital costs for the regional solution. Community Development Block Grants are discussed further in Attachment E1.

E.6 TABLES AND FIGURES

Table E.1

Active Residential Public Water Systems with Potential Water Quality Problems

Lubbock Area Regional Solution

PWS ID #	PWS Name	Population	Connections	Avg. Daily Consumption (mgd)	County
0170010	BORDEN COUNTY WATER SYSTEM	102	102	0.010	BORDEN
0580011	ACKERLY WATER SUPPLY CORP	230	125	0.115	DAWSON
0580013	WELCH WATER SUPPLY CORP	312	123	0.057	DAWSON
0580025	KLONDIKE HIGH SCHOOL	250	16	0.025	DAWSON
0830001	SEAGRAVES CITY OF	2400	974	0.473	GAINES
0830011	LOOP WATER SUPPLY CORP	350	117	0.053	GAINES
0830012	SEMINOLE CITY OF	6456	2641	1.531	GAINES
0850002	SOUTHLAND ISD	193	4	0.019	GARZA
1100004	ROPESVILLE CITY OF	517	196	0.094	HOCKLEY
1100010	SMYER CITY OF	480	180	0.051	HOCKLEY
1100011	WHITHARRAL WATER SUPPLY CORP	275	82	0.043	HOCKLEY
1100030	OPDYKE WEST WATER SUPPLY	140	63	0.018	HOCKLEY
1520005	WOLFFORTH CITY OF	3000	1150	0.439	LUBBOCK
1520009	BIG Q MOBILE HOME ESTATES	200	70	0.013	LUBBOCK
1520025	BUSTERS MOBILE HOME PARK	20	8	0.002	LUBBOCK
1520026	FAMILY COMMUNITY CENTER MHP	88	40	0.011	LUBBOCK
1520027	WAGON WHEEL MOBILE VILLAGE HOME PR	30	21	0.003	LUBBOCK
1520036	GREEN MOBILE HOME PARK	50	28	0.004	LUBBOCK
1520039	PECAN GROVE MOBILE HOME PARK	100	50	0.008	LUBBOCK
1520062	PLOTT ACRES	201	63	0.019	LUBBOCK
1520067	114TH STREET MOBILE HOME PARK	96	43	0.009	LUBBOCK
1520080	FRANKLIN WATER SERVICE COMPANY	152	64	0.011	LUBBOCK
1520094	TOWN NORTH VILLAGE WATER SYSTEM	330	117	0.031	LUBBOCK
1520106	COX ADDITION WATER SYSTEM	133	40	0.014	LUBBOCK
1520122	LUBBOCK COOPER ISD	1900	14	0.190	LUBBOCK
1520123	ROOSEVELT ISD	1600	11	0.048	LUBBOCK
1520149	WHORTON MOBILE HOME PARK	75	26	0.008	LUBBOCK
1520152	TOWN NORTH ESTATES	227	67	0.015	LUBBOCK
1520154	CHARLIE BROWNS LEARNING CENTER	47	3	0.005	LUBBOCK
1520155	COUNTRY SQUIRE MHP 2	75	16	0.008	LUBBOCK
1520156	ELM GROVE MOBILE HOME PARK	24	20	0.002	LUBBOCK
1520158	MILLER MOBILE HOME PARK	60	33	0.005	LUBBOCK
1520185	LUBBOCK RV PARK	133	100	0.009	LUBBOCK
1520188	CASEY ESTATES WATER	312	104	0.026	LUBBOCK
1520192	TERRELLS MOBILE HOME PARK	50	22	0.005	LUBBOCK
1520198	VALLEY ESTATES	70	36	0.007	LUBBOCK
1520199	WOLFFORTH PLACE	460	123	0.041	LUBBOCK
1520211	TEXIN ENTERPRISES	27	9	0.002	LUBBOCK
1520217	SOUTHWEST GARDEN WATER	375	125	0.028	LUBBOCK
1520223	PAUL COBB WATER SYSTEM	30	18	0.003	LUBBOCK
1520225	FAY BEN MOBILE HOME PARK	90	55	0.007	LUBBOCK
1520241	MANAGED CARE CENTER	40	5	0.003	LUBBOCK
1520247	COUNTRY VIEW MHP	67	24	0.007	LUBBOCK
1530001	ODONNELL CITY OF	1100	392	0.139	LYNN
1530004	NEW HOME CITY OF	280	125	0.055	LYNN
1530005	GRASSLAND WATER SUPPLY CORP	80	30	0.008	LYNN
2230002	MEADOW CITY OF	547	230	0.138	TERRY
2230003	WELLMAN PUBLIC WATER SYSTEM	236	95	0.046	TERRY
	TOTALS	**24,010**	**8,000**	**3.856**	

