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

GREENWOOD VENTURES
PWS ID# 1650006

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

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August 2006

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 study 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 study was to promote compliance with Texas drinking water standards using sound engineering and financial methods and data for PWSs that had recently recorded sample results exceeding maximum contaminant levels (MCL). The primary objectives of this study 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 Greenwood Ventures PWS, which provides drinking water to a small mobile home park located east of Midland, Texas (hereinafter referred to as the Greenwood Ventures PWS). The Greenwood Ventures PWS recorded arsenic concentrations that ranged from 0.0126 milligrams per liter (mg/L) to 0.0257 mg/L. These results exceeded the arsenic MCL of .01 mg/L that went into effect January 23, 2006 (USEPA 2005a; TCEQ 2004). The Greenwood Ventures PWS recorded nitrate concentrations with an average of approximately 20 mg/L, which exceeds the nitrate MCL of 10 mg/L as nitrogen. Additionally, Greenwood Ventures PWS measured combined uranium at 0.073 mg/L, which exceeds the uranium MCL of 0.030 mg/L.

Basic system information for the Greenwood Ventures PWS is shown in Table ES1.

Table ES1 Greenwood Ventures PWS Basic System Information

Population served	50
Connections	21
Average daily flow rate	0.0038 million gallons per day
Peak demand flow rate	8 gallons per minute
Water system peak capacity	0.029 mgd
Typical total arsenic range	0.0126-to 0.0257 mg/L
Average nitrate	20.6 mg/L
Combined uranium result	0.073 mg/L

STUDY METHODS

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

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

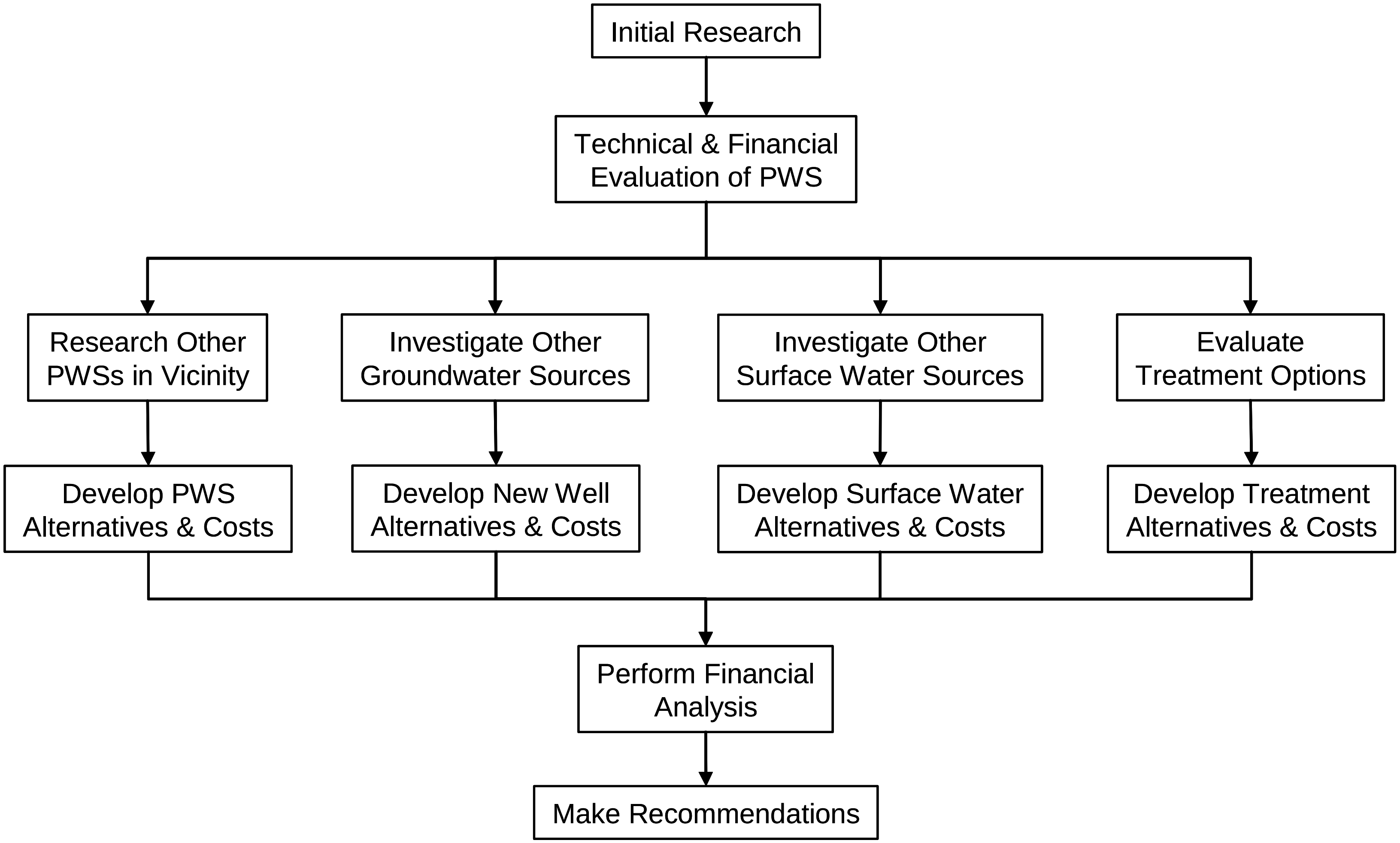
1. Gather data from the TCEQ and Texas Water Development Board databases, from TCEQ files, and from information maintained by the PWS;
2. Conduct financial, managerial, and technical (FMT) evaluations of the PWS;
3. Perform a geologic and hydrogeologic assessment of the study area;
4. Develop treatment and non-treatment compliance alternatives which, in general, consist of the following possible options:
   a. 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;
   b. Installing new wells within the vicinity of the PWS into other aquifers with confirmed water quality standards meeting the MCLs;
   c. 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;
   d. Treating the existing non-compliant water supply by various methods depending on the type of contaminant; and
   e. Delivering potable water by way of a bottled water program or a treated water dispenser as an interim measure only.
5. Assess each potential alternatives with respect to economic and non-economic criteria; and
6. Prepare a feasibility report and present the results to the PWS.

This basic approach is summarized in Figure ES-1.

HYDROGEOLOGICAL ANALYSIS

The Greenwood Ventures PWS obtains groundwater from the Ogallala Aquifer at a location that is underlain by the Edwards Trinity Aquifer. Arsenic and nitrate are commonly found in area Ogallala wells at concentrations greater than the respective MCLs. The arsenic may be naturally occurring, but the nitrate may be the result of agricultural or other human activity. It is unclear what the source or sources may be for the uranium that has been detected. The concentrations of the contaminants can vary based on location, so it may be possible to construct a new well at another location that would produce compliant water.

Figure ES-1 Summary of Project Methods



However, the variability of concentrations makes it difficult to determine where wells can be located to produce acceptable water, and a review of existing nearby wells did not identify existing compliant wells. It may also be possible to install a deeper well into the Edwards Trinity aquifer, but more investigation is required to determine the water quality in the Edwards Trinity aquifer at the site.

COMPLIANCE ALTERNATIVES

The Greenwood Ventures PWS is owner operated. Overall, the system has inadequate FMT capacity due mainly to deficiencies with financial capability; however, the system does have many positive aspects, including a knowledgeable and dedicated owner/operator, and very good communication with customers. Areas of concern for the system included inadequate financial accounting for the water system, inability to meet operating expenses, lack of a reserve account, and lack of long-term planning.

There are several PWSs within 10 miles of the Greenwood Ventures Inc. mobile home park. Few of these nearby systems also have good water quality. In general, feasibility alternatives were developed based on obtaining water from the nearest PWSs with good quality water, either by directly purchasing water or by expanding the existing well field. One alternative also explores construction of a deeper on-site well into the Edward Trinity aquifer. There is a minimum of surface water available in the area, and obtaining a new surface water source is considered through the alternatives where treated surface water is obtained from the Cities of Midland, Stanton, and Odessa which obtain raw surface water from the Colorado River Municipal Water District.

A centralized treatment alternative that utilizes reverse osmosis for removal of arsenic, nitrate, and uranium has been developed for this report. Point-of-use (POU) and point-of-entry 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.

If compliant groundwater can be found, developing a new well on-site or near the Greenwood Ventures PWS is likely to be one of the best solutions. Having a new well near the Greenwood Ventures PWS is likely to be one of the lower cost alternatives since the PWS already possesses the technical and managerial expertise needed to implement this option. The cost of new well alternatives quickly increases 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.

Central treatment can be cost-competitive with the alternative of new nearby wells, but would require significant institutional changes to manage and operate. Similar to 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 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 Greenwood Ventures PWS indicated that current water rates are under funding operations, and a rate increase of approximately 8 percent would be necessary to meet operating expenses. This increase would raise the average annual water bill from $180 to $195. The current average water bill represents approximately 0.5 percent of the median household income (MHI) for the area, and would also represent approximately 0.5 percent of the MHI with the increase. 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	$180	0.5
To meet current expenses	NA	$195	0.5
New Well at Greenwood Ventures	100% Grant	$195	0.5
	Loan/Bond	$385	1.0
Purchase Water from the City of Stanton	100% Grant	$1,635	4.4
	Loan/Bond	$11,922	32
Central treatment	100% Grant	$2,189	5.9
	Loan/Bond	$4,732	13
Point-of-use	100% Grant	$878	2.4
	Loan/Bond	$932	2.5

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ACRONYMS AND ABBREVIATIONS

µL	microgram per liter
AA	activated alumina
AFY	acre-feet per year
BAT	best available technology
BEG	Bureau of Economic Geology
CA	chemical analysis or cellulous acetate
CCN	Certificate of Convenience and Necessity
CFR	Code of Federal Regulations
CO	correspondence
CR	county road
CRMWD	Colorado River Municipal Water District
EDR	Electrodialysis reversal
ENR	Engineering News Record
FM	farm-to-market
FMT	financial, managerial, and technical
GAM	groundwater availability model
gpm	gallons per minute
GVI	Greenwood Ventures Inc.
IH	Interstate Highway
IX	ion exchange
kWH	kiloWatt hours
m	meter
MCL	maximum contaminant level
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
MHI	median household income
MOR	monthly operating report
NF	nanofiltration
NLCD	National Land Cover Dataset
NMEFC	New Mexico Environmental Financial Center
NURE	National Uranium Resource Evaluation
O&M	operation and maintenance
Parsons	Parsons Infrastructure and Technology Group Inc.
pCi/L	picoCuries per liter
POE	point-of-entry
POU	point-of-use
ppb	parts per billion
psi	pounds per square inch
PSOC	potential sources of contamination
PWS	public water system
RO	reverse osmosis
RR	ranch road
SDWA	Safe Drinking Water Act
SH	state highway
SSCT	small system compliance technology
TCEQ	Texas Commission on Environmental Quality
TDS	total dissolved solids

TFC	thin film composite
TSS	total suspended solids
TTHM	total trihalomethanes
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), were 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 for PWSs that recently had sample results that exceeded 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 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 subsequent evaluation, selection, and implementation of a compliance alternative.

This feasibility report provides an evaluation of water supply compliance options for the Greenwood Ventures Inc. Public Water System, PWS ID# 1650006, located in Midland County, Texas (hereinafter referred to as the Greenwood Ventures PWS). Recent sample results from the Greenwood Ventures PWS exceeded the MCL for arsenic of 10 micrograms per liter (µg/L) that went into effect January 23, 2006 (USEPA 2005; TCEQ 2004), and the MCL for nitrate of 10 mg/L (USEPA 2005; TCEQ 2004). Recent sample results also exceeded the MCL for uranium of 0.03 mg/L (USEPA 2005; TCEQ 2004).

The location of the Greenwood Ventures 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 to evaluate alternate water supplies that may be available in the area.

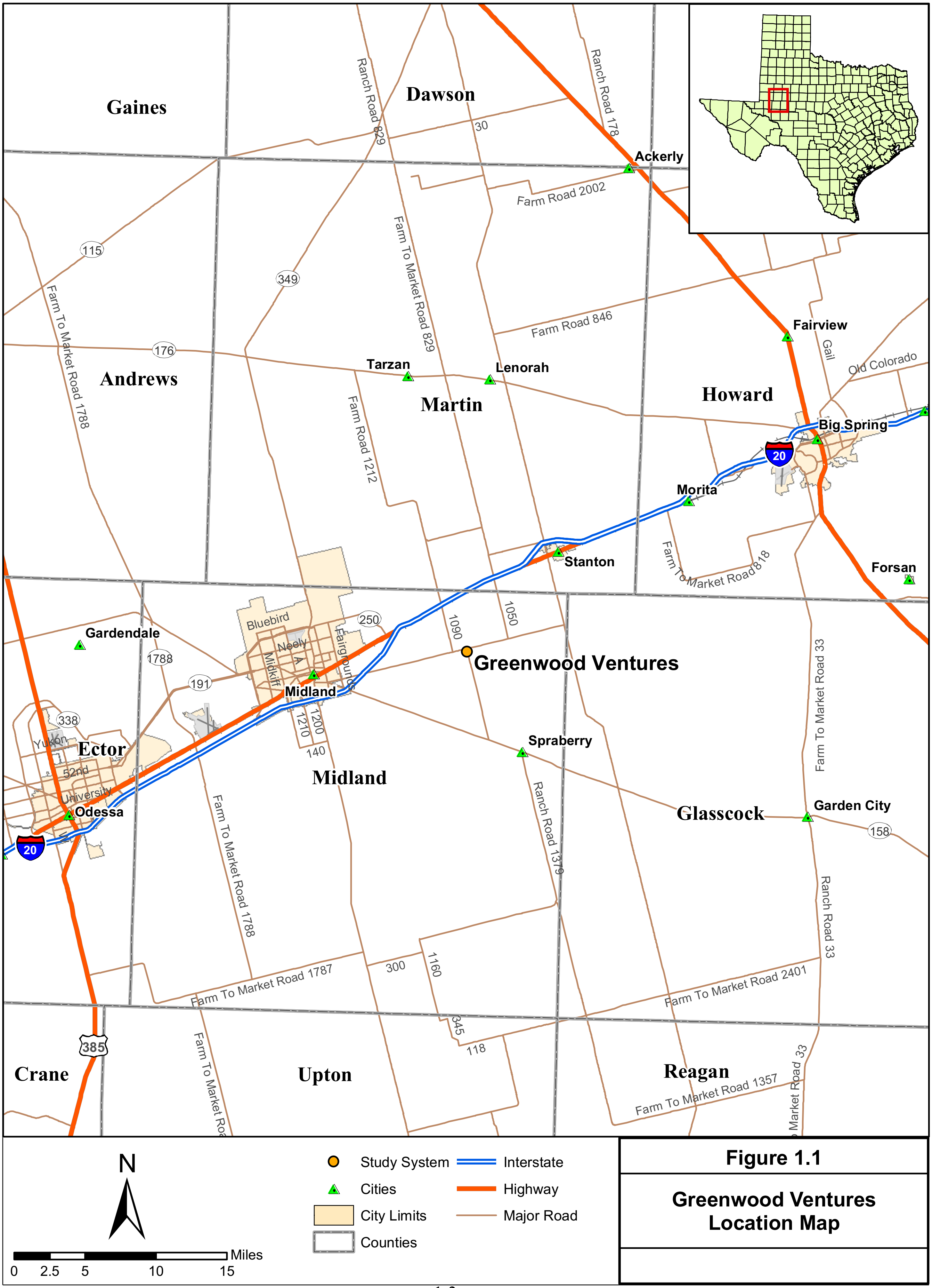

Figure 1.1

Greenwood Ventures Location Map

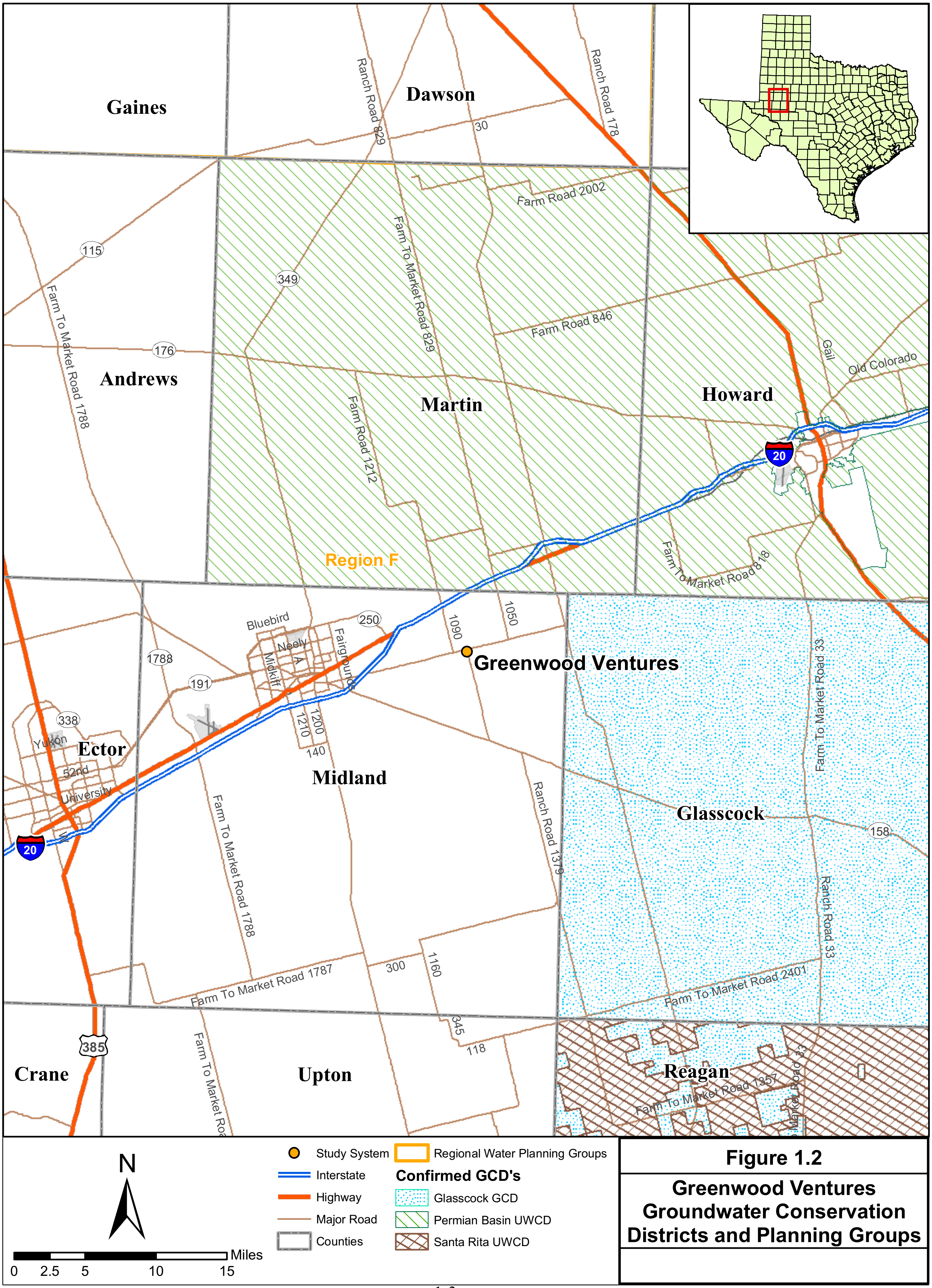

Figure 1.2

Greenwood Ventures Groundwater Conservation Districts and Planning Groups

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1.1 PUBLIC HEALTH AND COMPLIANCE WITH MCLS

The goal of this project is to promote compliance for PWSs that supply drinking water containing contaminants that exceed regulatory MCLs. This project only addresses contaminants and does not address any other violations that may exist for a PWS. As mentioned above, Greenwood Ventures PWS had recent sample results that exceeded the MCLs for arsenic, nitrate, and uranium. Health concerns related to drinking water above MCLs for these three chemicals are briefly described below.