Table E.2
Public Water Systems associated with LARS-Lubbock Treatment Plant

PWS ID #	PWS Name	Population	Connections	Avg. Daily Consumption (mgd)	County
0850002	SOUTHLAND ISD	193	4	0.019	GARZA
1100010	SMYER CITY OF	480	180	0.051	HOCKLEY
1100011	WHITHARRAL WATER SUPPLY CORP	275	82	0.043	HOCKLEY
1100030	OPDYKE WEST WATER SUPPLY	140	63	0.018	HOCKLEY
1520005	WOLFFORTH CITY OF	3000	1150	0.439	LUBBOCK
1520009	BIG Q MOBILE HOME ESTATES	200	70	0.013	LUBBOCK
1520025	BUSTERS MOBILE HOME PARK	20	8	0.002	LUBBOCK
1520026	FAMILY COMMUNITY CENTER MHP	88	40	0.011	LUBBOCK
1520027	WAGON WHEEL MOBILE VILLAGE HOME PR	30	21	0.003	LUBBOCK
1520036	GREEN MOBILE HOME PARK	50	28	0.004	LUBBOCK
1520039	PECAN GROVE MOBILE HOME PARK	100	50	0.008	LUBBOCK
1520062	PLOTT ACRES	201	63	0.019	LUBBOCK
1520067	114TH STREET MOBILE HOME PARK	96	43	0.009	LUBBOCK
1520080	FRANKLIN WATER SERVICE COMPANY	152	64	0.011	LUBBOCK
1520094	TOWN NORTH VILLAGE WATER SYSTEM	330	117	0.031	LUBBOCK
1520106	COX ADDITION WATER SYSTEM	133	40	0.014	LUBBOCK
1520122	LUBBOCK COOPER ISD	1900	14	0.190	LUBBOCK
1520123	ROOSEVELT ISD	1600	11	0.048	LUBBOCK
1520149	WHORTON MOBILE HOME PARK	75	26	0.008	LUBBOCK
1520152	TOWN NORTH ESTATES	227	67	0.015	LUBBOCK
1520154	CHARLIE BROWNS LEARNING CENTER	47	3	0.005	LUBBOCK
1520155	COUNTRY SQUIRE MHP 2	75	16	0.008	LUBBOCK
1520156	ELM GROVE MOBILE HOME PARK	24	20	0.002	LUBBOCK
1520158	MILLER MOBILE HOME PARK	60	33	0.005	LUBBOCK
1520185	LUBBOCK RV PARK	133	100	0.009	LUBBOCK
1520188	CASEY ESTATES WATER	312	104	0.026	LUBBOCK
1520192	TERRELLS MOBILE HOME PARK	50	22	0.005	LUBBOCK
1520198	VALLEY ESTATES	70	36	0.007	LUBBOCK
1520199	WOLFFORTH PLACE	460	123	0.041	LUBBOCK
1520211	TEXIN ENTERPRISES	27	9	0.002	LUBBOCK
1520217	SOUTHWEST GARDEN WATER	375	125	0.028	LUBBOCK
1520223	PAUL COBB WATER SYSTEM	30	18	0.003	LUBBOCK
1520225	FAY BEN MOBILE HOME PARK	90	55	0.007	LUBBOCK
1520241	MANAGED CARE CENTER	40	5	0.003	LUBBOCK
1520247	COUNTRY VIEW MHP	67	24	0.007	LUBBOCK
1530004	NEW HOME CITY OF	280	125	0.055	LYNN
	TOTALS	**11,430**	**2,959**	**1.167**	

Table E.3
Public Water Systems associated with LARS-Lamesa Treatment Plant

PWS ID #	PWS Name	Population	Connections	Avg. Daily Consumption (mgd)	County
0170010	BORDEN COUNTY WATER SYSTEM	102	102	0.010	BORDEN
0580011	ACKERLY WATER SUPPLY CORP	230	125	0.115	DAWSON
0580013	WELCH WATER SUPPLY CORP	312	123	0.057	DAWSON
0580025	KLONDIKE HIGH SCHOOL	250	16	0.025	DAWSON
1530001	ODONNELL CITY OF	1100	392	0.139	LYNN
1530005	GRASSLAND WATER SUPPLY CORP	80	30	0.008	LYNN
	TOTALS	**2,074**	**788**	**0.354**	

Table E.4
Public Water Systems associated with LARS-Brownfield Treatment Plant

PWS ID #	PWS Name	Population	Connections	Avg. Daily Consumption (mgd)	County
0830001	SEAGRAVES CITY OF	2400	974	0.473	GAINES
0830011	LOOP WATER SUPPLY CORP	350	117	0.053	GAINES
0830012	SEMINOLE CITY OF	6456	2641	1.531	GAINES
1100004	ROPESVILLE CITY OF	517	196	0.094	HOCKLEY
2230002	MEADOW CITY OF	547	230	0.138	TERRY
2230003	WELLMAN PUBLIC WATER SYSTEM	236	95	0.046	TERRY
	TOTALS	**10,506**	**4,253**	**2.335**	

Table E.5
Summary of Cost Components
Lubbock Area Regional Solution (LARS)

Cost Item	Capital	O&M	Annualized 20 yr, 6%
LARS - Lamesa			
Wells	$ 783,000	$ 78,578	$ 146,844
Treatment Plant	$ 3,271,200	$ 308,989	$ 594,187
Pipeline and Pump Stations	$ 20,323,892	$ 108,939	$ 1,880,869
Subtotal	**$ 24,378,092**	**$ 496,506**	**$ 2,621,899**
LARS - Brownfield			
Wells	$ 5,383,125	$ 540,224	$ 1,009,550
Treatment Plant	$ 14,734,900	$ 1,563,235	$ 2,847,891
Pipeline and Pump Stations	$ 70,140,452	$ 1,578,779	$ 7,693,944
Subtotal	**$ 90,258,477**	**$ 3,682,239**	**$ 11,551,384**
LARS - Lubbock			
Wells	$ 2,740,500	$ 275,023	$ 513,952
Treatment Plant	$ 7,397,900	$ 816,460	$ 1,461,443
Pipeline and Pump Stations	$ 17,931,065	$ 415,323	$ 1,978,635
Subtotal	**$ 28,069,465**	**$ 1,506,807**	**$ 3,954,030**
TOTAL	**$ 142,706,034**	**$ 5,685,551**	**$ 18,127,314**

Table E.6
Lubbock Area Regional Solution - Treatment Plant at Lubbock
Summary of Cost Components

Item	Quantity	Unit	Capital	O&M
Wells				
New wells	28	EA	$ 1,890,000	$ 275,023
Contingency	20%		$ 378,000	
Design & Constr Management	25%		$ 472,500	
Subtotal			**$ 2,740,500**	**$ 275,023**
Treatment				
RO Treatment Plant	1	EA	$ 5,102,000	$ 816,460
Contingency	20%		$ 1,020,400	
Design & Constr Management	25%		$ 1,275,500	
Subtotal			**$ 7,397,900**	**$ 816,460**
Pipeline				
4" Pipeline w/complete installation	49.07	Miles	$ 8,636,689	$ 11,450
6" Pipeline w/complete installation	3.66	Miles	$ 642,002	$ 849
10" Pipeline w/complete installation	2.17	Miles	$ 612,761	$ 542
Contingency	20%		$ 1,978,290	
Design & Constr Management	25%		$ 2,472,863	
Subtotal			**$ 14,342,605**	**$ 12,841**
Pump Stations				
Pump Stations	13	EA	$ 2,474,800	$ 402,482
Contingency	20%		$ 494,960	
Design & Constr Management	25%		$ 618,700	
Subtotal			**$ 3,588,460**	**$ 402,482**
TOTAL COSTS			**$ 28,069,465**	**$ 1,506,807**

Table E.7

Lubbock Area Regional Solution - Treatment Plant at Lamesa

Summary of Cost Components

Item	Quantity	Unit	Capital	O&M
Wells				
New wells	8	EA	$ 540,000	$ 78,578
Contingency	20%		$ 108,000	
Design & Constr Management	25%		$ 135,000	
Subtotal			**$ 783,000**	**$ 78,578**
Treatment				
RO Treatment Plant	1	EA	$ 2,256,000	$ 308,989
Contingency	20%		$ 451,200	
Design & Constr Management	25%		$ 564,000	
Subtotal			**$ 3,271,200**	**$ 308,989**
Pipeline				
4" Pipeline w/complete installation	33.30	Miles	$ 5,484,498	$ 8,326
6" Pipeline w/complete installation	15.15	Miles	$ 2,966,562	$ 3,787
8" Pipeline w/complete installation	22.89	Miles	$ 5,203,212	$ 5,722
Contingency	20%		$ 2,730,854	
Design & Constr Management	25%		$ 3,413,568	
Subtotal			**$ 19,798,695**	**$ 17,835**
Pump Stations				
Pump Stations	5	EA	$ 362,205	$ 91,104
Contingency	20%		$ 72,441	
Design & Constr Management	25%		$ 90,551	
Subtotal			**$ 525,197**	**$ 91,104**
TOTAL COSTS			**$ 24,378,092**	**$ 496,506**

Table E.8
Lubbock Area Regional Solution - Treatment Plant at Brownfield
Summary of Cost Components

Item	Quantity	Unit	Capital	O&M
Wells				
New wells	55	EA	$ 3,712,500	$ 540,224
Contingency	20%		$ 742,500	
Design & Constr Management	25%		$ 928,125	
Subtotal			**$ 5,383,125**	**$ 540,224**
Treatment				
RO Treatment Plant	1	EA	$ 10,162,000	$ 1,563,235
Contingency	20%		$ 2,032,400	
Design & Constr Management	25%		$ 2,540,500	
Subtotal			**$ 14,734,900**	**$ 1,563,235**
Pipeline				
4" Pipeline w/complete installation	3.43	Miles	$ 543,272	$ 857
6" Pipeline w/complete installation	16.36	Miles	$ 3,206,887	$ 4,090
8" Pipeline w/complete installation	1.01	Miles	$ 284,268	$ 251
24" Pipeline w/complete installation	16.66	Miles	$ 15,300,032	$ 4,166
30" Pipeline w/complete installation	24.72	Miles	$ 28,023,581	$ 6,180
Contingency	20%		$ 9,471,608	
Design & Constr Management	25%		$ 11,839,510	
Subtotal			**$ 68,669,159**	**$ 15,544**
Pump Stations				
Pump Stations	6	EA	$ 1,014,685	$ 137,212
Contingency	20%		$ 202,937	
Design & Constr Management	25%		$ 253,671	
Subtotal			**$ 1,471,293**	**$ 137,212**
TOTAL COSTS			**$ 90,258,477**	**$ 2,256,215**

Table E.9

Lubbock Area Regional Solution (LARS)

Cost of Service

Component	Lubbock	Lamesa	Brownfield	Combined
Capital Cost	$ 28,069,465	$ 24,378,092	$ 90,258,477	$ 142,706,034
Annual O&M	$ 1,506,807	$ 496,506	$ 3,682,239	$ 5,685,551
Annualized 20 yr., 6%	$ 3,954,030	$ 2,621,899	$ 11,551,384	$ 18,127,314
Population	11,430	2,074	10,506	$ 24,010
Connections	2,959	788	4,253	$ 8,000
Annualized/Population	$ 345.93	$ 1,264.18	$ 1,099.50	$ 754.99
Annualized/Connection	$ 1,336.27	$ 3,327.28	$ 2,716.06	$ 2,265.91
Annualized/Connection as % of MHI*	4%	9%	8%	6%
Annualized/Connection/Month	**$ 111.36**	**$ 277.27**	**$ 226.34**	**$ 188.83**
Annual O&M/Population	$ 131.83	$ 239.40	$ 350.49	$ 236.80
Annual O&M/Connection	$ 509.23	$ 630.08	$ 865.80	$ 710.69
Annual O&M/Connection as % of MHI*	1%	2%	2%	2%
Annual O&M/Connection/Month	**$ 42.44**	**$ 52.51**	**$ 72.15**	**$ 59.22**

* Percentage of MHI calculated based on the MHI for Lubbock County of $35,189.