In general, contaminant(s) in drinking water above the MCL(s) can have both short-term (acute) and long-term or lifetime (chronic) effects. Short-term effects of nitrate in drinking water above the MCL have caused serious illness and sometimes death. Drinking water health publications conclude that the populations most susceptible to adverse nitrate health effects include infants less than 6 months of age; women who are pregnant or nursing; and individuals with enzyme deficiencies or a lack of free hydrochloric acid in the stomach. The serious illness in infants is due to the conversion of nitrate to nitrite by the body, which can interfere with the oxygen-carrying capacity of the child's blood. Symptoms include shortness of breath and blue-baby syndrome. Lifetime exposure to nitrates at levels above the MCL has the potential to cause the following effects: diuresis, increased starchy deposits, and hemorrhaging of the spleen (USEPA 2005a; 2005b).

Potential health effects from long-term ingestion of water with levels of arsenic above the MCL (0.01 µg/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 2005c).

Radionuclides emit "ionizing radiation" when they decay. Ionizing radiation is a known carcinogen and, consequently, long-term exposure to radionuclides in drinking water may result in an increased cancer risk. Additionally, exposure to uranium in drinking water may result in toxic effects to the kidneys as well as increasing the risk of cancer (USEPA 2005).

1.2 METHOD

The method for this project follow that of the pilot study performed in 2004 and 2005 by TCEQ, BEG, and Parsons. The pilot study evaluated water supply alternatives for PWSs that supply drinking water with nitrate concentrations above U.S. Environmental Protection Agency (USEPA) and Texas drinking water standards. Three PWSs were evaluated in the pilot study 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 developed in the pilot study.

Other tasks of the feasibility study are as follows:

- Identifying available data sources;
- Gathering and compiling data;

- Conducting FMT evaluations of the selected PWSs;
- Performing a geologic and hydrogeologic assessment of the study 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 nitrate, arsenic, and uranium abatement options. Section 2 describes the method used to develop and assess compliance alternatives. The groundwater sources of nitrate, arsenic, and uranium are addressed in Section 3. Findings for the Greenwood PWS, along with development and evaluation of compliance alternatives, 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), including 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 Greenwood Ventures PWS involved nitrate, arsenic, and uranium. The following subsections explore alternatives considered as potential options for obtain/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 so 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 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 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:

- Use existing data sources (see below) to identify wells in the areas that have satisfactory quality. For the Greenwood Ventures PWS, 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);
  - Arsenic concentrations less than 0.008 mg/L (below the MCL of 0.01 mg/L); and
  - Uranium concentrations less than 0.024 mg/L (below the MCL of 0.03 mg/L).
- Review the recorded well information 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, wells used by other communities, etc.
- Identify wells of sufficient size that have been 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 that well characteristics are known and the well meets construction standards.
- 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" 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 U.S. 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

Various treatment technologies were investigated as compliance alternatives for treatment of arsenic, nitrate, and uranium to regulatory levels (*i.e.*, MCL). Numerous options have been identified by the USEPA as best available technologies (BAT) and Small Systems Compliance Technologies (SSCT) for non-compliant constituents. Identification and descriptions of the various BATs and SSCTs are provided in the following sections.

1.4.4.1 Treatment Technologies for Nitrates

The MCL for nitrate (as nitrogen) was set at 10 mg/L by the USEPA on January 30, 1992, as part of the Phase II Rules, and became effective on July 30, 1992 (USEPA 1992). This MCL applies to all community water systems, regardless of size.

BATs identified by USEPA for removal of nitrates include:-

- reverse osmosis (RO);
- ion exchange (IX); and
- Electrodialysis reversal (EDR).

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 rule 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 must be at or below 0.01 mg/L at each entry point to the distribution system, although point-of-use (POU) treatment can be instituted in place of centralized treatment. All surface water treatment systems must complete initial monitoring for the new arsenic MCL or have a state-approved waiver by December 31, 2006. All groundwater systems must complete initial monitoring or have a state-approved waiver by December 31, 2007.

The following BATs were identified in the final rule for achieving compliance with the arsenic MCL:

- RO;
- IX;
- EDR;
- Activated Alumina (AA);
- Oxidation/Filtration;
- Enhanced Coagulation/Filtration; and

- Enhanced Lime Softening.

In addition, the following technologies are listed in the final rule as SSCTs:

- RO (centralized and POU);
- IX;
- EDR;
- AA (centralized and POU);
- Oxidation/Filtration, Enhanced Coagulation/Filtration, and Coagulation-Assisted Microfiltration; and
- Lime Softening and Enhanced Lime Softening.

1.4.4.3 Treatment Technologies for Uranium

USEPA initially published the Radionuclides Rule in 1976, and published the revised Radionuclides Final Rule December 7, 2000. The Final Rule became effective December 8, 2003. In accordance with the Final Rule, all community water systems must complete initial compliance monitoring by December 8, 2007. The MCL for uranium (including isotopes U-234, U-235 and U-238) is 30 µg/L (equivalent to 20.1 picoCuries per liter [pCi/L] in radioactivity).

The following BATs were identified in the Radionuclides Final Rule for achieving compliance with the uranium MCL:

- IX;
- RO;
- Lime Softening; and
- Coagulation/Filtration.

In addition, the following technologies are included in the Radionuclide Final Rule as SSCTs:

- IX (centralized and POU);
- RO (centralized and POU);
- Lime Softening;
- AA; and
- Coagulation/Filtration.

1.4.5 Treatment Technologies Description

Reverse Osmosis is the only processes identified by USEPA as BAT or SSCT common to the treatment of arsenic, nitrate, and uranium. In this case, IX is not effective for removal of arsenic, nitrate, and uranium because of the high total dissolved solids (TDS) and sulfate concentrations in the groundwater. EDR is not effective for removal of uranium; subsequently, RO is the only applicable process in this case. A description of the RO process follows.

1.4.5.1 Reverse Osmosis

Process. 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) and 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 new, lower pressure type of membrane which is similar in operation to RO, is nanofiltration (NF) which has higher rejection for divalent ions (*e.g.*, Ca^{++} and $SO_4^{=}$) than mono-valent ions (*e.g.*, Na^{+} and Cl^{-}). NF is sometimes used instead of RO for treating water with high hardness and sulfate concentrations.

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 95 percent of arsenic, nitrate, and uranium, while NF has a lower rejection efficiency of these contaminants. The treatment process is relatively insensitive to pH. Water recovery is 60-80 percent, depending on raw water characteristics. 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 pretreatment 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 or sequestering 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 solids; IX softening to remove hardness; antiscalant feed; temperature and pH adjustment to improve 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 foulants and scalants. The system is then flushed with clean water and returned to service. RO stages are cleaned sequentially. Frequency of membrane replacement is dependent on raw water characteristics, pre-treatment, recovery rate, 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.
- Lower 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 recovery rate.
- Concentrate disposal required.

A concern with RO for treatment of inorganics is that if the full stream is treated, then most of the alkalinity and hardness would 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 portion of the raw water and blend the treated stream with raw water rather than treat the full stream. The amount of water rejected is also an issue with RO. Discharge concentrate can be between 10 and 50 percent of the influent flow.

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

Point-of-entry (POE) and POU treatment systems can be used to provide compliant drinking water. For nitrate, arsenic, and uranium removal, these systems typically use small RO treatment units installed “under the sink” in the case of POU, and where water enters a residence or building in the case of POE. 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. POE and

POU treatment units would be purchased and owned by the PWS. These solutions are decentralized in nature, and require utility personnel to enter into houses or at least onto private property for installation, maintenance, and testing. Due to the number of treatment units that would be employed which would not under direct control by the PWS, it is very difficult to ensure 100 percent compliance. Prior to selection of a POE or POU program for implementation, consultation with TCEQ would be required to address measurement and determination of the level of compliance.

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 include:

- 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 compliance with MCLs. The water system must retain unit ownership and oversight of unit installation, maintenance, and sampling; the utility is ultimately 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 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 the 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 will 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.

With regard to using POE and POU devices for SDWA compliance, the following observations were made (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 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 the 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). Such a system may appear to be lowest cost to the utility; however, should a consumer experience ill effects from contaminated water and take legal action, the ultimate cost could increase significantly.

The ideal system would:

- Completely identify the susceptible population. If bottled water is only provided to customers who are part of the susceptible population, the utility should have an active means of identifying the susceptible population. Problems with illiteracy, language fluency, fear of legal authority, desire for privacy, and apathy may be reasons that some members of the susceptible population do not become known to the utility, and do not take part in the water delivery program.
- Maintain customer privacy by eliminating the need for utility personnel to enter the home.
- Have buffer capacity (*e.g.*, two bottles in service, so when one is empty, the other is being used over a time period sufficient to allow the utility to change out the empty bottle).
- Provide for regularly scheduled delivery so the customer would not have to notify the utility when the supply is low.
- Use utility personnel and equipment to handle water containers, without requiring customers to lift or handle bottles with water in them.
- Be sanitary (*e.g.*, where an outside connection is made, contaminants from the environment must be eliminated).
- Be vandal-resistant.
- Avoid heating the water due to exterior temperatures and solar radiation.
- Avoid freezing the water.

SECTION 2
EVALUATION METHODS

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 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 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 Certificate of Convenience and Necessity (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