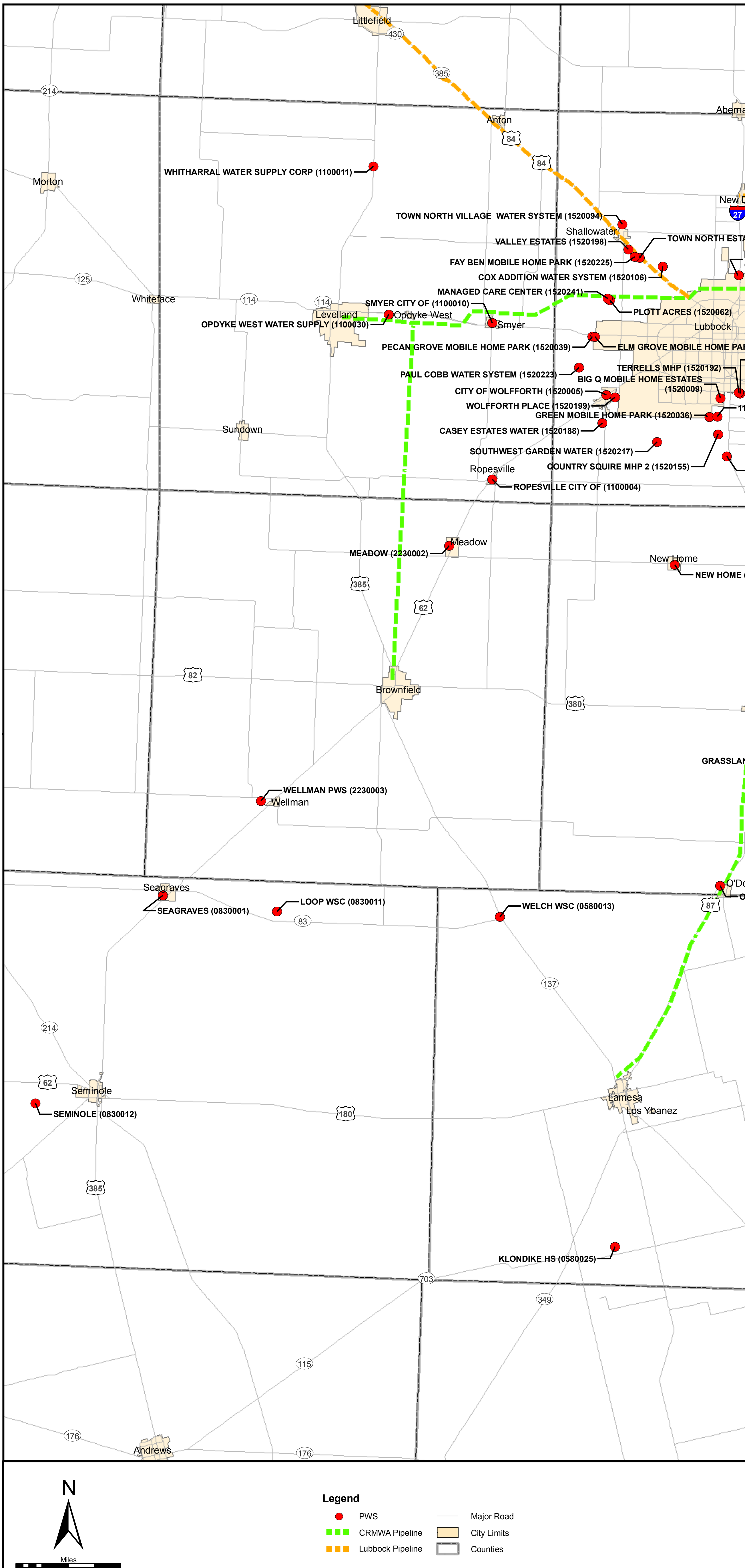

Figure E.1

EXISTING INFRASTRUCTURE & ACTIVE RESIDENTIAL PWS's WITH POTENTIAL WATER QUALITY PROBLEMS

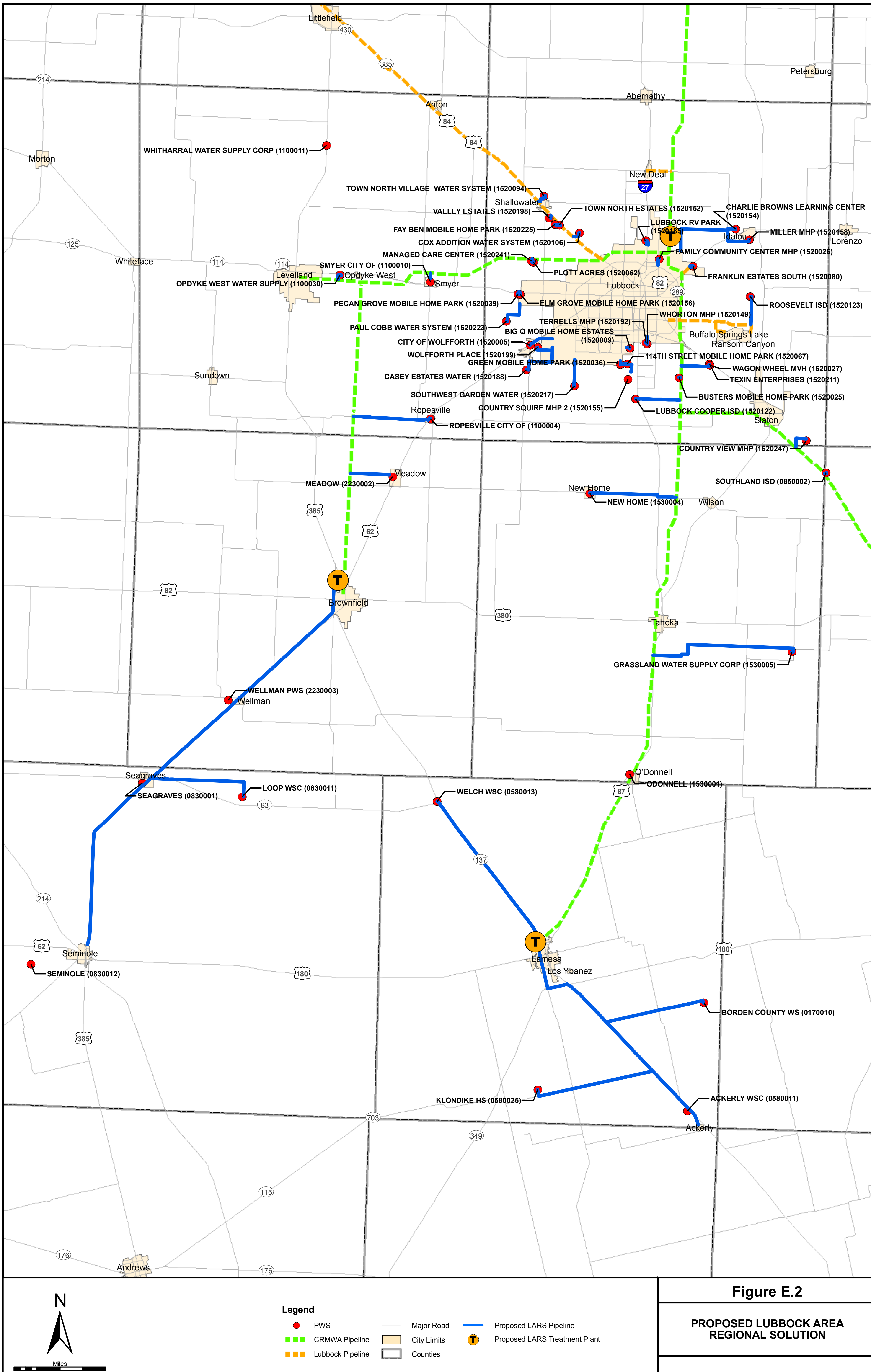

Figure E.2

PROPOSED LUBBOCK AREA REGIONAL SOLUTION

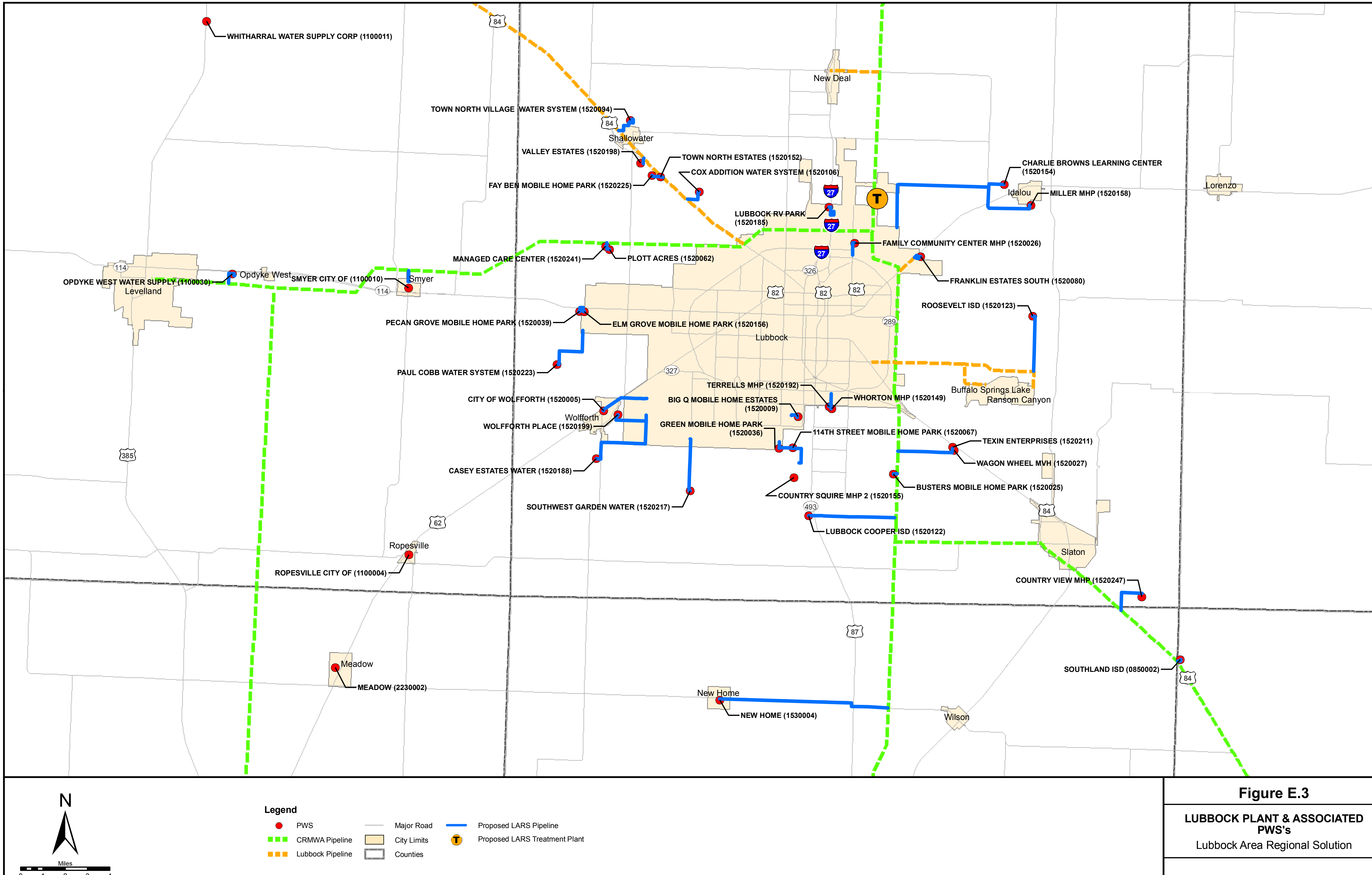

Figure E.3

LUBBOCK PLANT & ASSOCIATED PWS's

Lubbock Area Regional Solution

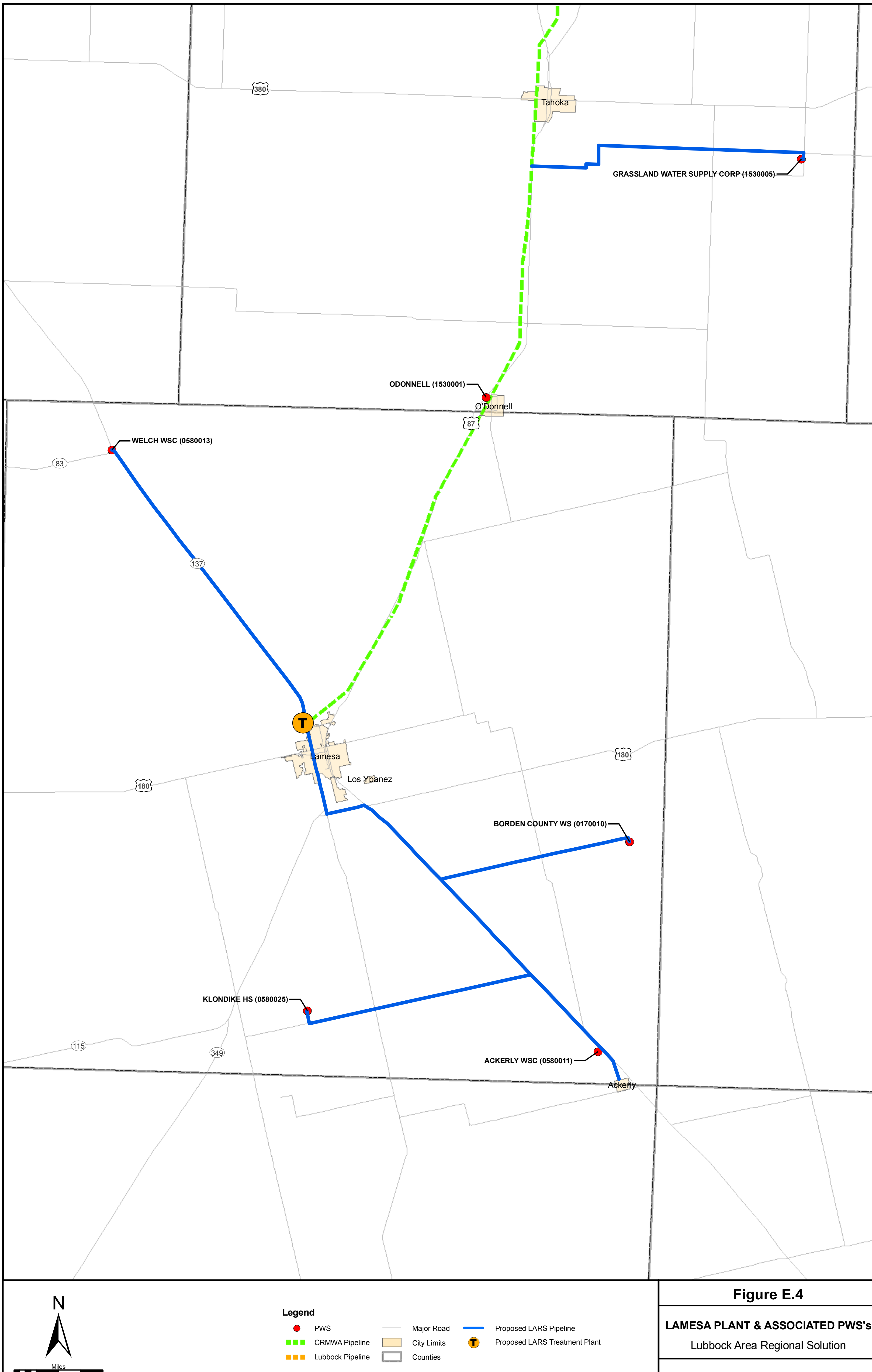

Figure E.4

LAMESA PLANT & ASSOCIATED PWS's

Lubbock Area Regional Solution

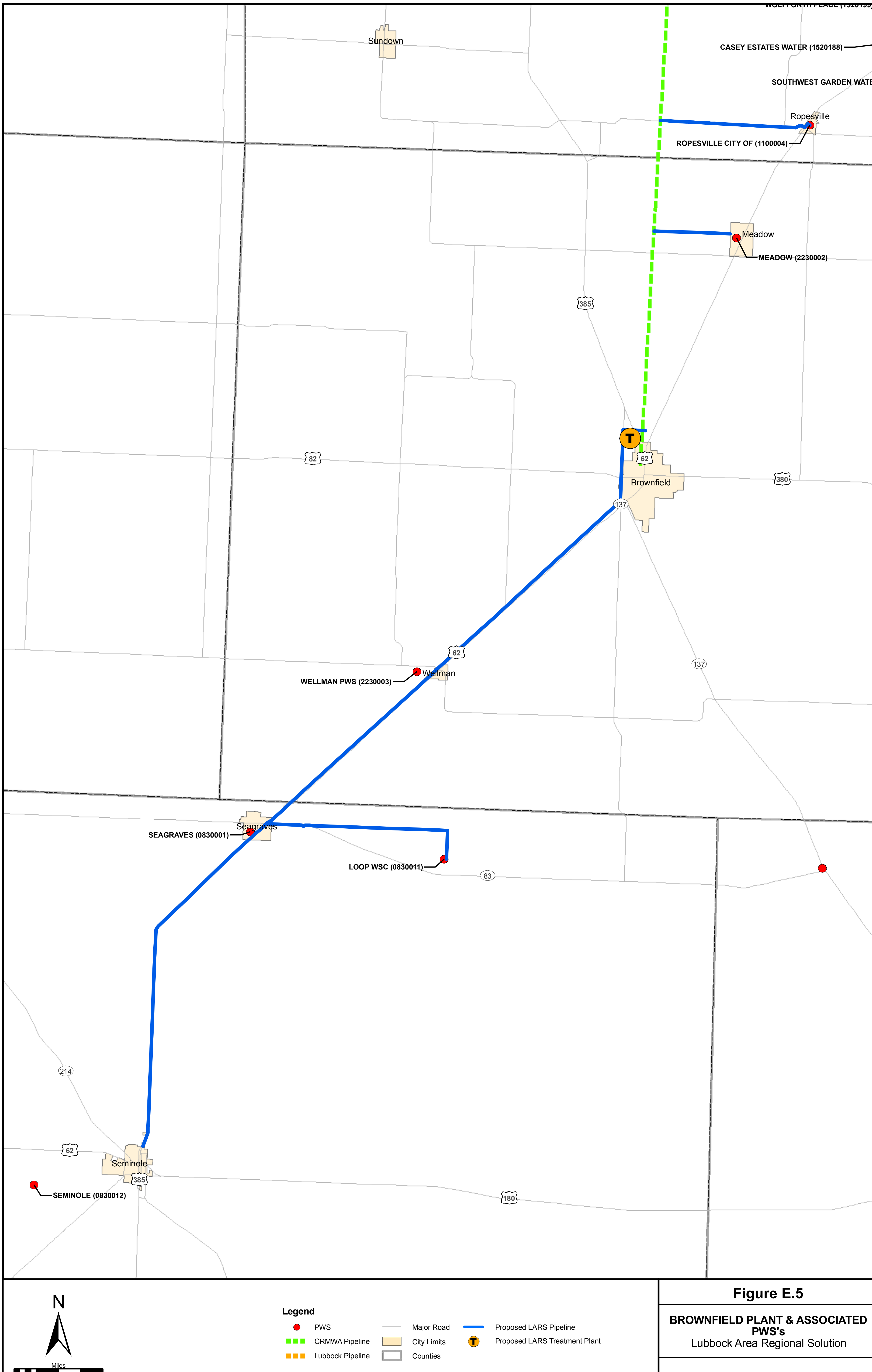

Figure E.5

BROWNFIELD PLANT & ASSOCIATED PWS's

Lubbock Area Regional Solution

ATTACHMENT E1
TEXAS COMMUNITY DEVELOPMENT BLOCK GRANTS

INTRODUCTION

Every year, the U.S. Department of Housing and Urban Development (HUD) provides federal Community Development Block Grant (CDBG) funds directly to states, which, in turn, provide the funds to small, rural cities with populations of less than 50,000, and to counties that have a non-metropolitan population under 200,000 and are not eligible for direct funding from U.S. Department of Housing and Urban Development (HUD). These small communities are called "non-entitlement" areas because they must apply for CDBG dollars through the Office of Rural Community Affairs (ORCA). The grants may be used for community and economic development activities, but are primarily used for housing rehabilitation, public infrastructure projects (*e.g.,* wastewater and drinking water facilities), and economic development. Seventy percent of grant funds must be used for activities that principally benefit low- and moderate-income persons.

ORCA administers the State of Texas CDBG Program, called the Texas Community Development Block Grant Program (Texas CDBG). The Texas Department of Agriculture (TDA) administers the Texas Capital Fund through an interagency agreement between ORCA and TDA.