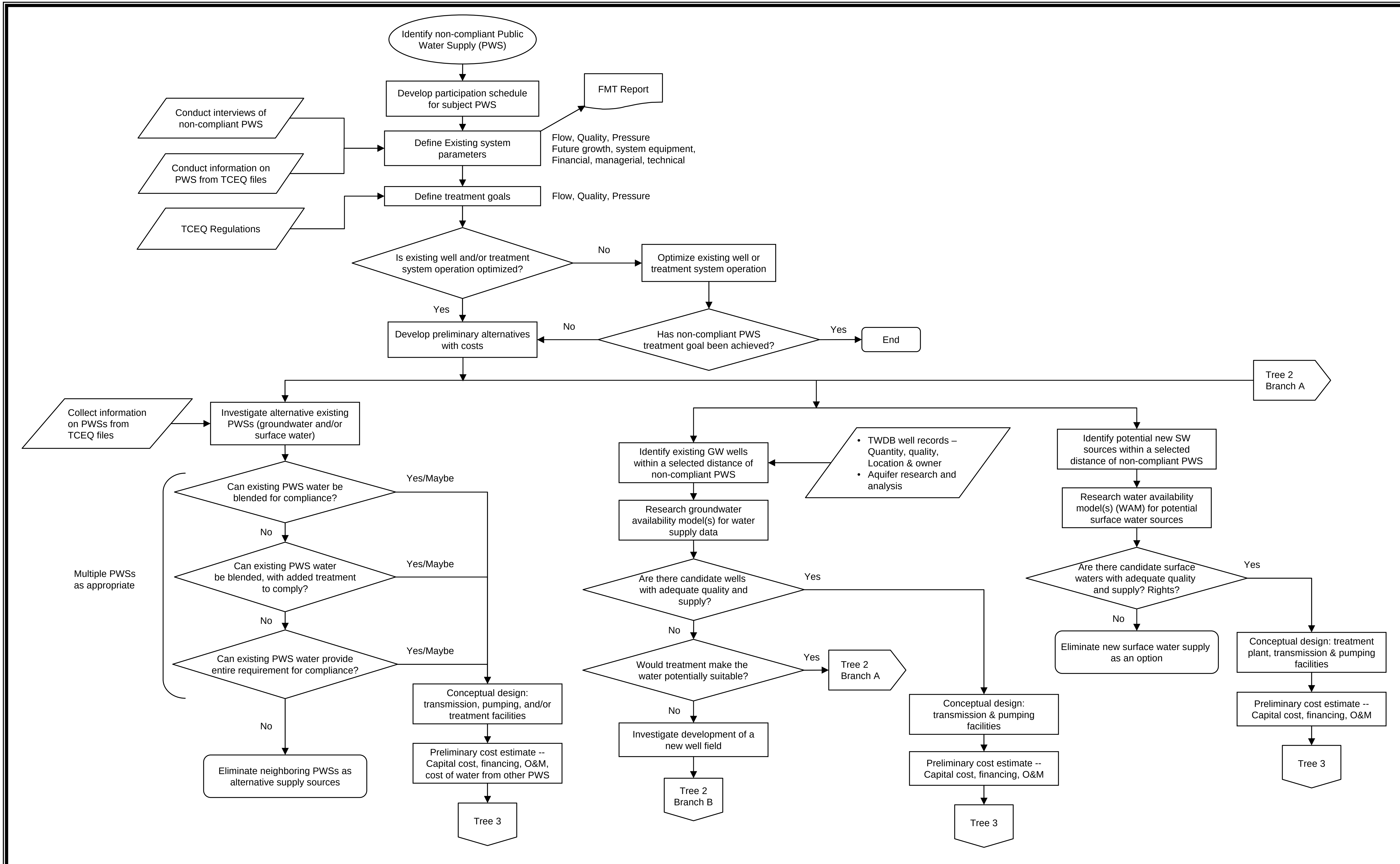


Figure 2.2
TREE 2 – DEVELOP TREATMENT ALTERNATIVES

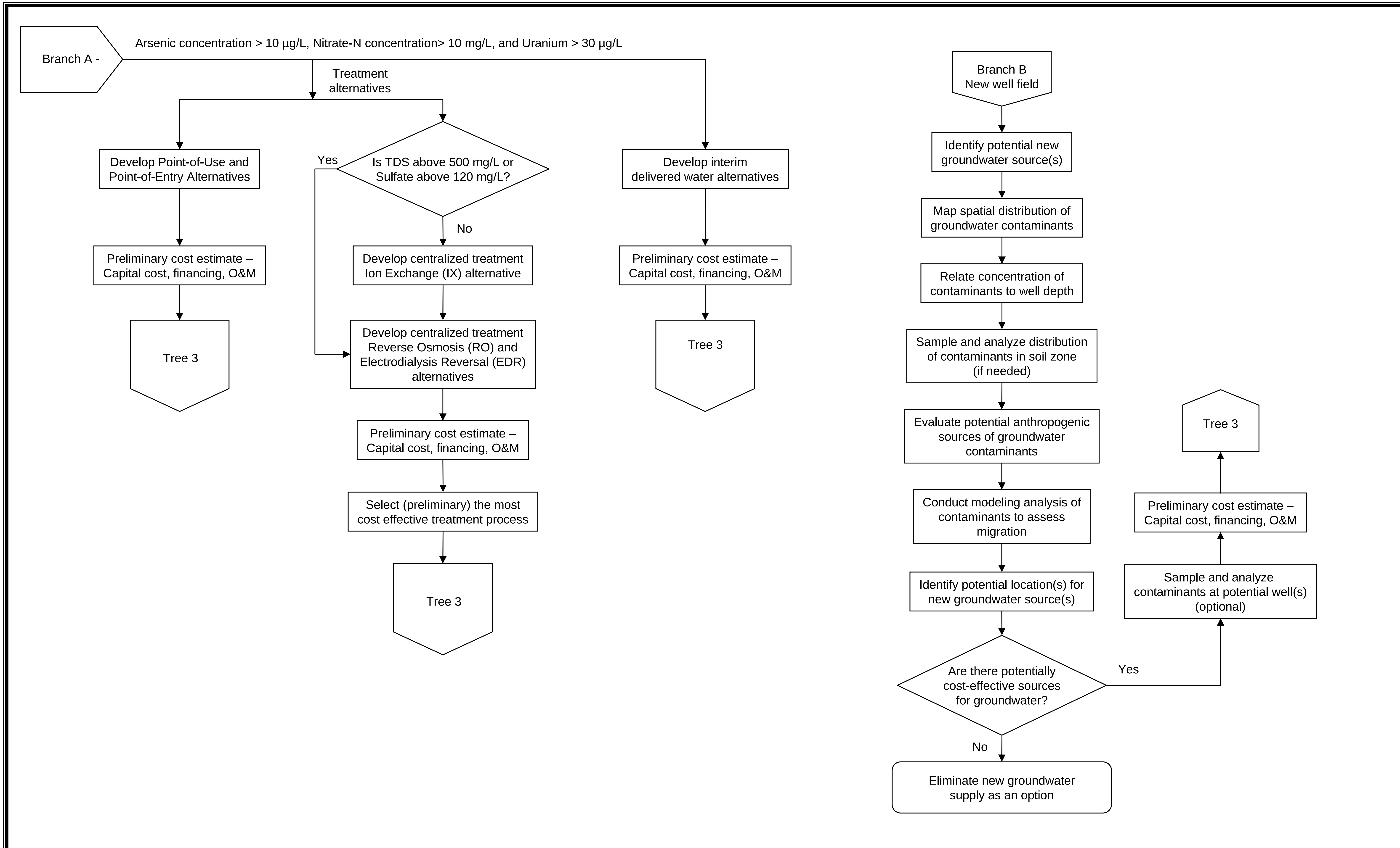


Figure 2.3
Tree 3 – PRELIMINARY ANALYSIS

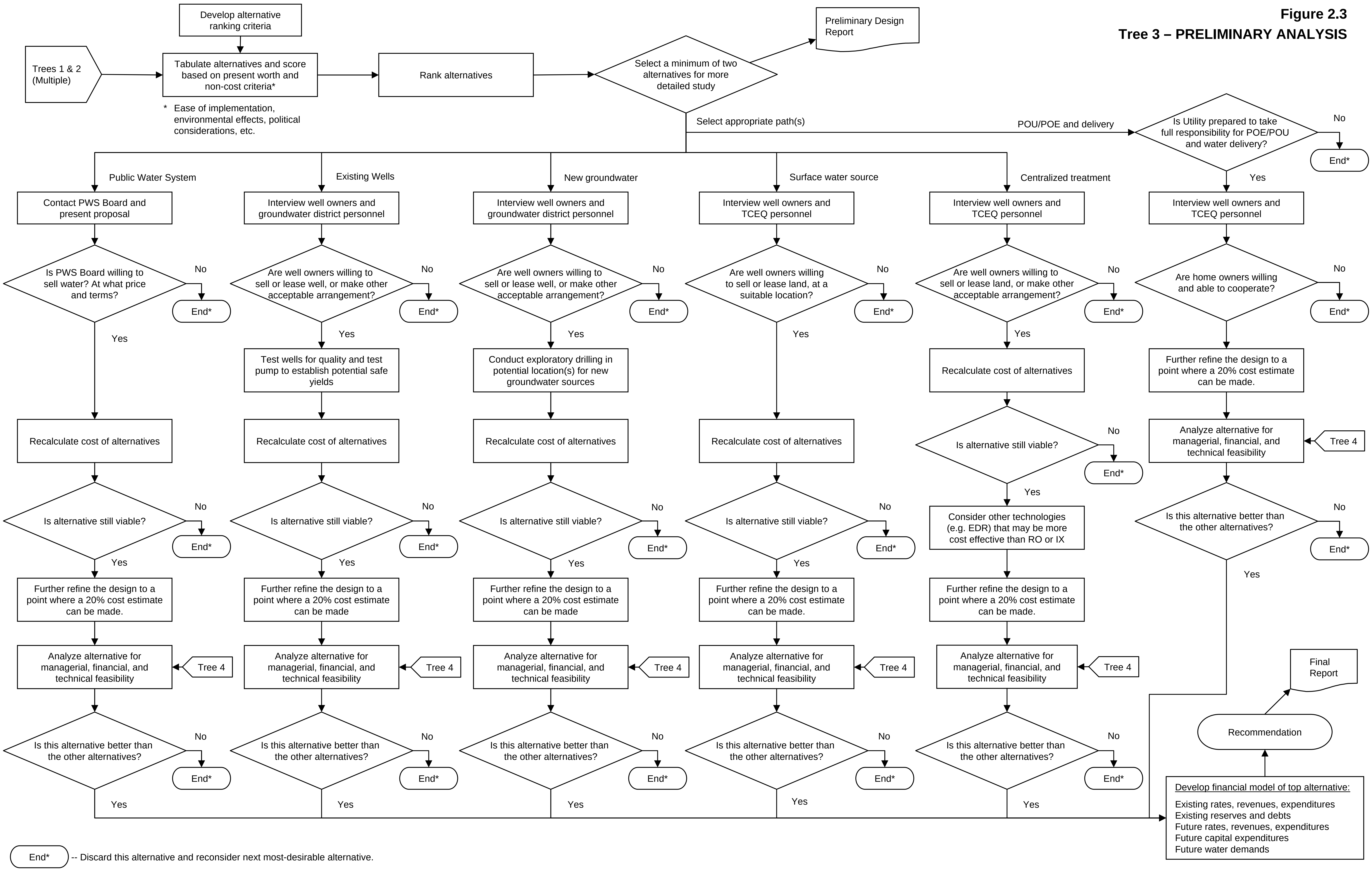
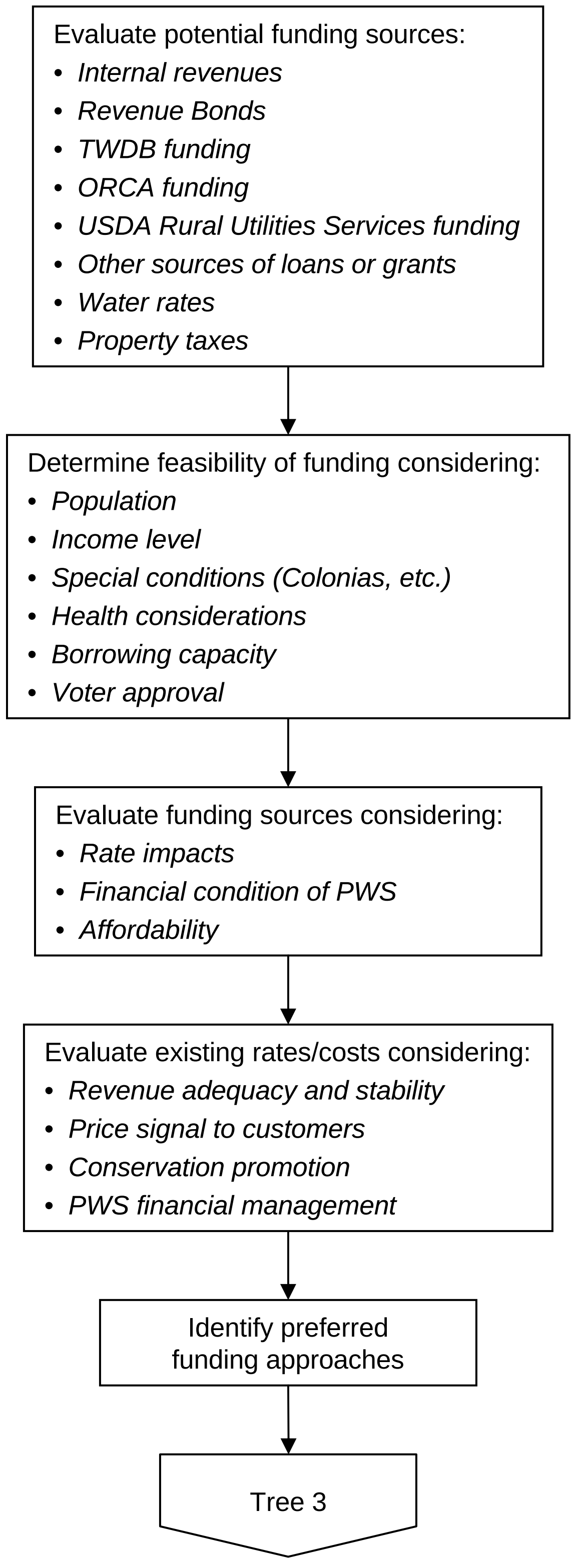


Figure 2.4
TREE 4 – FINANCIAL



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 study area:

- Texas Commission on Environmental Quality www3.tnrcc.state.tx.us/iwud/pws/index.cfm?. Under "Advanced Search," type in the name(s) of the county(ies) in the study 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. For this study, it was assumed that the nitrate concentration given in this database was the concentration of nitrate, with a molecular weight of 62. To convert to the same basis used for the MCL (Nitrate-N), the value given in the TWDB database was divided by 4.5.

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 and Edwards-Trinity Plateau aquifers 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 and 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 U.S. 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 evaluation of a water system's FMT 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 O&M of the system.

FMT capacity is made up of 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 SDWA regulations. It refers to the physical infrastructure of the water system, including 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, require 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 FMT 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 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 was 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 30 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 study 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, and 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 study 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 technology considered potentially applicable for removal of arsenic, nitrate, and uranium is RO. IX is not economically feasible because of the high TDSs (>2,000 mg/L). RO treatment is considered for the central treatment alternative, as well as POU and POE. The RO treatment produces a reject stream that is a liquid waste. 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 treatment is implemented. 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. 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 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.

2.4 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. For service areas with a sparse population base, county data may be the most reliable, and for many rural areas corresponds to census tract data. 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; and
  - Membership fees.
  - Capital Funding receipts from:
    - Grants; and
    - Proceeds from borrowing.
- Operating expenditures:
  - Water purchases;
  - Utilities;
  - Administrative costs; and
  - Salaries.
- Capital expenditures;
- Debt service:
  - Existing principal and interest payments; and
  - Future principal and interest necessary to fund viable operations.
- Net cash flow; and

- Restricted or desired cash balances:
  - Working capital reserve (based on 1-4 months of operating expenses); and
  - 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 annual MHI 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 is greater than 75 percent of state MHI, standard terms, currently at 3.8 percent interest for non-rated entities. Additionally:
  - If local MHI = 70-75 percent of state MHI, 1 percent interest rate on loan.
  - If local MHI = 60-70 percent of state MHI, 0 percent interest rate on loan.

    - If local MHI = 50-60 percent of state MHI, 0 percent interest and 15 percent forgiveness of principal.
    - 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 for each alternative are presented in Table 4.4 in Section 4 of this report. The model used six funding alternatives: paying cash up front (all revenue); 100 percent grant; 75 percent grant; 50 percent grant, State Revolving Fund (SRF); and obtaining a Loan/Bond. Table 4.4 shows the projected average annual water bill, the maximum percent of household income, and the percentage rate increase over current rates.

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:

- TWDB;
- 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:

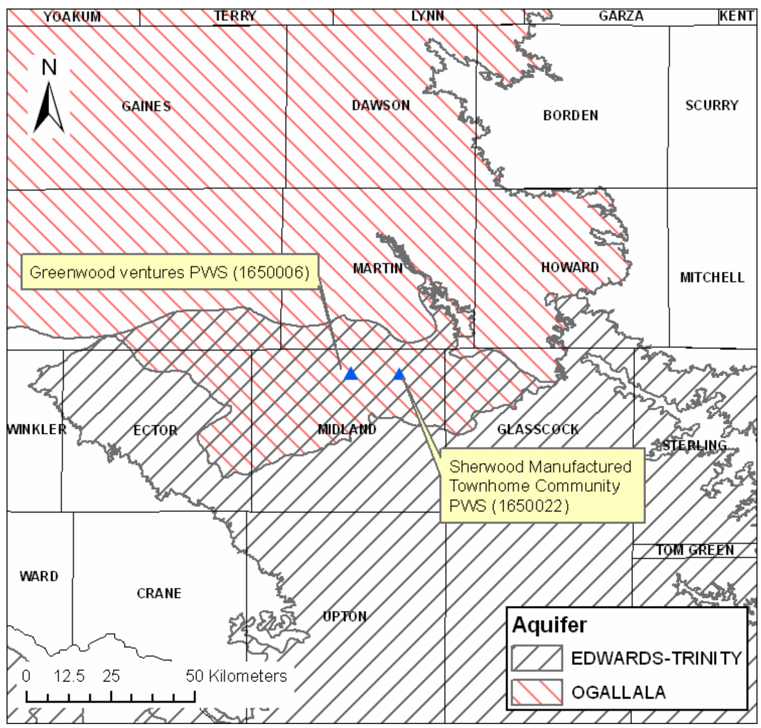
- United States Department of Agriculture, Rural Utilities Service; and
- United States Housing and Urban Development.

SECTION 3
UNDERSTANDING SOURCES OF CONTAMINANTS

3.1 REGIONAL HYDROGEOLOGY

The major aquifers in the vicinity of the evaluated PWSs are the Ogallala aquifer and the Edwards Trinity (Plateau) aquifer (Figure 3.1).

Figure 3.1 Public Water Systems and Major Aquifers in the Study Area



The Ogallala Formation consists of sandstone and conglomerates of late Tertiary (Miocene-Pliocene) age (Nativ 1988). The sediments consist of basal coarse fluvial clastics deposited in paleovalleys in a mid-Tertiary erosional surface with upper eolian sands also present in intervening upland areas (Gustavson and Holliday 1985). The Ogallala formation is approximately 30 meters (m) thick in the south (Ector-Midland Counties). The top of the Ogallala formation is marked by a resistant calcite layer termed the "caprock" caliche.

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 ("paleovalleys"). 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 shaley formations, including the Walnut, Comanche Peak, and Edwards formations, as well as the

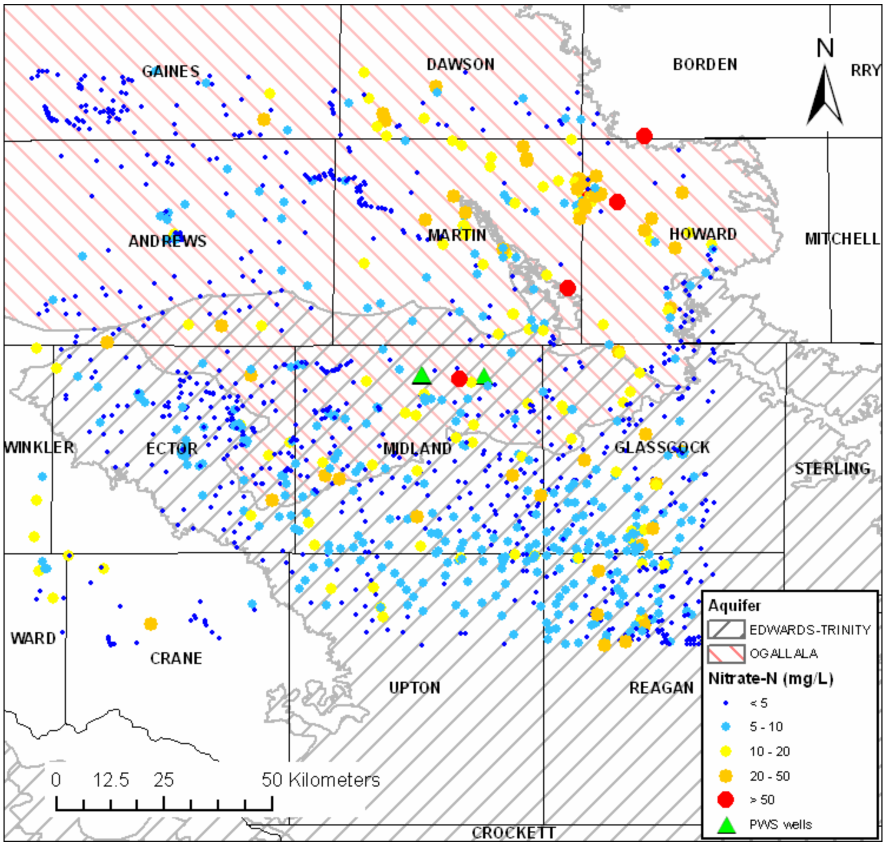
Kiamichi formation); and (3) the Washita Group (low-permeability, shaley sediments of Duck Creek formation) (Nativ 1988). The sequence results in two main aquifer units: the Antlers Sandstone (also termed the Trinity or Paluxy Sandstone, approximately 15m thick in the overlap area with the Ogallala aquifer) and the Edwards Limestone (~ 30m thick). The Antlers Sandstone consists of basal gravels overlain by fluvial-deltaic sands deposited on a pre-Cretaceous unconformity developed on Paleozoic and earlier Mesozoic rocks. The basal gravels are thicker in paleovalleys. The carbonate-dominated with interbedded sandstone formations of the Fredericksburg Group of Lower Cretaceous age were exposed and karstified during Cretaceous times (Mace, *et al.* 2004). The terminology can be complicated at times; for example, the Edwards Limestone transitions laterally in name to the Fort Terrett formation (base) and Fort Lancaster formation in some places and Segovia formation in other places. The term Edwards Trinity (High Plains) aquifer is generally used to describe these water-bearing Mesozoic units subcropping in the High Plains and disconnected from the main Edwards Trinity (Plateau) aquifer that covers most of southwest Texas from west of San Antonio to Reeves County (Ashworth and Hopkins 1995). The term High Plains aquifer denotes the combination of the generally hydrologically connected Ogallala aquifer and the Edwards Trinity (High Plains) aquifer.

The Edwards Trinity (Plateau) aquifer underlies the extreme southern outcrops of the Ogallala formation in Andrews, Martin, Ector, Midland, and Glasscock Counties, and crops out south of this region. This section of the Edwards Trinity aquifer is in continuity with the main outcropping areas of the Edwards Trinity (Plateau) aquifer, and is generally attached to it despite being overlain by Ogallala deposits (*e.g.,* Mace, *et al*. 2004). However, in some areas only the Cretaceous unit is saturated, and the Ogallala sediments are in the unsaturated zone. The Edwards Trinity (Plateau) aquifer is recognized as a major aquifer in the state (Ashworth and Hopkins 1995). This aquifer consists predominantly of the Trinity Group and includes the Antlers Sandstone in Ector and Midland Counties, which is overlain by the Washita and Fredericksburg Divisions in Glasscock County (Barker and Ardis 1996). Water quality is generally good (Anaya and Jones 2004).

3.2 GENERAL TRENDS IN NITRATE CONCENTRATIONS

The geochemistry of nitrate is described in Appendix E. Regional nitrate trends in the area of the assessed public water supplies were examined to assess spatial trends, as well as correlations with other water quality parameters. Nitrate-N concentrations are spatially variable in the study region (Figure 3.2).

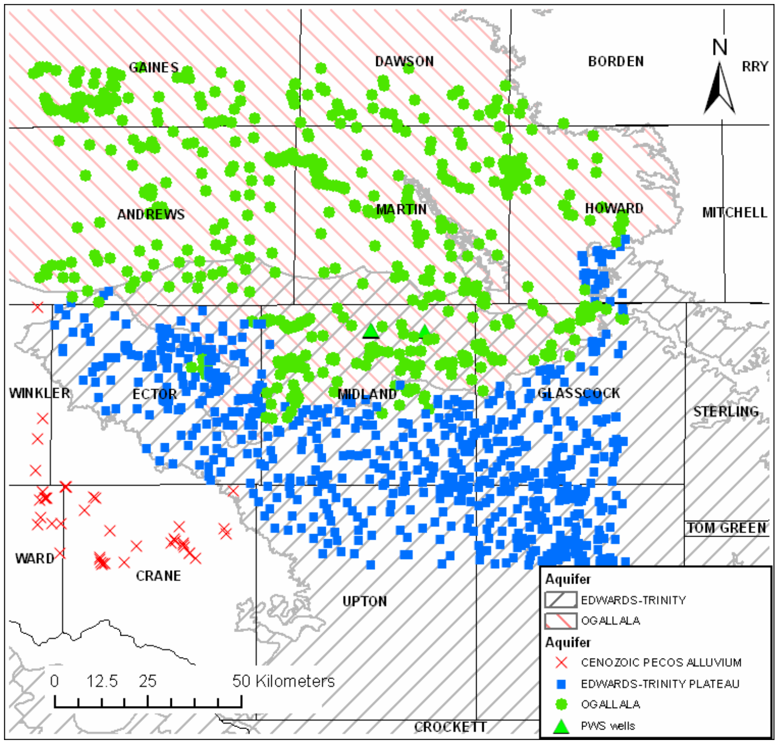
Figure 3.2 Most Recent Detectable Nitrate-N Concentrations in Groundwater



Data from the TWDB database, analyses from 1937 through 2004.

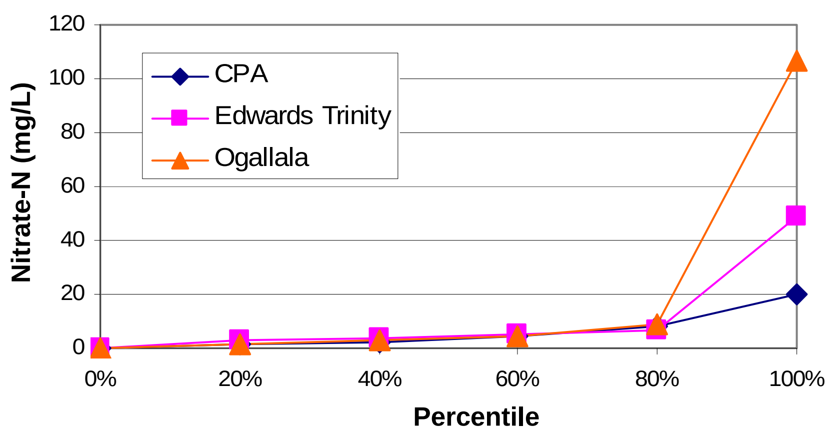
A total of 1,401 measurements were extracted from the TWDB database. In all analyses in this study, the most recent sample was used for each well (if more than one sample exists for the most recent date, the average for that date was calculated). Samples were limited to an area delimited by the following coordinates: bottom left corner -102.84E, 31.46N and upper right corner -101.41E, 32.66N. Coordinates are in decimal degrees and the datum is North American Datum 1983 (NAD 1983). Wells in the study area are designated in three major aquifers, the Ogallala, Edwards Trinity (Plateau), and Cenozoic Pecos Alluvium aquifers (Figure 3.3).

Figure 3.3 Wells with Nitrate Samples Categorized by Aquifer



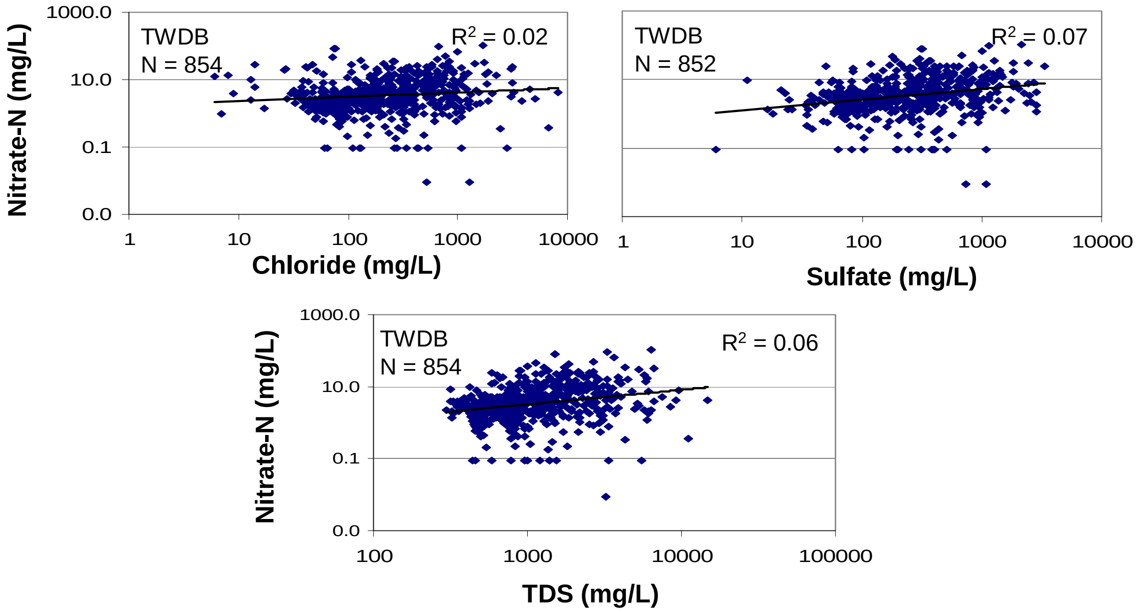
From the 1,401 wells, 774 are in the Edwards Trinity (Plateau) aquifer, 584 in the Ogallala aquifer, and 43 in the Cenozoic Pecos Alluvium aquifer. The distribution of nitrate-N concentrations within the three aquifers is similar (Figure 3.4). The similarity in nitrate-N levels among the aquifers suggests that the source of nitrate is not a particular geologic unit but may be anthropogenic.

Figure 3.4 Distribution of Nitrate-N Concentrations in the Cenozoic Pecos Alluvium, Edwards Trinity (Plateau), and Ogallala Aquifers



Nitrate-N is not strongly related to general water quality parameters (sulfate, chloride, and total dissolved solids) in the Ogallala aquifer (Figure 3.5). Similar results were found for the Edwards-Trinity (Plateau) aquifer ($r^2 < 0.1$), further suggesting that nitrate-N sources are probably not geologic.

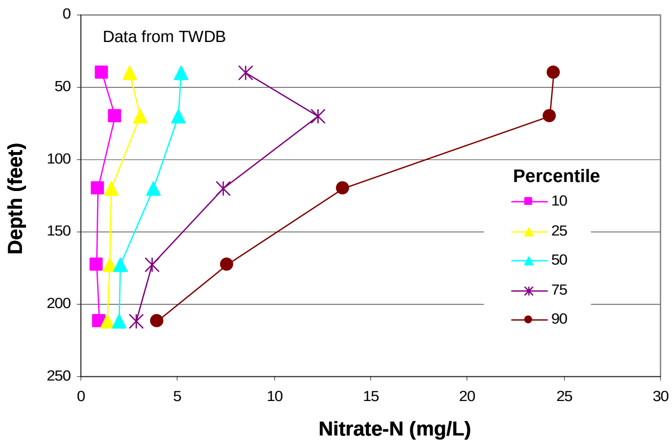
Figure 3.5 Correlation of Nitrate-N with Chloride, Sulfate, and TDSs in the Ogallala Aquifer



Data are from the TWDB groundwater database. N represents the number of wells in the analysis. The most recent measurement is shown for each well (when there is more than one sample for the most recent date, the average was calculated; only seven wells had more than one sample for the most recent date).

Nitrate-N concentrations were compared with well depth to assess stratification in nitrate concentrations in the Ogallala aquifer (Figure 3.6) and Edwards Trinity (Plateau) aquifer (Figure 3.7).

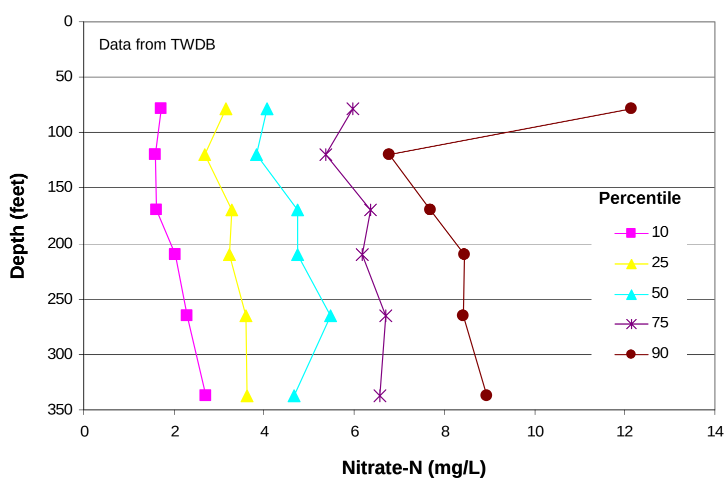
Figure 3.6 Relationship Between Nitrate-N Concentrations and Well Depth in the Ogallala Aquifer



Depth interval (feet)	Min. depth (feet)	Max. depth (feet)	Median depth (feet)	No. of wells
< 50	20	49	40	31
50-100	50	99	70	150
100-150	100	148	120	158
150-200	150	197	173	126
> 200	200	306	212	49

Data are from the TWDB groundwater database. Wells were divided into depth bins, and for each bin the nitrate-N concentration is shown with respect to the median depth. The table on the right summarizes depth values for each bin and gives the number of wells in the analysis for that depth range. The analysis shows that within the Ogallala aquifer highest nitrate-N concentrations are found in shallower wells (depth <100 feet), and nitrate-N concentrations generally decrease with depth, particularly the 75th and 90th percentile values. A similar analysis is shown for the Edwards Trinity (Plateau) aquifer in Figure 3.7.

Figure 3.7 Relationship between Nitrate-N Concentrations and Well Depth in the Edwards Trinity (Plateau) Aquifer



Depth range (feet)	Min. depth (feet)	Max. depth (feet)	Median depth (feet)	No. of wells
< 100	37	99	79	77
100-150	100	149	120	170
150-200	150	197	170	143
200-250	200	248	211	106
250-300	250	297	265	72
> 300	300	495	337	116

The analysis shows that within the Edwards Trinity (Plateau) aquifer, nitrate-N concentrations generally show no systematic variation with depth. In general, concentrations remain constant with depth, although some relationship is seen within the 90th percentile, where the shallowest wells (<100 feet) have higher concentrations.

Nitrate-N concentrations were compared with land use from the National Land Cover Dataset (NLCD) (NLCD 1992). Land-use datasets are categorized into three groups (rangeland, cultivated, and urban) and compared with nitrate-N concentrations within the study area. High concentrations of nitrate-N are generally found in cultivated areas (Figure 3.8). Nitrate-N concentrations in groundwater were compared with land use within a 1-km radius of well locations (Figure 3.9).

Figure 3.8 Spatial Relationship between Land Cover and Nitrate-N Concentrations

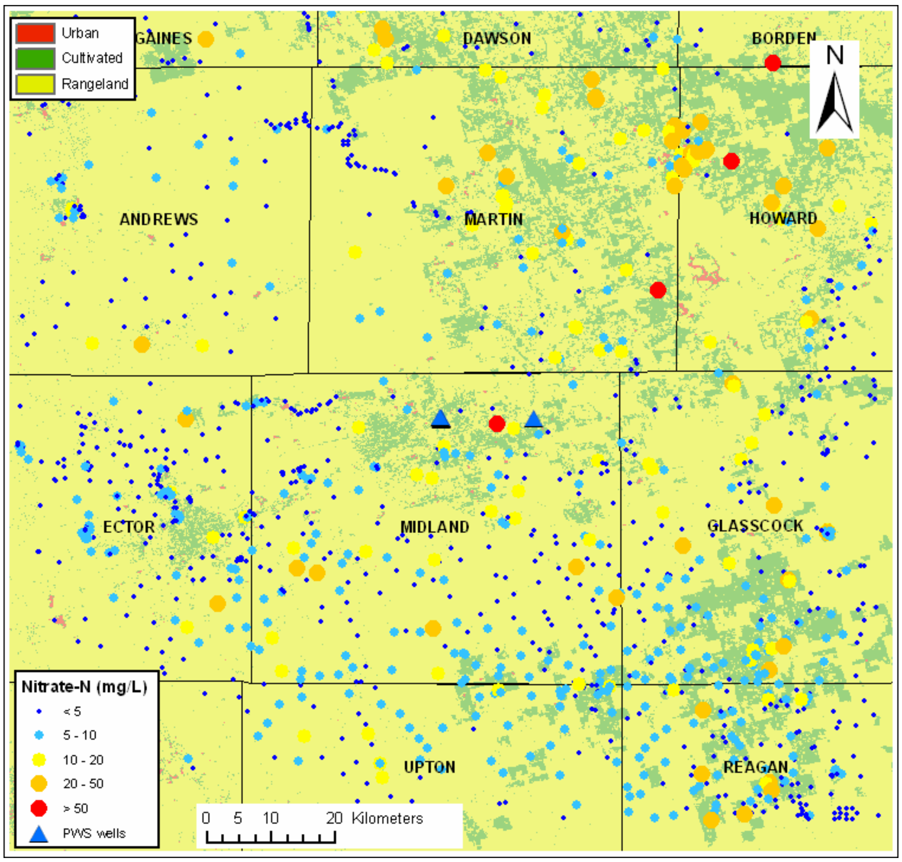
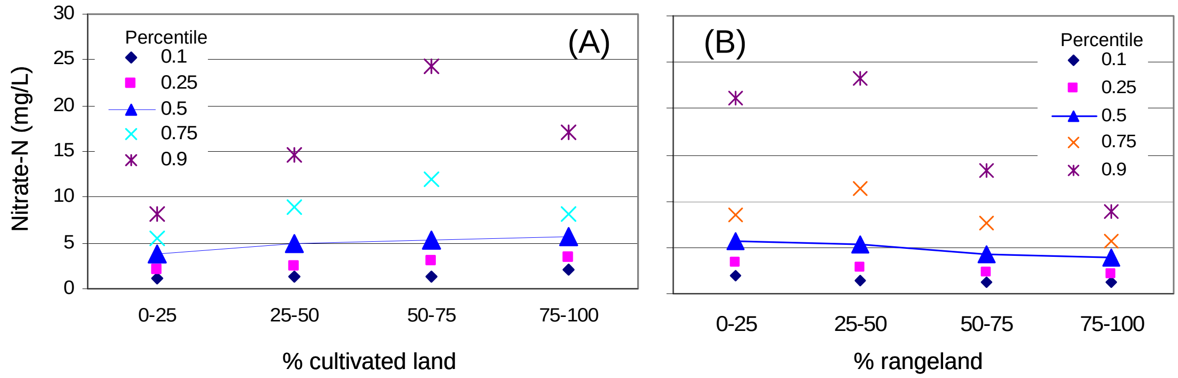


Figure 3.9 Correlation Between Nitrate-N Concentrations and Percentage of (A) Cultivated Land, and (B) Rangeland within a 1-km Buffer of Wells

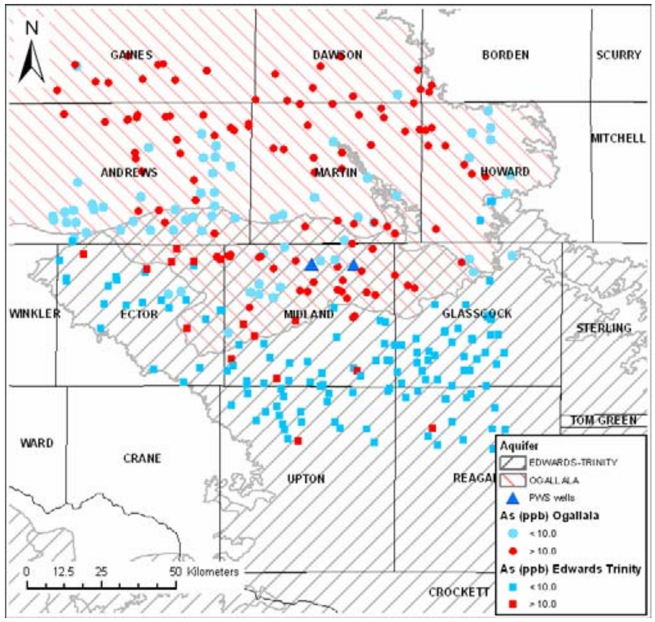


Land use was obtained from the NLCD and was categorized into the following land-use types: rangeland (NLCD codes 51, 71, 41, 42, and 43), cultivated (NLCD codes 81, 82, 83, and 61), and urban (NLCD codes 21, 22, 23, and 85). The complementary analysis accounts for more than 90 percent of the land use in over 95 percent of the wells. Nitrate-N concentrations are from the TWDB database. Nitrate-N concentrations generally increase with percentage of cultivated land (Figure 3.9A) and decrease with percentage of rangeland (Figure 3.9b). The two plots are generally complementary, showing an increase in nitrate-N concentrations with cultivation and a decrease with higher percentage of rangeland. The greatest increases in nitrate-N concentrations with cultivation occur in the upper 75th and 90th percentiles. Population means of the land-use groups (percentage bins) are statistically different ($P < 1E-9$, ANOVA single factor test) for both land-use categories.

3.3 GENERAL TRENDS IN ARSENIC CONCENTRATIONS

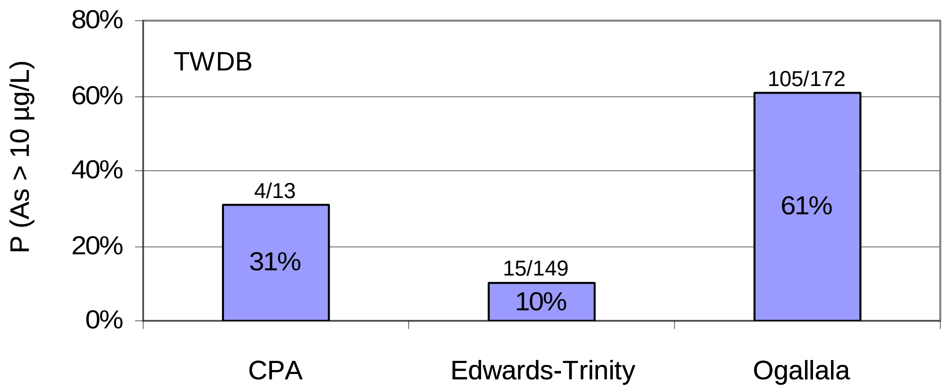
The geochemistry of arsenic is described in Appendix F. Arsenic trends in the vicinity of the analyzed public water supplies were examined to assess spatial trends, as well as correlations with other water quality parameters. Arsenic samples were obtained from the TWDB database and from a subset of the National Geochemical Database, also known as the NURE (National Uranium Resource Evaluation) database. The spatial distribution of arsenic concentrations correlates with the distribution of geologic formations (Figure 3.10). High arsenic concentrations (> 10 parts per billion [ppb]) also correlate with geologic formations (Figure 3.11).