ORCA's CDBG program is the largest in the nation. The rural-focused program serves approximately 1,017 eligible rural communities, 245 rural counties, and provides services to over 375,000 low- to moderate-income beneficiaries each year. Of the 1,017 communities eligible for CDBG funds, 740 have a population of less than 3,000, and 424 have a population of less than 1,000. The demographics and rural characteristics of Texas have shaped a program that focuses on providing basic human needs and sanitary infrastructure to small rural communities in outlying areas.

PROGRAM ADMINISTRATION

ORCA administers the CDBG programs in accordance to funding rules and regulations set by HUD. Each year, ORCA submits an Action Plan for the next fiscal year. The Action Plan describes the methods ORCA will use for distributing funds among the various CDBG programs, including award amounts per program, application selection process, *etc*. Once HUD approves the Action Plan, it becomes codified into the Texas Administrative Code under Title 10 TAC Chapter 255. The agency then makes applications available in accordance with each program's funding cycle. Applications received for competitive funding programs are reviewed and scored using program-specific criteria and processes. These processes may include scoring by Regional Review Committees and review by the State Review Committees.

Once awards are made from ORCA's CDBG program, contracts are executed between the agency and the city or county officials, and the grantee begins the implementation of their proposed project. To guide grantees in the implementation of their projects, the grantees follow the 2005 CDBG Implementation Manual. The Manual describes the methods a CDBG grant recipient uses to administer the CDBG contract, and includes relevant forms.

ELIGIBLE APPLICANTS

Eligible applicants are nonentitlement general purpose units of local government, including cities and counties that are not participating or designated as eligible to participate in the entitlement portion of the federal CDBG. Nonentitlement cities that are not participating in urban county programs through existing participation agreements are eligible applicants (unless the city's population is counted toward the urban county CDBG allocation).

Nonentitlement cities are located predominately in rural areas and are cities with populations less than 50,000 thousand persons; cities that are not designated as a central city of a metropolitan statistical area; and cities that are not participating in urban county programs. Nonentitlement counties are also predominately rural in nature and are counties that generally have fewer than 200,000 persons in the nonentitlement communities and unincorporated areas located in the county.

ELIGIBLE ACTIVITIES

Eligible activities under the Texas CDBG Program are listed in 42 United States Code (USC) Section 5305. The Texas CDBG staff reviews all proposed project activities included in applications for all fund categories except the Texas Capital Fund (TCF), to determine eligibility. The Texas Department of Agriculture determines the eligibility of activities included in TCF applications.

All proposed activities must meet one of the following three National Program Objectives:

1. Benefit principally low- and moderate-income persons; or
2. Aid in the elimination of slums or blight; or
3. Meet other community development needs of particular urgency that represent an immediate threat to the health and safety of residents of the community.