Figure 3.10 Spatial Distribution of Arsenic Concentrations in the Edwards Trinity (Plateau) and Ogallala Aquifers



Data from the TWDB database.

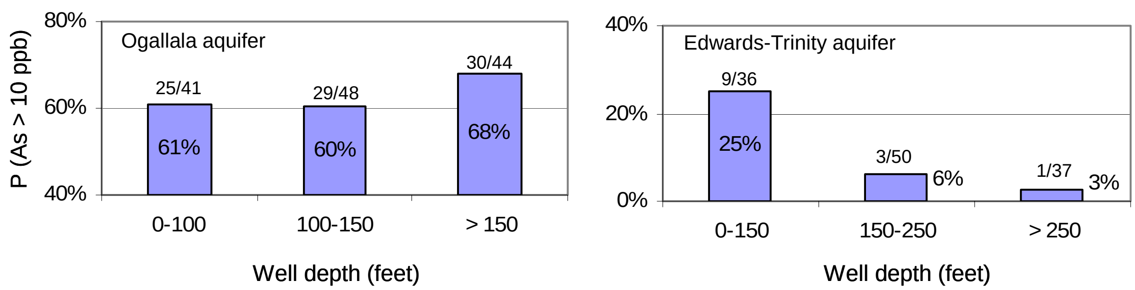
Figure 3.11 Probabilities of Arsenic Concentrations Exceeding the 10 ppb MCL for Aquifers in the Study Area



Data in Figures 3.10 and 3.11 are from the TWDB database. The Ogallala aquifer shows the highest percentage of wells with arsenic concentrations >10 ppb (Figure 3.11). Within the Ogallala aquifer, 61 percent of the wells had arsenic concentrations >10 ppb, in comparison with the Cenozoic Pecos Alluvium (31%) and Edwards Trinity (Plateau) (10%) aquifers. A closer review of the spatial distribution of wells in the Edwards Trinity (Plateau) with high arsenic concentrations reveals that almost all wells with high arsenic concentrations are within the area overlapping the Ogallala aquifer (only seven wells with high arsenic concentrations are outside the area overlapping the aquifer, and three of those seven are within 5 km of the aquifer boundary). It is possible that these wells are screened within the Ogallala aquifer or screened across the Edwards Trinity (Plateau) and Ogallala aquifers together. This assumption cannot be verified because only one well of the seven had a secondary aquifer (Dockum) designation in the TWDB database.

To assess relationships between elevated arsenic concentrations and specific stratigraphic units, arsenic concentrations were compared with well depth for the Ogallala and Edwards Trinity (Plateau) aquifers separately (Figure 3.12). Within the Ogallala aquifer, arsenic concentrations are not strongly correlated with well depth. However, within the Edwards Trinity (Plateau) aquifer, shallower wells (<150 feet) have higher probabilities of arsenic concentrations exceeding 10 ppb. The shallower wells are closer to the Ogallala formation (which overlies the Edwards Trinity Plateau), and these wells may be screened within the Ogallala formation or across both the Edwards Trinity (Plateau) and Ogallala formations. This restriction of high arsenic levels to shallow wells in the Edwards Trinity (Plateau) aquifer suggests that the source of contamination for wells within the Edwards Trinity (Plateau) aquifer is actually from the overlying Ogallala formation.

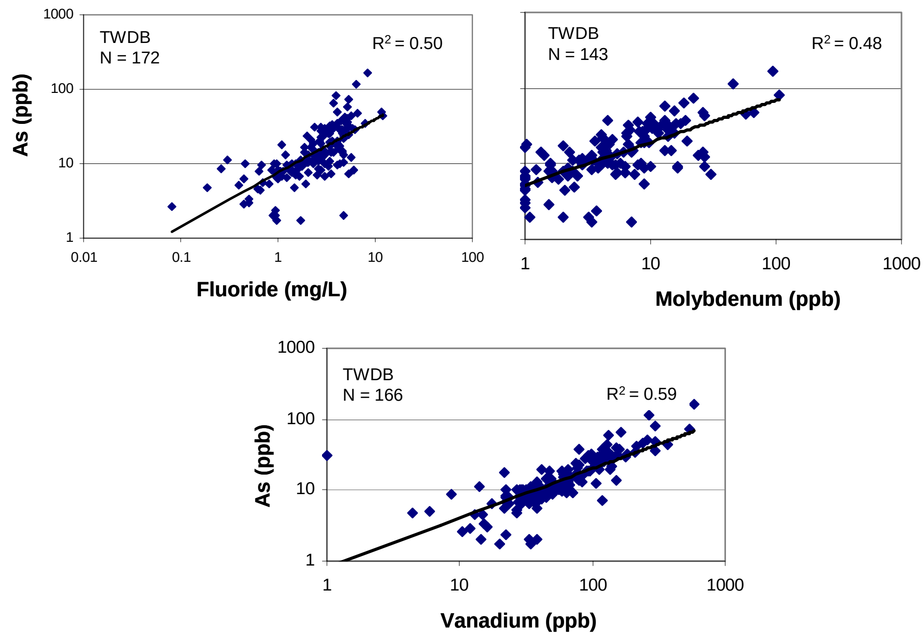
Figure 3.12 Relationship between Arsenic Concentrations and Well Depth



Data shown in Figure 3.12 are from the TWDB database. Numbers above each column represent the number of arsenic samples that are >10 ppb and the total number of analyses in the bin. For example, 25/41 represents 24 samples >10 ppb out of 41 analyses at a well depth between 0 and 100 feet.

Relationships between arsenic and pH, sulfate, fluoride, chloride, TDSs, vanadium, and molybdenum were evaluated using data from the TWDB database. Data from the NURE database were used to evaluate the relationship between arsenic and dissolved oxygen. Strong correlations were found between arsenic and fluoride (R^2 = 0.50), vanadium (R^2 = 0.59), and molybdenum (R^2 = 0.48) within the Ogallala aquifer (Figure 3.13). Arsenic and vanadium were also correlated within the Edwards Trinity (Plateau), but other parameters were not highly correlated with arsenic within the Edwards Trinity (Plateau) aquifer.

Figure 3.13 Relationship between Arsenic and Fluoride, Molybdenum, and Vanadium within the Ogallala Aquifer



Data shown in Figure 3.13 are from the TWDB database. The most recent arsenic sample in each well was used in the analysis. Fluoride, molybdenum, and vanadium concentrations are from the same date as that of the most recent arsenic sample. A total of nine arsenic measurements within the database are below detection limit of 10 ppb, and two samples are below detection limit of 2 ppb. These samples are plotted as equal to the detection limits (10 and 2, respectively). Vanadium samples have a detection limit of 1 ppb and are plotted as equal to the detection limit. Molybdenum concentrations in the TWDB database have detection limits of 50, 20, 4, 2, and 1 ppb. Values below detection limits of 50 and 20 ppb were excluded from the analysis, and the remaining were plotted as equal to detection limits.

Within the NURE database only 25 wells were sampled in the study area. Dissolved oxygen in the 25 samples ranged from 6.7 to 14.3 mg/L. There is no aquifer designation in the NURE database, but 21 of the 25 wells are within the Ogallala aquifer boundary and the other four are proximal to it (<15 km). Well depths for these wells range from 6 to 70 feet, also suggesting they are in the shallow Ogallala aquifer.

Generally high correlations between arsenic and fluoride, molybdenum, and vanadium (Figure 3.13) and dissolved oxygen concentrations from the NURE database suggest natural sources of elevated arsenic within the Ogallala aquifer. Within the Edwards Trinity (Plateau) aquifer, correlations are not as strong, and it is more likely that the source of arsenic is from the Ogallala aquifer overlying the Edwards Trinity (Plateau) aquifer.

3.4 DETAILED ASSESSMENT

The Greenwood Ventures PWS has one well, G1650006A, in the Ogallala with a well depth of 96 feet. Table 3.1 summarizes arsenic concentrations measured at the Greenwood Ventures PWS.

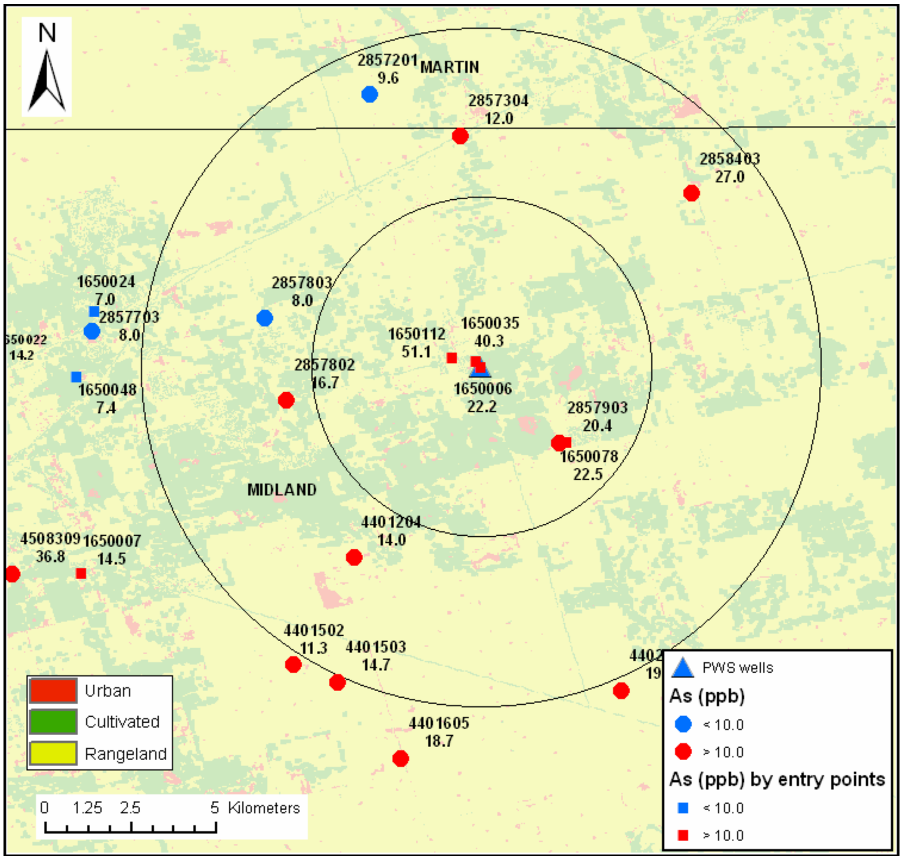
Table 3.1 Arsenic Concentrations in the Greenwood PWS

Date	As (ppb)	Source
2/3/1998	22.8	TCEQ
6/25/2001	25.7	TCEQ
2/10/2004	12.6	TCEQ
3/1/2005	22.2	TCEQ

Data from the TCEQ database.

The four samples taken are between 1998 and 2005, and all samples exceed the arsenic MCL (10 ppb). The spatial distribution of arsenic concentrations within 5- and 10-km buffers of the Greenwood Ventures PWS well is shown in Figure 3.14.

Figure 3.14 Arsenic Concentrations in 5- and 10-km Buffers of the Greenwood PWS Well



Data from TWDB and TCEQ databases. Wells are symbolized by PWS ID (TCEQ database) or well identifier (TWDB database).

Data in Figure 3.14 are from the TCEQ and TWDB databases, and the most recent arsenic concentration is shown for each well. Two types of samples were included in the analysis: from the TCEQ database the most recent sample taken at an entry point (shown as squares on the map), and from the TWDB database samples from single wells (shown as circles in the map). Within the 10-km buffer there are only two wells (2857201 and 2857803) that show arsenic concentrations <10 ppb, and even those are close to the MCL (8.0 and 9.6 ppb). The depth of Well 2857803 is 75 feet, and both wells are within the Ogallala. Two public water supplies in the vicinity of the Greenwood PWS (PWS 1650112 and 1650035) also have high arsenic concentrations (51.1 and 40.3 ppb).

To the west outside the 10-km buffer there are two public water supplies (1650024 and 1650048) with arsenic concentrations <10 ppb. The wells of these water supplies are at depth of 97-120 feet and are within the Ogallala. Some of the wells in the Pecan Grove PWS (1650024) have completion information, and these wells have openings at depths of 30-100 feet. Well 2857703 is also in that area and shows arsenic below the MCL. The well is in the Ogallala and has a depth of 70 feet.

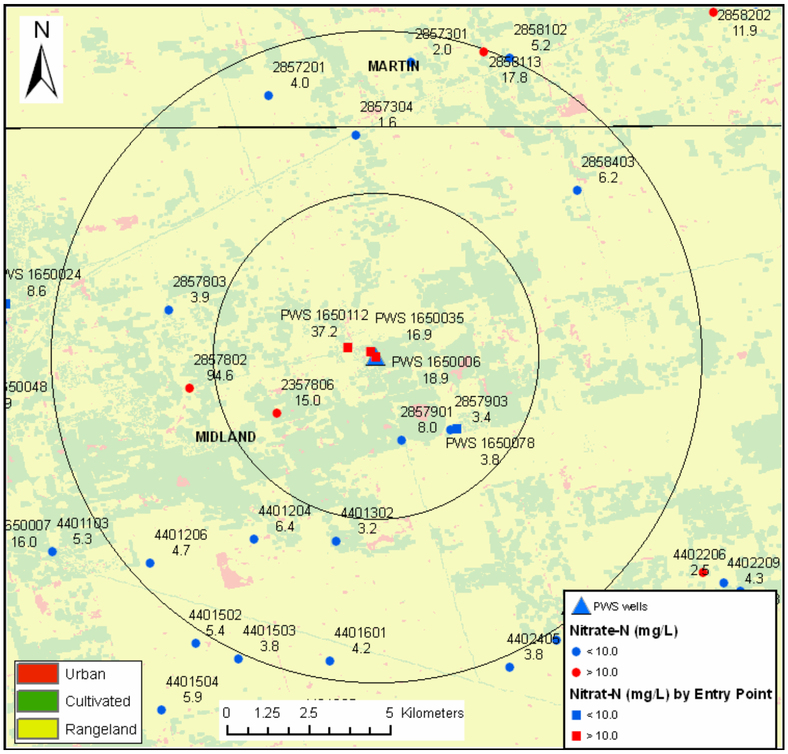
Table 3.2 summarizes nitrate-N concentrations measured at the Greenwood Ventures PWS. There were 19 nitrate-N samples taken, and all were close to the MCL. All samples since 2001 showed nitrate-N concentrations above the MCL.

Table 3.2 Nitrate-N Concentrations in the Greenwood PWS

Date	Nitrate-N (mg/L)	Source
3/19/1997	9.4	TCEQ
6/26/1997	9.99	TCEQ
8/4/1998	8.67	TCEQ
6/30/1999	9.28	TCEQ
8/17/1999	8.83	TCEQ
11/1/1999	8.96	TCEQ
2/8/2000	8.72	TCEQ
6/25/2001	12.3	TCEQ
3/26/2002	14.72	TCEQ
6/24/2002	14.16	TCEQ
8/13/2002	14.86	TCEQ
11/25/2002	15.75	TCEQ
4/24/2003	16.77	TCEQ
7/23/2003	16.4	TCEQ
12/8/2003	18.76	TCEQ
2/10/2004	11.8	TCEQ
9/23/2004	19.8	TCEQ
11/30/2004	20.6	TCEQ
3/1/2005	18.9	TCEQ

Date from the TCEQ database.

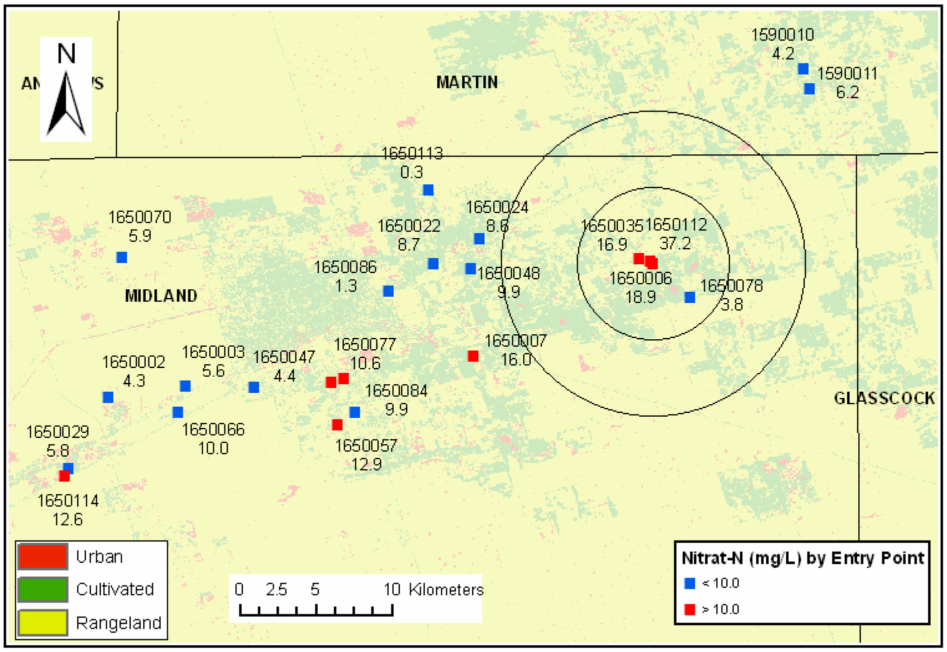
Figure 3.15 Nitrate-N Concentrations in 5- and 10-km Buffers of the Greenwood PWS Well



Data from TWDB and TCEQ databases. Wells are symbolized
by PWS ID (TCEQ database) or well identifier (TWDB database)

Data in Figure 3.15 include entry point samples from the TCEQ database (shown as squares on the map) and raw samples from the TWDB database (shown as circles). The most recent sample is shown for each well or entry point. In the vicinity of the Greenwood Ventures PWS there are two other public water supplies (1650112 - well depths 120 feet, and 1650035 - well depths 90-103 feet) with nitrate-N concentrations >10 mg/L. Approximately 2.5-3 km south-southeast from the Greenwood Ventures PWS well, there are a number of wells with nitrate-N concentrations <10 mg/L. These include PWS well 2857901 (unknown depth and 2857903 (depth 160 feet), and in PWS 1650078 (depths range from 100 to 180 feet with openings between 60 and 180 feet). All these wells are within the Ogallala aquifer.