INELIGIBLE ACTIVITIES

In general, any type of activity not described or referred to in 42 USC Section 5305 is ineligible. Specific activities ineligible under the Texas CDBG Program are:

1. Construction of buildings and facilities used for the general conduct of government (*e.g*. city halls, courthouses, *etc*.);
2. Construction of new housing, except as last resort housing under 49 CFR Part 24 or affordable housing through eligible subrecipients in accordance with 24 CFR 570.204;

3. Financing of political activities;
4. Purchases of construction equipment (except in limited circumstances under the STEP Program);
5. Income payments, such as housing allowances; and
6. Most O&M expenses (including smoke testing, televising/video taping line work, or any other investigative method to determine the overall scope and location of the project work activities)

The TCF will not accept applications in support of public or private prisons, racetracks, and projects that address job creation/retention through a government supported facility. The TCF Program may be used to financially assist/facilitate the relocation of a business when certain requirements, as defined in the application guidelines, are met.

PRIMARY BENEFICIARIES

The primary beneficiaries of the Texas CDBG Program are low to moderate income persons as defined under HUD, Section 8 Assisted Housing Program (Section l02(c)). Low income families are defined as those earning less than 50 percent of the area MHI. Moderate income families are defined as those earning less than 80 percent of the area MHI. The area median family can be based on a metropolitan statistical area, a non-metropolitan county, or the statewide non-metropolitan MHI figure.