Figure 3.16 Nitrate-N Concentrations Sampled at Entry Points of Public Water Systems



Data from the TCEQ databases. Entry points are symbolized by PWS ID and the most recent nitrate-N sample

Figure 3.16 shows a number of public water supplies with nitrate-N concentrations <10 mg/L. A number of these PWS have wells within the Edwards Trinity (Plateau) aquifer (PWS 1650048, 1650047, 1650066, and 1650002) and others are designated within the Ogallala aquifer but have greater depths than the Greenwood Ventures PWS well (PWS 1650048 depths 115-120 feet, PWS 1650086 depths 120 feet, PWS 1590011 depth 186 feet, and PWS 1650002 depth 184 feet).

Existing wells in the vicinity of the Greenwood Ventures PWS well with nitrate-N concentrations below the MCL are shown in Figures 3.15 and 3.16. Most of those wells are deeper than the Greenwood Ventures PWS well, and some are in the Edwards Trinity (Plateau) aquifer. There is the possibility that extending the Greenwood Ventures PWS well to greater depth will yield lower nitrate levels.

Table 3.3 summarizes uranium concentrations measured at the Greenwood Ventures PWS. There was only one uranium sample taken in 2001, and that sample was above the MCL for uranium (30 ppb, equivalent to 20 pCi/L).

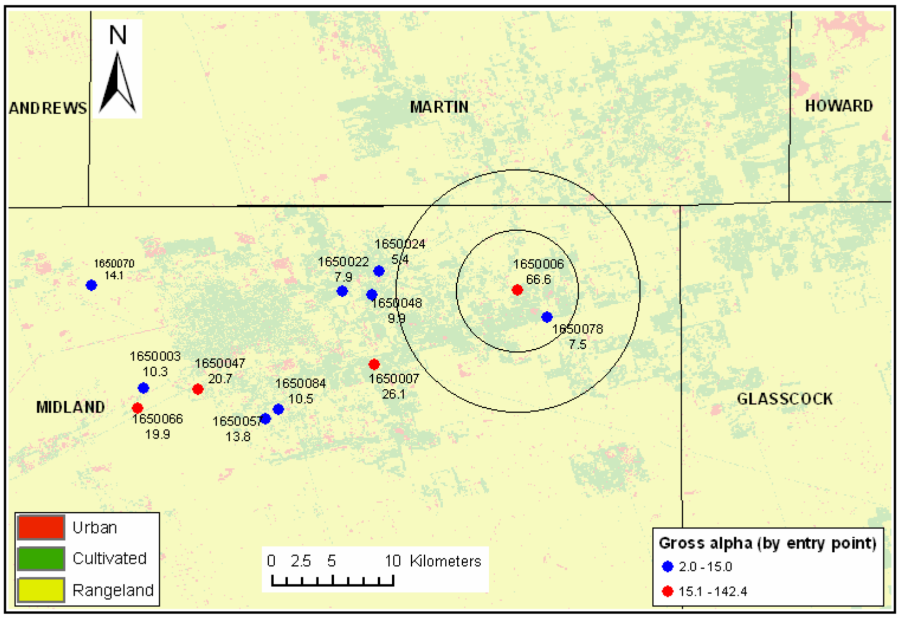
Table 3.3 Uranium Concentrations in the Greenwood PWS

Date	Uranium (pCi/L)	Source
6/25/2001	61.6	TCEQ

Data from the TCEQ database.

There are not enough uranium samples in the vicinity of the Greenwood Ventures PWS to assess the distribution of uranium directly, thus gross alpha is used as an indicator for uranium (where there is low gross alpha there is low uranium). Gross alpha concentrations in the vicinity of the Greenwood PWS are shown in Figure 3.17.

Figure 3.17 Distribution of Gross Alpha in the Vicinity of the Greenwood PWS



Data from the TCEQ databases. First row in the symbology is the PWS ID and the second row is the most recent gross alpha sample (pCi/L).

In the vicinity of the Greenwood Ventures PWS there are a number of PWSs with gross alpha below the 15 pCi/L MCL. PWS 1650078 is nearest, located about 3 km southeast of the Greenwood Ventures PWS well. The wells of this PWS are also within the Ogallala aquifer with depths between 100 and 180 feet, and openings at depths of 60 to 180 feet. Other PWSs in the vicinity are 1650024, 1650022, and 1650048 and have wells within the Ogallala aquifer with depths of 90-120 feet, similar to the Greenwood Ventures PWS well.

3.4.1 Potential Point Sources of Contamination

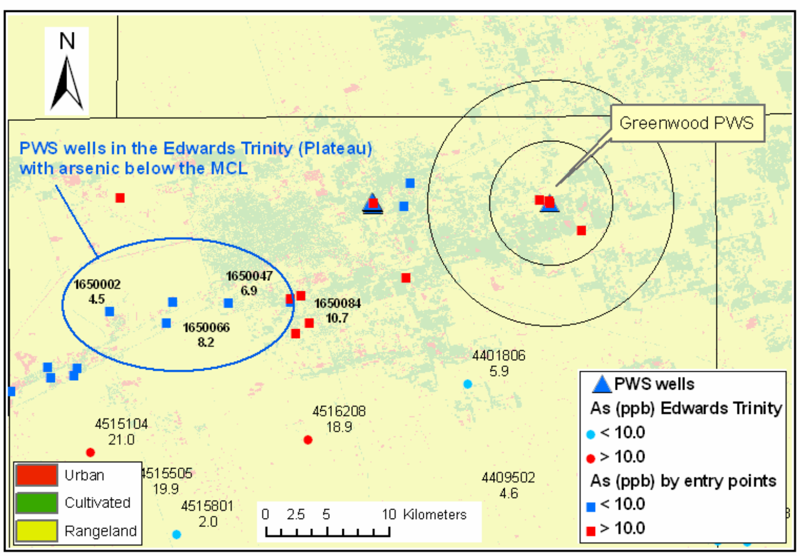
Potential Sources of Contamination (PSOC) are identified as part of TCEQ's Source Water Assessment Program. Within the vicinity (5 km) of the Greenwood Ventures PWS, no PSOC sites were identified for arsenic and uranium. A number of nitrate PSOC sites were identified within the 5-km buffer, but all sites, except for a cemetery located about 230 m north of the PWS well, are more than 1 km away from the Greenwood Ventures PWS well. It should be emphasized that the cemetery site is a potential source of contamination; therefore, further investigation is required to establish any connection between nitrate groundwater concentrations and the PSOC site.

3.4.2 Summary of Alternative Groundwater Sources for the Greenwood Ventures PWS

The Greenwood Ventures PWS is not in compliance with regard to arsenic, nitrate, and uranium. No groundwater sources with arsenic concentrations below the MCL in the vicinity (5 km) could be identified (Figure 3.14). To the west in the 10-km buffer there is one well identified with lower arsenic levels, and just outside the 10-km buffer there are a number of wells with arsenic concentrations below the MCL. All these wells are within the Ogallala aquifer. This is a possible area for alternative water sources, although arsenic concentrations are still close to the MCL (>7 ppb).

Another option is to extend the existing well into the underlying Edwards Trinity (Plateau) aquifer. In general, wells in the Edwards Trinity (Plateau) aquifer have lower arsenic concentrations, although the level of arsenic in this particular area cannot be determined due to limited information. No wells in the Edwards Trinity (Plateau) aquifer exist within the 10-km buffer of the Greenwood Ventures PWS well, but 20-25 km to the southwest there are a number of other PWS wells (PWS 1650047, 1650066, and 1650002) within the Edwards Trinity (Plateau) aquifer with arsenic <10 ppb (Figure 3.18). Depths of these wells are between 110 and 140 feet. Only two wells of PWS 1650002 have construction information, and they show openings at depths of 90 to 130 feet. The nearest TWDB well (with arsenic samples) in the Edwards Trinity (Plateau) aquifer is well 4401806, which is located about 16 km south of the Sherwood PWS wells and has a depth of 80 feet. PWS 1650084 (located about 20 km southwest of the Greenwood Ventures PWS) has wells within the Edwards Trinity (Plateau), with depths of 120 feet. Those PWS wells have arsenic concentrations above the MCL. Given the lack of local information in the vicinity of the Greenwood Ventures PWS well, this option requires further investigation.

Figure 3.18 Wells with Low Arsenic in the Edwards Trinity (Plateau) Aquifer

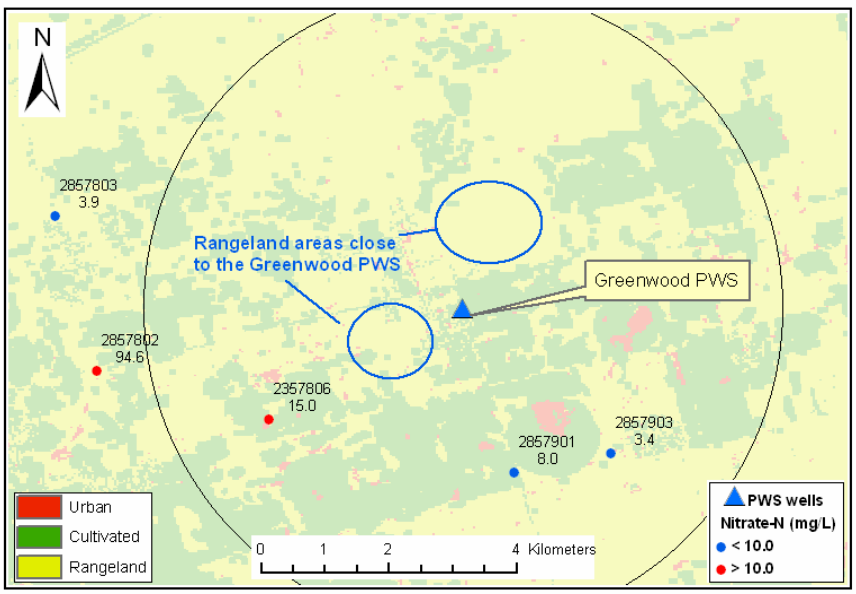


Data from the TWDB and TCEQ databases.

Regarding nitrate, the regional analysis shows that nitrate concentrations correlate with cultivated areas in the vicinity of the water supply wells, in that areas with higher percentages of cultivation around the wells have higher nitrate concentrations in groundwater. Nitrate was also found to be related to well depths, in that deeper wells have lower nitrate concentrations. Figures 3.15 and 3.16 show existing wells in the vicinity of the Greenwood Ventures PWS well with nitrate-N concentrations below the MCL. Most of these wells are deeper than the Greenwood Ventures PWS well, and some are in the Edwards Trinity (Plateau) aquifer.

These data suggest two options for alternative water sources: the first is to add new wells outside of cultivated areas. Figure 3.19 shows two options of rangeland areas in the proximity of the existing Greenwood Ventures PWS well.

Figure 3.19 Potential Areas for New Wells Outside Cultivated Zones Near the Greenwood PWS



The second option is to extend the existing Greenwood PWS well to greater depth into the underlying Edwards Trinity (Plateau) aquifer and use this water to dilute or replace existing water from the Ogallala aquifer. Given the lack of local information in the vicinity of the Greenwood Ventures PWS well, this option requires further investigation.

Identifying alternative water sources with low uranium concentrations is somewhat challenging due to the lack of uranium samples in the area of the Greenwood Ventures PWS. Even when using gross alpha to identify areas of low uranium, not many sources appear in the proximity of the Greenwood Ventures PWS well. The nearest water source with gross alpha <15 pCi/L is located 3 km from the Greenwood Ventures PWS well (Figure 3.17); thus, more data in the proximity of the Greenwood Ventures well are required to establish alternative water sources.

SECTION 4
ANALYSIS OF THE GREENWOOD VENTURES PWS

4.1 DESCRIPTION OF EXISTING SYSTEM

4.1.1 Existing System

Location of the Greenwood Ventures Inc. (GVI) mobile home park is shown in Figure 4.1. The mobile home park has one active well that is approximately 96 feet deep and produces 20 gallons per minute (gpm). The well feeds into six pressure tanks with a total capacity of 750 gallons. A well pump pumps into the six hydropneumatic tanks, which in turn feed the distribution system. The water is chlorinated before flowing into the hydropneumatic tanks. A flow meter measures the volume of water fed to the distribution system.

The treatment employed for disinfection is not appropriate or effective for removal of arsenic, uranium, or nitrate, so optimization is not expected to be effective in increasing removal of these contaminants. It may be possible to identify arsenic- or uranium-producing strata through comparison of well logs or through sampling of water produced by various strata intercepted by the well screen.

Basic system information is as follows:

- Population served: 50
- Connections: 21
- Average daily flow: 0.0038 mgd
- Total production capacity: 0.03 mgd

Basic system raw water quality data is as follows:

- Average nitrate: 20.6 mg/L (MCL: 10 mg/L)
- Typical total arsenic range: 0.0126-to 0.0257 mg/L (MCL: 0.010 mg/L)
- Combined uranium: 0.073 mg/L (MCL: 0.030 mg/L)
- Average total dissolved solids: 2,141 mg/L (Secondary TX MCL: 1000 mg/L)
- Average conductivity: 4,464 µS/cm
- Average sulfate: 569 mg/L (Secondary TX MCL: 300 mg/L)
- Average pH: 7

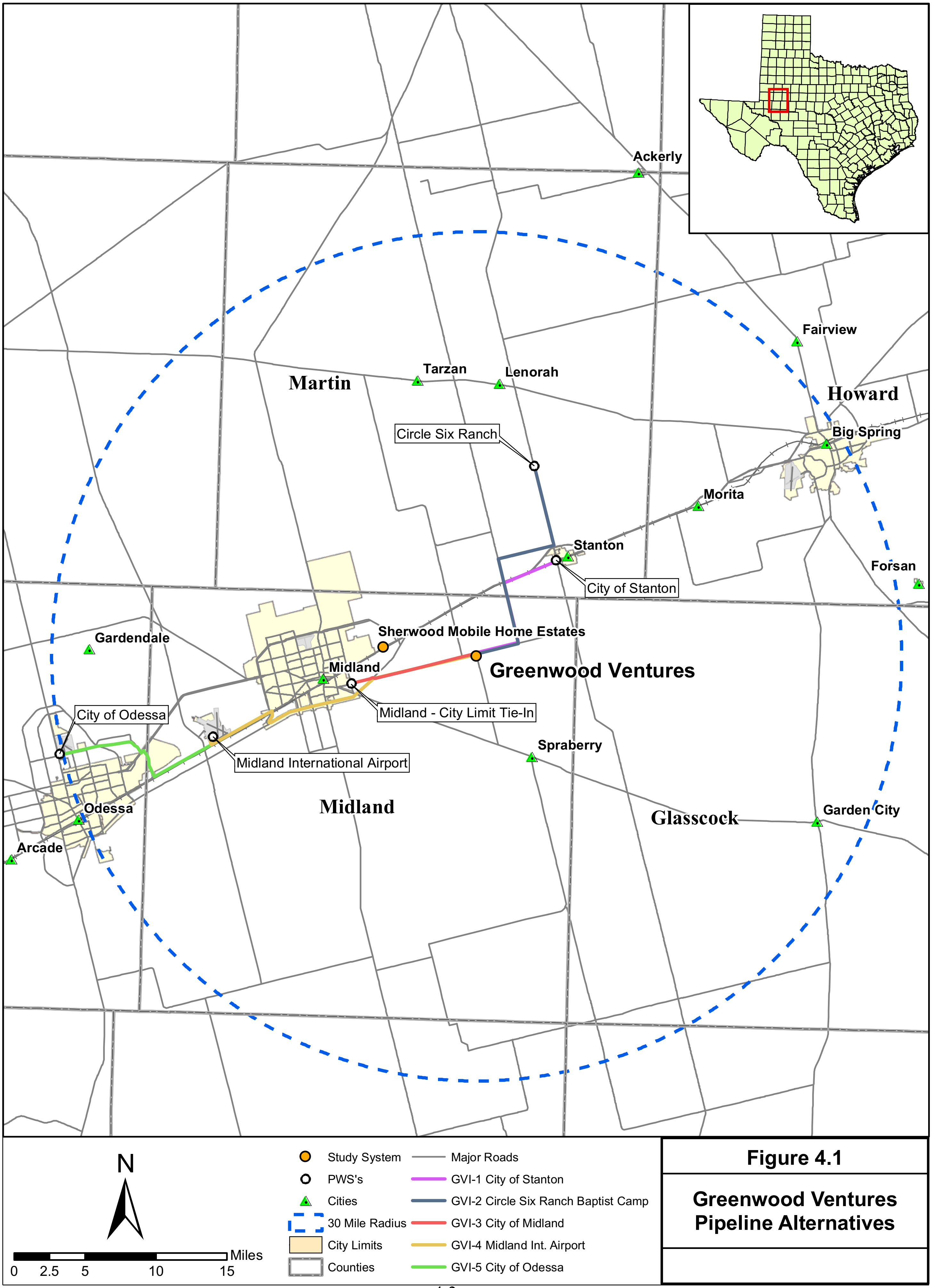


Figure 4.1

Greenwood Ventures Pipeline Alternatives

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4.1.2 Capacity Assessment for Greenwood Ventures PWS

The project team conducted a capacity assessment of the Greenwood Ventures PWS. The 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 FMT capability of the water system. The positive aspects of capacity describe those factors that the system is doing well. These factors should provide opportunities for the system to build upon 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 proper operation of the system. The last category, capacity concerns, includes items not currently associated with a significant problem for the system. However, the system should consider addressing those items so they do not have the opportunity to cause problems in the future.

The project team interviewed Patricia Williams, Owner of Greenwood Ventures Inc.

4.1.2.1 General Structure of the Water System

Greenwood Ventures Inc. operates a convenience store and mobile home park east of Midland, Texas. The business owner, Patricia Williams, is also the operator of the water system which supplies water to the mobile home park and to the convenience store. She manages and operates the system on a daily basis and is a certified operator.

The Greenwood Ventures PWS serves 21 mobile homes, with a population of 50 and one retail building. Most of the residents of the park are low-income. The system consists of one well with a chlorinator and a pressure tank. The well is located on property owned by the Greenwood Independent School District. Each mobile home lot has its own septic tank and the mobile home park manages the pumping of the septic tanks. The water and septic tank services are included in the monthly lot rental fee.

The convenience store has a small RO treatment system operated under a contract with Culligan, which is responsible for testing the water every month. The store sells approximately 300 to 350 gallons of bottled water a month from this system to customers of the convenience store.

4.1.2.2 General Assessment of Capacity

Based on the team's assessment, the Greenwood Ventures PWS has an inadequate level of capacity due mainly to deficiencies with financial capabilities. There are several positive managerial and technical aspects of the PWS, but there are also a number of deficiencies that prevent it from being able to comply with the nitrate standard now or the arsenic standard in the future. The deficiencies may also impact the PWS's long-term sustainability.

4.1.2.3 Positive Aspects of Capacity

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

- Knowledgeable and Dedicated Owner/Operator – Patricia Williams has owned and operated the system for the past 10 years, including operating the system by herself for the past 6 years. She is a certified operator and has a strong commitment to providing safe water to the residents. She is on call 24 hours a day. She occasionally has to contract for work on the water system. However, she has a strong community network and can call on other people, such as the operator for the Greenwood Schools, for assistance when needed.
- Communication with Customers – The owner tries hard to keep the residents of the mobile home park informed about the water system. Greenwood Ventures PWS issues a Public Notice regarding the nitrate violation every 3 months as required. The notices are posted at the convenience store and the owner also hand-delivers notices to every resident. While there are no formal cross-connection control or water conservation programs, the owner does make the residents aware of these issues.

4.1.2.4 Capacity Deficiencies

The following capacity deficiencies, which seriously impact the ability of the water system to comply with current and future regulations and to ensure long-term sustainability, were noted while conducting the assessment:

- **Inadequate Financial Accounting for the Water System** – Greenwood Ventures PWS charges the residents of the mobile home park a flat fee for lot rental. This rental fee has stayed relatively stable over the years and the owner has been reluctant to increase it because most of the residents are low-income families. The owner believes that the expenses of the water system are covered by the lot rental fees, but does not track these expenses separately from other expenses of GVI. There is no separate operating budget for the mobile home park, just a Profit/Loss Statement for the business. Without tracking expenses and revenues specifically for the PWS, it is not possible to know if the amount of money collected through lot rental fees is sufficient to cover the costs of current operation, repair and replacement, compliance with the nitrate and arsenic regulations, as well as providing a reserve fund.
- **Inability to Meet Operating Expenses -** Greenwood Ventures PWS receives a letter from TCEQ at the beginning of the year with information on what sampling will be done throughout the year and the cost. The letter does not provide a schedule of the sampling. At least once the owner has not been able to pay the full bill for the analysis

and has had to make payments over time. Because there are no funds set aside for this purpose, the owner has had to make payments to the lab for sampling and does not receive the results until the fees have been paid. Delays in receiving information could increase the risk to public health.

- **No Reserve Account –** The lack of a reserve account for anticipated expenses, emergencies, and future capital expenditures, is a problem. The owner covers these expenses with funds from the business as the need occurs. Several years ago the pump went out. The owner was able to have it repaired in a timely manner, but had to pay off the bill over three months. In addition, funds have not been set aside to address the current nitrate compliance problem.
- **Lack of Long-Term Planning for Compliance and Sustainability –** The lack of planning negatively impacts the ability of the PWS to develop a budget and associated rate structure that will provide for long term needs. There is no additional water storage and no fire hydrants. The owner indicated she would like to install these components but does not know how she will pay for them. Additional storage would be desirable for times the well is out of service, since there is only one well. The owner has not been able to plan for the cost of compliance with the nitrate standard over the long term. There are no pregnant women, infants, or elderly people among the residents; however, the owner will provide bottled water for any who are visiting, but this is not a permanent solution.

4.1.2.5 Potential Capacity Concerns

The following items were concerns regarding capacity but no particular FMT problems can be attributed to these items at this time. The system should focus on addressing the deficiencies noted above in the capacity deficiency section, but should address the items listed below to further improve FMT capabilities.

- **Sustainability of Water Supply –** The well is located on property owned by the Greenwood Independent School District. There does not appear to be a written agreement with the School District giving Greenwood Ventures PWS access. It could be an issue for long-term sustainability of the water supply if there is no formal agreement. The owner of GVI would like to have a storage tank on the business property, as well as a new building with a chlorination system. However, she does not have the money available for those projects at this time.
- **Written Procedures –** There are no written procedures for operation of the PWS. At this time, the owner knows what tasks need to be done and is able to operate the system without written procedures. However, if the owner leaves or if additional staff is hired, the lack of written operating procedures may cause problems.
- **Preventative Maintenance –** There are no valves so the owner must shut down the whole system to repair any leaks. Installation of valves could limit the inconvenience to customers when repairs are made on the distribution lines.

- **Lack of Emergency Plan -** The system does not have a written emergency plan, nor does it have emergency equipment such as generators. The system should have an emergency or contingency plan that outlines what actions will be taken and by whom. The emergency plan should meet the needs of the facility, the geographical area, and the nature of the likely emergencies. Conditions such as storms, floods, major line breaks, electrical failure, drought, system contamination, or equipment failure should be considered. The emergency plan should be updated annually, and larger facilities should practice implementation of the plan annually.

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, PWSs surrounding the Greenwood Ventures PWS were reviewed with regard to their reported drinking water quality and production capacity. PWSs that appeared to have wells with water quality issues were ruled out from consideration as alternative sources, while those without identified water quality issues were investigated further. If it was determined that those PWSs had excess supply capacity and might be willing to sell the excess, or might be a suitable location for a new Greenwood Ventures PWS groundwater well, the system was taken forward for further consideration.

Table 4.1 is a list of the existing PWSs within approximately 30 miles of the Greenwood Ventures PWS. Thirty miles was selected as the radius for the evaluation owing to the small number of PWSs with compliant water in proximity to the Greenwood Ventures PWS.

Based on the initial screening summarized in Table 4.1, five alternatives were selected for further evaluation. These alternatives were selected based on factors such as water quality, distance from the Greenwood Ventures PWS, sufficient total production capacity for selling or sharing water, and willingness of the PWS to sell or share water or drill a new well. These alternatives are summarized in Table 4.2.

Table 4.1 Existing Public Water Systems within 30 miles of Greenwood Ventures Public Water System

System Name	Dist. From GVI WS (Miles)	Comments/Other Issues
Greenwood ISD	0.1	Small system with WQ issues: arsenic, TDS, nitrate, total hardness
Greenwood Water System	2.0	Small system with WQ issues: As, fluoride; marginal exceedances: TDS
Pecan Grove Mobile Home Park	6.0	Small system with WQ issues: TDS; marginal exceedances: NO3
Valley View Mobile Home Park	7.2	Small system with WQ issues: As, TDS, NO3, gross alpha; marginal exceedances: Se
Water Runners Inc.	8.2	Small system; current use requires extensive treatment to

System Name	Dist. From GVI WS (Miles)	Comments/Other Issues
		address WQ issues.
Texas Water Station	8.9	Small system; current use requires extensive treatment to address WQ issues.
City of Stanton	9.5	Large System (>1 mgd) with WQ issues: As, Fe, TDS, NO3; marginal exceedances: Se. Uses compliant surface water. Evaluate Further.
South Midland Co. Water Systems	11.6	Small system with WQ issues: As, TDS, NO3
Warren Roads	12.0	Small system with WQ issues: As, TDS, NO3
Johns Mobile Home Park	12.1	Small system with WQ issues: As, TDS, NO3
Twin Oaks Mobile Home Park	12.7	Small system with WQ issues: As, TDS, NO3; marginal exceedances: Se
Circle Six Ranch Baptist Camp Inc	14.0	Small system with marginal As WQ issues. Evaluate Further.
City of Midland	14.0	Large system (>60 mgd) that uses both surface water and groundwater. No current violations. Evaluate Further.
Country Village Mobile Home Estates	14.4	Small system with WQ issues: As, TDS, NO3
Westgate Mobile Home Park	14.7	Small system with marginal As, TDS exceedances
Airline Mobile Home Park LTD	16.9	Small system with WQ issues: TDS, gross alpha; marginal exceedances: As
Martin County Freshwater District	17.3	Small system with WQ issues: NO3; marginal exceedances: As, TDS
Spring Meadow Mobile Home Park	17.5	Small system with WQ issues: As, TDS; marginal exceedances: NO3
Pecan Acres Homeowners Association	18.4	Small system with WQ issues: As, TDS; marginal exceedances: gross alpha
Grady ISD	20.0	Small system with WQ issues: As, TDS, NO3
Midland International Airport	19.6	Large system (>1 mgd) with no known WQ issues. Evaluate Further.
City of Odessa	30.0	Large system (>80 mgd) that uses both surface water and groundwater. No current violations. Evaluate Further.

Table 4.2 Public Water Systems Within 30 miles of the Greenwood Ventures PWS Selected for Further Evaluation

System Name	Pop	Conn	Total Production (mgd)	Ave Daily Usage (mgd)	Approx. Dist. from GVI Water System	Comments/Other Issues
Greenwood Ventures PWS	65	25	0.05	0.015	n/a	n/a
City of Stanton	2,556	998	1.678	0.379	9.5 miles	Large System (>1 mgd) with WQ issues: As, Fe, TDS, NO3; marginal exceedances: Se. Uses compliant surface water. .
Circle Six Ranch Baptist Camp Inc	350	40	0.180	–	14.0 miles	Small system with marginal As WQ issues
City of Midland	98,045	35,494	64.644	23.040	14.0 miles	Large system (>60 mgd) that uses both surface water and groundwater. No current violations.
Midland International Airport	1,000	56	1.880	0.327	20.0 miles	Large system (>1 mgd) with no known WQ issues
City of Odessa	101,719	41,588	80.2	19.583	30.0 miles	Large system (>80 mgd) that uses both surface water and groundwater. No current violations.

4.2.1.1 Colorado River Municipal Water District

The Colorado River Municipal Water District (CRMWD) supplies raw water to the Cities of Midland and Odessa and, while it would not supply water directly to the Greenwood Ventures PWS, a brief description is included here because of its role in supplying water to these two cities. The CRMWD was authorized in 1949 by the 51st Legislature of the State of Texas for the purpose of providing water to the District's Member cities of Odessa, Big Spring, and Snyder. The CRMWD also has contracts to provide specified quantities of water to the Cities of Midland, San Angelo, Stanton, Robert Lee, Grandfalls, Pyote, and Abilene (through the West Central Texas Municipal Water District).

The CRMWD owns and operates three major surface water supplies on the Colorado River in west Texas. These are Lake J.B. Thomas, the E.V. Spence Reservoir, and the O.H. Ivie Reservoir. Together, the combined capacity of these reservoirs is 1.272 million acre-feet. Additionally, CRMWD operates five well fields for water supply. Three of those fields were developed by the Member Cities prior to 1949. The fourth field, located in Martin County, began delivering water in 1952. The fifth field, located in Ward County southwest of Monahans, can supply up to 28 million gallons per day (mgd). CRMWD primarily uses these well fields to supplement surface water deliveries during the summer months.

4.2.1.2 City of Stanton

The City of Stanton is located approximately 9.5 miles northwest of the Greenwood Ventures PWS. Stanton is under contract with the CRMWD to receive up to 90 million gallons (MG) of raw water per year via pipeline to Stanton's water treatment facility. Over the past few years, the water source has been either Lake Ivie or Lake Thomas, both located southeast of Stanton. In 2004, Stanton received a total of 113 MG of water or 0.31 mgd from CRMWD. In addition to receiving surface water from CRMWD, Stanton also has an emergency source consisting of a six-well ground water collection system. When water is needed, it is pumped to a central storage area consisting of two 150,000-gallon storage tanks. Each well is completed to approximately 180 feet in the Ogallala aquifer, and each well is capable of producing an average sustained rate of 65 gpm. The wells were tested individually, and sample results indicate elevated levels of nitrate above the MCL and also arsenic just below the current MCL. In 2004, no water was pumped from the six-well system.

The utility department in Stanton is currently providing water to several rural communities beyond city limits and is willing to provide water to other communities. However, the current water treatment plant serving Stanton was built in 1965 and needs to be replaced or upgraded prior to allocating any excess water supplies to additional users. Trucking of treated water to a nearby community can be approved by the Stanton utility manager. If a community requests treated water be piped to its area, then the plan must be approved by the five-member city council.

Current rates for city residential areas are as follows:

- Raw water – Minimum use of 3,000 gallons/month for a cost of $4.55 and $1.50/every 1,000 gallons over the initial 3,000 gallons.
- Treated water – Minimum use of 3,000 gallons/month for a cost of $21.00 and $3.50/every 1,000 gallons over 3,000 gallons.
- The current rate for outlying communities using City of Stanton water is:
- Treated water - $42.00 for the first 3,000 gallons and then $7.00 for every 1,000 gallons over 3,000 gallons.

The population of Stanton is around 2,700 with approximately 1,000 connections. There is no anticipated growth for Stanton.

4.2.1.3 Circle Six Ranch Baptist Camp Inc.

The Circle Six Ranch Baptist Camp is located adjacent to Highway 137 north of the City of Stanton. The camp, which is approximately 14 miles from the Greenwood Ventures PWS, contains bunkhouses, a motel, and conference centers, and serves a population of 350 with 40 connections. The PWS is supplied by five local groundwater wells (G1590003 A, B, C, D, and E), all of which were drilled to a depth of 110 feet with a rated flow rate of 20 to 30 gpm. The total system production is 0.180 mgd, the average daily consumption is unknown, the total storage is 0.085 MG, the booster pump capacity is 0.864 mgd, and the pressure tank capacity is

0.003 MG. The water is used primarily for summer camp purposes. The water is hypochlorinated for disinfection before distribution.

The wells do not have enough capacity to meet the peak demand flow rate of the Greenwood Ventures PWS. However, based on the Circle Six Ranch Baptist Camp water quality data and its proximity to the Greenwood Ventures PWS, Circle Six Ranch Baptist Camp may provide a suitable location for a new well.

4.2.1.4 City of Midland

The center of the City of Midland is located approximately 15 miles northwest of the Greenwood Ventures PWS. The City of Midland purchases approximately 75 to 80 percent of its water from the CRMWD through a 1966 contract. This purchased water comprises mainly untreated surface water from several reservoirs, including Lake J.B. Thomas, Lake E.V. Spence, and Lake O.H. Ivie, though the CRMWD may also supplement the supply with groundwater during the high demand summer months. The City of Midland gets the other 20 to 25 percent of its water from various city-owned well fields, which provide lower quality water. Midland is classified as a member city of CRMWD and is allowed to use alternate water supplies, unlike Odessa whose water can only be provided by CRMWD.

As part of Midland's primary water sources, raw water from CRMWD is delivered to one of three reservoirs. Two of the three reservoirs are owned by CRMWD and include a 15 MG reservoir located at the water purification plant and the 100 MG Terminal Reservoir located on FM 1788, approximately 2 miles south of Highway 191. The Terminal Reservoir is shared by both Midland and Odessa. The third reservoir, Lake Peggy Sue, is owned by Midland and is located approximately 2 miles west of the City's water treatment plant. In addition to the surface water provided by CRMWD, under a 1995 agreement, Midland owns 16.54 percent of Lake Ivie, located approximately 170 miles southwest of Midland. Each day, 15 MGs from Lake Ivie and 16 MGs from CRMWD reservoirs are delivered via pipeline from Ballinger to San Angelo, and then to one of the three reservoirs around Midland.

In addition to CRMWD surface water, the City owns or leases water rights in three well fields. The McMillen well field was in operation from the early 1950s until it was depleted in the mid 1960s. It was used as a reserve water supply but is no longer used following detection of perchlorate in water samples from the well field. The Paul Davis well field, located 30 miles north of Midland, was developed in the late 1950s and is used during peak periods to offset the demand exceeding the 31 mgd provided by the surface water from CRMWD reservoirs. The well field can sustain a pumping rate of 18 to 19 mgd, but normally averages 10 mgd annually. The well field currently consists of two 2.5-MG tanks that receive groundwater from 29 wells. These wells are installed between 150 and 200 feet deep in the Ogallala aquifer (Code 121OGLL). Since arsenic, fluoride, perchlorate, and radionuclides were reported, both in samples from individual wells and in batch samples from the well field, the City of Midland carefully monitors the blending of surface water from CRMWD and the groundwater from the Paul Davis Well Field to maintain a potable water supply that does not exceed the MCLs for these four constituents. The third well field is the T-Bar Ranch, located in western Winkler

County approximately 70 miles west of Midland. This well field is still being developed and will be brought online as the Paul Davis well field is depleted.

The City of Midland operates two treatment plants to treat surface water supplied by CRMWD and provides water to a service population of approximately 100,000. The City has a total of approximately 35,000 connections, about 32,000 of which are metered. The major users of water in Midland include college, parks, and schools which use the water for irrigation. The current monthly rates per connection are a $12 base charge for the first 2,000 gallons and $2.75 for each additional 1,000 gallons.

In Fall 2003, the Midland City Council decided that water can only be provided to areas annexed by the City of Midland. Consequently, while the City of Midland does have sufficient excess drinking water capacity, any location to receive water from the City would have to agree to be annexed. To be annexed, a commission representing the community to be annexed must submit a petition signed by at least 50 percent of the community residents wanting to be annexed. This commission would then appoint a Public Improvement District to build a water line from a Midland supply line to the community. In the past, Midland has financed the Public Improvement District through the sale of bonds. The community would be subject to the same rates as the other residences in Midland.

A connection to Midland's potable water distribution system can be made near the city limits boundary on the southeast side. The distance from the southeast side of Midland to the Greenwood Ventures PWS is 9.3 miles long.