SECTION 108 LOAN GUARANTEE PROGRAM

Section 108 is the loan guarantee provision of the Texas CDBG Program. Section 108 provides communities with a source of financing for economic development, housing rehabilitation, public facilities, and large-scale physical development projects. This makes it one of the most potent and important public investment tools that HUD offers to local governments. It allows these local governments to transform a small portion of their CDBG funds into federally guaranteed loans large enough to pursue physical and economic revitalization projects that can renew entire neighborhoods. Such public investment is often needed to inspire private economic activity, providing the initial resources, or simply the confidence that private firms and individuals may need to invest in distressed areas. Section 108 loans are not risk-free; however, local governments borrowing funds guaranteed by Section 108 must pledge their current and future CDBG allocations to cover the loan amount as security for the loan.

The loan is made by a private lender to an eligible nonentitlement city or county. HUD guarantees the loan; however, Texas CDBG must pledge the state's current and future CDBG nonentitlement area funds to cover any losses. To provide eligible nonentitlement communities an additional funding source, the State is authorizing a loan guarantee pilot program for 2008 consisting of one application up to a maximum of $500,000 for a particular project. An application guide containing the submission date and qualifications will be available for applicants interested in being selected as the pilot project under this program.

APPENDIX F
GENERAL CONTAMINANT GEOCHEMISTRY

Arsenic

The geochemistry of arsenic is complex because of the possible coexistence of two or even three redox states (-III, III, V) and because of the strong interaction of most arsenic compounds with soil particles, particularly iron oxides. Because groundwater is generally oxidizing in the High Plains, Edwards Trinity (Plateau), and Cenozoic Pecos Alluvium aquifers, it is expected to be in the arsenate form (V). Correlations between arsenic and vanadium and fluoride suggest a geologic rather than an anthropogenic source of arsenic. The large number of potential geologic sources include: volcanic ashes in the Ogallala and underlying units, shales in the Cretaceous, and saline lakes in the Southern High Plains that were evaluated in a separate study and described in Scanlon, *et al.* (2005). Arsenic mobility is generally not controlled by solubility of arsenic-bearing minerals because these minerals are highly soluble. Under oxidizing conditions, arsenic mobility increases with increasing pH (Smedley and Kinniburg 2000). Phosphate can also increase arsenic mobility because phosphate preferentially sorbs onto clays and iron oxides relative to arsenic.

Nitrate

Nitrate is negatively charged and behaves conservatively; *i.e.*, it does not sorb onto soil, volatilize, precipitate readily, *etc*. Natural sources of nitrate include fixed nitrogen by shrubs such as mesquite in rangeland settings. Nitrate concentrations in soil profiles in most rangeland settings in the Southern High Plains are generally low (Scanlon, *et al*. 2003; McMahon, *et al*. 2005). Conversion of rangeland to agriculture can result in nitrification of soil organic matter. Anthropogenic sources of nitrate include chemical and organic (manure) fertilizers, nitrogen fixation through growth of leguminous crops, and barnyard and septic tank effluent. Nitrogen isotopes have been used to distinguish these various sources; however, such a study has not been conducted in the Southern High Plains. Nitrogen profiles measured in soil in Dawson County, Texas, indicated that nitrate concentrations in soil pore water were generally low to moderate (Scanlon, *et al*. 2003). The highest concentrations were found in irrigated areas because irrigation water contains higher nitrate concentrations than rain water and irrigation rates are low enough to result in evapoconcentration of nitrate in the soil.

Fluoride

Fluorine exists naturally in solution under one valence, F-, the fluoride ion. Fluoride tends to make complexes and ion pairs with trace elements. It can also sorb significantly to oxides, especially aluminum oxides, and clays (Hem 1985). Its concentration controlled by calcium, as fluorite (CaF_2) is the most common fluorine mineral. Apatite (a calcium phosphate) can also contain a significant amount of fluorine.

Selenium

Selenium has a chemistry similar to that of sulfur, existing naturally in four redox states VI, IV, 0, and –II, with selenate, selenite, and selenide ions occurring in Eh-pH conditions largely parallel to those of arsenic. In oxic conditions, the selenate ion, SeO_4^{-2}, is the dominant species across all natural pHs. In slightly reducing conditions, the selenite ion exists from the fully deprotonated form, SeO_3^{-2}, at alkaline pHs to the neutral H_2SeO_3 at acid pHs and the $HSeO_3^{-1}$ form at neutral pHs. However, here are several differences with arsenic. The selenate ion is a weak sorber and its behavior resembles more that of sulfate than that of arsenate ion (White and Dubrovsky 1994). Organo-selenium compounds and possibly native selenium are also more widespread. All selenate and selenite minerals are highly soluble. Native selenium, or more likely ferroselite (pyrite with some Se substituted for S), can precipitate at relatively high Eh neutral pH. However, kinetics issues may keep selenium in solution even at reducing Ehs (Henry, *et al*. 1982).

Uranium

The geochemistry of uranium is complicated but can be summarized by the following. Uranium(VI) in oxidizing conditions exists as the soluble positively charged uranyl UO_2^{+2}. Solubility is higher at acid pHs, decreases at neutral pHs, and increases at alkaline pHs. The uranyl ion can easily form aqueous complexes, including with hydroxyl, fluoride, carbonate, and phosphate ligands. Hence, in the presence of carbonates, uranium solubility is considerably enhanced in the form of uranyl-carbonate (UO_2CO_3) and other higher order carbonate complexes: uranyl-di-carbonate ($UO_2(CO_3)_2^{-2}$ and uranyl-tri-carbonates $UO_2(CO_3)_3^{-4}$. Adsorption of uranium is inversely related to its solubility and is highest at neutral pHs (De Soto 1978). Uranium sorbs strongly to metal oxides and clays. Uranium(IV) is the other commonly found redox state. In that state, however, uranium is not very soluble and precipitates as uranite, UO_2, coffinite, $USiO_4{}^nH_2O$ (if SiO_2>60 mg/L (Henry, *et al.* 1982), or related minerals. In most aquifers, no mineral controls uranium solubility in oxidizing conditions. However, uranite and coffinite are the controlling minerals if Eh drops below 0-100 mV.

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