4.2.1.5 Midland International Airport

Midland International Airport is located approximately 20 miles west of the Greenwood Ventures PWS. The Midland International Airport is supplied by 10 groundwater wells which are completed in the Antler Sands aquifer (Code 218ALRS), range in depth from 85 to 130 feet, and are rated from 61 to 203 gpm. These wells are maintained and operated by the City of Midland Utility Department. Water from the wells is chlorinated and piped to an elevated 500,000-gallon storage tank before entering the airport's distribution system. The system is capable of producing up to 1.5 mgd, and average daily consumption is approximately 0.5 mgd.

A Midland consulting firm, Arcadis, is currently evaluating the ability for the Midland International Airport well field to continue meeting the demands of the airport. Currently, operators of the Midland International Airport PWS do not consider there to be sufficient excess capacity to provide water to offsite facilities or areas. However, based on available water quality data, the location may be a suitable point for a new groundwater well.

4.2.1.6 City of Odessa

The intake point for the City of Odessa is located approximately 30 miles west of the Greenwood Ventures Inc PWS. The City of Odessa is one of three original members of CRMWD and, by contract, may only obtain its water supply through them. The water supplied to the City of Odessa originates in a network of three reservoirs (Lake Ivie, Lake Spence, and Lake Thomas), but this water may be supplemented with groundwater during the high-demand summer months. The untreated water from the reservoirs is pumped from Ballinger, Texas to San Angelo, Texas via a 60-inch pipeline and then through a 53-inch pipeline from San Angelo northwest to Odessa, which is 1,400 feet higher in elevation than San Angelo. Ground water is pumped from a well field in Ward County.

The raw water is delivered to a treatment facility, where it is filtered and chlorinated, and then stored in a 4.3 MG concrete storage tank prior to distribution to the City of Odessa. In addition to the water delivered via CRMWD pipeline, a relatively small amount of water (less than 10%) is also delivered by a second pipeline from the Ward County well field located approximately 60 miles west of Odessa. This water is pH-adjusted and chlorinated prior to being pumped to the 4.3 MG storage tank.

In 2004, approximately 6.7 billion gallons of water were delivered to Odessa via the CRMWD pipeline, and 4.5 percent or 0.31 billion gallons, originated from the Ward County well field. Average usage by the City of Odessa ranges from 12 to 15 mgd in the winter to 35 to 36 mgd in the summer. The City of Odessa provides water to a population of approximately 108,000 and has a total of approximately 42,000 connections. The current customer rate per connection for potable water is $2.50 per 1,000 gallons.

The City of Odessa has an excess capacity of treated water and may be willing to sell water to other PWSs. A community wanting to purchase treated water from the City of Odessa must submit a formal request to the City for review by the five-member city council. The community does not have to be annexed in order to receive treated water via pipeline, but it would have to fund the cost of the connecting pipeline.

4.2.2 Potential for New Groundwater Sources

4.2.2.1 Installing New Compliant Wells

A review of the water quality data of the groundwater from existing wells within 10 miles of the Greenwood Ventures PWS did not find any groundwater suitable for a new well. Nevertheless, costs to develop a well will be provided for comparison purposes.

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 operator of the Greenwood Ventures PWS is already familiar with 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.

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 the existing well. This will ensure the well characteristics are known and that well construction meets standards for drinking water wells.

Some of the alternatives suggest new wells be drilled in areas where existing wells are compliant. In developing the cost estimates, it is 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. Two wells are used in cases where the PWS is large enough that two wells are required by TCEQ rules.

4.2.2.2 Results of Groundwater Availability Modeling

Regional groundwater withdrawal in the area of the Greenwood Ventures PWS is extensive and likely to remain near current levels over the next decades. In northern Midland County, where the PWS is located, two aquifers (the Ogallala and the downdip of the Edwards Trinity Plateau) are potential groundwater sources for public supplies.

Supply wells for the Greenwood Ventures PWS and its vicinity withdraw groundwater primarily from the southern Ogallala aquifer. The 2002 Texas Water Plan anticipates 24 percent depletion in the Ogallala supply over the next decades, from 5,000,097 acre-feet per year (AFY) estimated in 2000 to 3,785,409 acre-feet per year in 2050. Nearly 95 percent of the groundwater pumped is used for irrigated agriculture.

A GAM for the Ogallala aquifer was recently developed by the TWDB (Blandford, *et al.* 2003). Modeling was performed to simulate historical conditions and to develop long-term groundwater projections. 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 (Blandford, *et al.* 2003). 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 northern Midland County, the simulated drawdown by the year 2050 would be more moderate, within the 0 to 25-foot range (Blandford, *et al*. 2003). The Ogallala aquifer GAM was not run for the Greenwood Ventures PWS. Water use by the system would represent a minor addition to regional withdrawal conditions, making potential changes in aquifer levels beyond the spatial resolution of the regional GAM model.

In northern Midland County, the downdip of the Edwards Trinity Plateau aquifer underlies the Ogallala aquifer. A GAM for the Edwards Trinity Plateau aquifer was published by the TWDB in September 2004 (Anaya and Jones 2004). GAM data for the aquifer indicate that total withdrawal in Midland County had a steady decline in recent years, from a peak annual use of 21,127 acre-feet in 1995 to 13,484 acre-feet in 2000. This reduced water withdrawal from the Edwards Trinity Plateau aquifer in Midland County is expected to remain nearly constant over the simulation period ending in the year 2050 (Anaya and Jones 2004).

4.2.3 Potential for New Surface Water Sources

The Greenwood Ventures PWS is located in the upper reach of the Colorado River Basin where current surface water availability is expected to steadily decrease as a result of the increased water demand. The Texas Water Development Board's 2002 Water Plan anticipates an 11 percent reduction in surface water availability in the Colorado River basin over the next 50 years, from 879,400 AFY in 2000 to 783,641 AFY in 2050.

There is a minimum potential for development of new surface water sources for the Greenwood Ventures PWS, as indicated by limited water availability over the entire river basin, and within the site vicinity.

In the site vicinity, and over all of Midland County, unappropriated flows of the Colorado River Basin for new uses are available at most 50 percent of the time. This supply is inadequate because the TCEQ requires 100 percent supply availability for a PWS.

4.2.4 New Water Source Options for Detailed Consideration

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

1. City of Stanton. Obtain treated CRMWD water through the City of Stanton PWS. A pipeline and pump station would be constructed to transfer the water to the Greenwood Ventures PWS (Alternative GVI-1).

2. Circle Six Ranch Baptist Camp Inc. A new well would be installed in the vicinity of the wells at the Circle Six Ranch Baptist Camp. A pipeline and pump station would be constructed to transfer the water to the Greenwood Ventures PWS (Alternative GVI-2).

3. City of Midland. Obtain treated CRMWD water through the City of Midland PWS. A pipeline and pump station would be constructed to transfer the water to the Greenwood Ventures PWS (Alternative GVI-3).

4. Midland International Airport. A new well would be installed in the vicinity of the wells at Midland International Airport. A pipeline and pump station would be constructed to transfer the water to the Greenwood Ventures PWS (Alternative GVI-4).

5. City of Odessa. Obtain treated CRMWD water through the City of Odessa system. A pipeline and two pump stations would be constructed to transfer the water to the Greenwood Ventures PWS (Alternative GVI-5).

6. Installing a new deeper well at the Greenwood Ventures PWS that would produce compliant water in place of the water produced by the existing active well (Alternative GVI-6).

7. Installing a new well within 10, 5, or 1 mile of the Greenwood Ventures PWS that would produce compliant water in place of the water produced by the existing active

well. A pipeline and pump station would be constructed to transfer the water to the Greenwood Ventures PWS (Alternative GVI-7, GVI-8 and GVI-9).

4.3 TREATMENT OPTIONS

4.3.1 Centralized Treatment Systems

Centralized treatment of well field water is identified as a potential alternative for the Greenwood Ventures PWS. RO is the potential applicable process. RO can reduce arsenic, nitrate, uranium, and gross alpha particle activity to produce compliant water. The central RO treatment alternative is GVI-10.

4.3.2 Point-of-Use Systems

POU treatment using RO technology is valid for nitrate and arsenic removal. The POU treatment alternative is GVI-11.

4.3.3 Point-of-Entry Systems

POE treatment using RO technology is valid for nitrate and arsenic removal. The POE treatment alternative is GVI-12.

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 a bottled water program. An alternative to providing bottled water is to provide a central, publicly accessible dispenser for treated drinking water. Alternatives addressing bottled water are GVI-13, GVI-14, and GVI-15.

4.5 ALTERNATIVE DEVELOPMENT AND ANALYSIS

A number of potential alternatives for compliance with the MCLs for nitrate 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 a 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 GVI-1: Purchase Treated Water from the City of Stanton

This alternative involves purchasing treated surface water from the City of Stanton, which would be used to supply Greenwood Ventures PWS. The City of Stanton currently has sufficient excess capacity for this alternative to be feasible and has indicated it would be amenable to negotiating an agreement to supply water to PWSs in the area. Records as late as 2004 indicate that the City of Stanton treated potable water has excessive concentrations of total trihalomethanes (TTHM). TTHMs are a disinfection by-product that can be reduced with operational and chemical use changes. The City of Stanford has also been cited for not reporting MCL exceedances to the public. These two issues would need to be resolved before this alternative is viable.

This alternative would require constructing a pipeline from the City of Stanton water main to a new storage tank for the Greenwood Ventures PWS. A pump station would also be required to overcome pipe friction and the elevation differences between Stanton and the Greenwood Ventures PWS. The 4-inch pipeline would primarily follow Interstate Highway (IH)-20W, County Road (CR) 1050, and CR 307. The pipeline would be approximately 11.8 miles long and would discharge to a new storage tank and feed pump set in the Greenwood Ventures PWS. The required pump horsepower would be 3 hp.

The pump station would include two pumps, including one standby, and would be housed in a building. A tank would also be constructed for the pumps to draw from. It is assumed the pumps and piping would be installed with capacity to meet all water demand for the Greenwood Ventures PWS, since the incremental cost would be relatively small, and it would provide operational flexibility.

This alternative involves regionalization by definition, since Greenwood Ventures PWS would be obtaining drinking water from an existing larger supplier. It is possible the Greenwood Ventures PWS could turn over provision of drinking water to the City of Stanton instead of purchasing water. Also, other PWSs near the Greenwood Ventures PWS 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, pump station, and storage tank with feed pumps. 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 Greenwood Ventures PWS well, 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 $2.62 million, and the alternative's estimated annual O&M cost is $28,720.

The reliability of adequate amounts of compliant water under this alternative is fair based on compliance history. From the perspective of the Greenwood Ventures PWS, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations are well understood. If the decision were made to perform blending then operational complexity would increase.

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

4.5.2 Alternative GVI-2: New Well at Circle Six Ranch Baptist Camp Inc.

This alternative consists of drilling a new well in the Circle Six Ranch Baptist Camp area that would replace Greenwood Ventures PWS's well. As a result, for this alternative, it is assumed that the Greenwood Ventures PWS would obtain all its water from the new well.

This alternative would require drilling a new well and installing a well pump, small ground storage tank, a pump station with two transfer pumps, a pipeline, and new storage tank and feed pump set at the Greenwood Ventures PWS. One of the two pumps in the pump station would be for backup in the event the other pump fails. The 4-inch pipeline would primarily follow farm-to-market road (FM) 307, state highway (SH) 1050, ranch road (RR) 829, RR 3113, and SH 137, would be approximately 19.2 miles long, and would discharge to a new storage tank in the Greenwood Ventures PWS. The required pump horsepower would be 3 hp.

This alternative presents a limited regional solution, since other PWSs in the area also need compliant water. Some regionalization could be accomplished by sharing the cost of drilling the well and possibly constructing the pipeline and pump station with other non-compliant PWSs in the area.

The estimated capital cost for this alternative includes constructing a new well and small ground storage tank, a pump station with two transfer pumps, a pipeline, and a new storage tank and feed pump set for the Greenwood Ventures PWS. The estimated O&M cost for this alternative includes 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 $4.19 million, and the estimated annual O&M cost for this alternative is $35,036.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of the Greenwood Ventures PWS, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pumps stations are well understood, and Greenwood Ventures PWS currently operates pumps.

The feasibility of this alternative is dependent on finding a suitable well site.

4.5.3 Alternative GVI-3: Purchase Treated Water from the City of Midland

This alternative involves purchasing treated water from the City of Midland, which will be used to supply the Greenwood Ventures PWS. The City of Midland 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. 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 the Greenwood Ventures PWS would obtain all its water from the City of Midland.

This alternative would require constructing a pipeline from the City of Midland water main to a new storage tank for the Greenwood Ventures PWS. A pump station would also be required to overcome pipe friction and elevation differences between Midland and the Greenwood Ventures PWS. The required pipeline would be approximately 9.3 miles long and would be constructed of 4-inch pipe, along FM 307. The required pump horsepower would be 3 hp.

The pump station would include two pumps, including one standby, and would be housed in a building. A storage tank would also be constructed for the pumps to draw from. It is assumed the pumps and piping would be installed with capacity to meet all water demand for the Greenwood Ventures PWS, since the incremental cost would be relatively small, and would provide operational flexibility.

This alternative involves regionalization by definition, since Greenwood Ventures PWS would be obtaining drinking water from an existing larger supplier. Also, other PWSs near Greenwood Ventures PWS 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, pump station, and storage tank and feed pump set. 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 Greenwood Ventures PWS well, 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 $2.12 million, and the alternative's estimated annual O&M cost is $28,261.

The reliability of adequate amounts of compliant water under this alternative should be good. City of Midland provides treated surface water on a large scale, facilitating adequate O&M resources. From the perspective of the Greenwood Ventures PWS, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations are well understood. If the decision is 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 Midland to purchase treated drinking water.

4.5.4 Alternative GVI-4: New Well at Midland International Airport

This alternative consists of drilling a new well in the Midland International Airport area that would replace Greenwood Ventures PWS's well. As a result, for this alternative, it is assumed that Greenwood Ventures PWS would obtain all its water from the new well.

This alternative would require drilling a new well and installing a well pump, small ground storage tank, a pump station with two transfer pumps, a pipeline, and new storage tank and feed pump set at the Greenwood Ventures PWS. One of the two pumps in the pump station is for backup in the event the other pump fails. The pipeline, approximately 22.1 miles long, would primarily follow FM 307, IH-20, and SH 80, and would be a 4-inch line that discharges to a new storage tank in the Greenwood Ventures PWS. The required pump horsepower would be 7.5 hp.

This alternative presents a limited regional solution, since other PWSs in the area also need compliant water. Some regionalization could be accomplished by sharing the cost of drilling the well and possibly constructing the pipeline and pump station with other non-compliant PWSs in the area.

The estimated capital cost for this alternative includes constructing a new well and small ground storage tank, a pump station with two transfer pumps, a pipeline, and storage tank with feed pump set for the Greenwood Ventures PWS. The estimated O&M cost for this alternative are related to maintenance costs for the pipeline and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $5.13 million, and the estimated annual O&M cost for this alternative is $35,607.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of the Greenwood Ventures PWS, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pumps stations are well understood, and Greenwood Ventures PWS currently operates pumps and a well.

The feasibility of this alternative is dependent on finding a suitable well site.

4.5.5 Alternative GVI-5: Purchase Treated Water from the City of Odessa

This alternative involves purchasing treated surface water from the City of Odessa, which will be used to supply the Greenwood Ventures PWS. The City of Odessa currently has sufficient excess capacity for this alternative to be feasible and has indicated it would be amenable to negotiating an agreement to supply water to PWSs in the area. Records indicate the City of Odessa water has low levels of nitrate (less than 1 mg/L) and arsenic (less than 0.004 mg/L), which is low enough to make blending a realistic consideration. However, for this alternative, it is assumed the Greenwood Ventures PWS would obtain all its water from the City of Odessa.

This alternative would require constructing a pipeline from the City of Odessa water main to a new storage tank and feed pump set for the Greenwood Ventures PWS. Two pump stations would also be required to overcome pipe friction and the elevation differences between Odessa and the Greenwood Ventures PWS. The 4-inch pipeline would primarily follow FM 307, IH-20, SH 80, Faudree Road, and Yukon Road, and would be approximately 34.8 miles long. The required pump horsepower would be 4 hp.

Each of the two pump stations would include two pumps, including one standby, and would be housed in a building. A tank would also be constructed for the pumps to draw from. It is assumed the pumps and piping would be installed with capacity to meet all water demand for the Greenwood Ventures PWS, since the incremental cost would be relatively small, and it would provide operational flexibility.

This alternative involves regionalization by definition, since Greenwood Ventures PWS would be obtaining drinking water from an existing larger supplier. It is possible that the Greenwood Ventures PWS could turn over provision of drinking water to the City of Odessa instead of purchasing water. Also, other PWSs near the Greenwood Ventures PWS 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, two pump stations, and storage tank and feed pump set. 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 Greenwood Ventures PWS well, plus maintenance cost for the pipeline, and power and O&M labor and materials for the two pump stations. The estimated capital cost for this alternative is $7.88 million, and the alternative's estimated annual O&M cost is $37,336.

The reliability of adequate amounts of compliant water under this alternative should be good. City of Odessa provides treated surface water on a large scale, facilitating adequate O&M resources. From the perspective of the Greenwood Ventures PWS, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations 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 Odessa to purchase treated drinking water.

4.5.6 Alternative GVI-6: New Well at Greenwood Ventures PWS

This alternative involves completing a new, deeper well at Greenwood Ventures PWS that would be screened in the Edwards Trinity aquifer, and tying it into the existing water system. The new well would be 140 feet deep. There are limited data available regarding water quality in the Edwards Trinity aquifer in this area, so further investigation would be necessary.

The estimated capital cost for this alternative includes completing the new well and constructing the connection piping to the existing treatment system. The estimated O&M cost for this alternative includes O&M costs for the new well (labor, power, and materials) minus O&M cost for operating the existing well. The estimated capital cost for this alternative is $48,445, and there is no annual O&M cost for this alternative.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of the Greenwood Ventures PWS, this alternative would be characterized as easy to operate and repair, since O&M and repair of the current system is well understood, and Greenwood Ventures PWS currently operates it. If the decision were made to perform blending then the operational complexity would increase.

Greenwood Ventures Inc. owns and operates the water system, so obtaining the necessary agreements to implement this option should not impact the feasibility of this alternative.

4.5.7 Alternative GVI-7: New Well at 10 miles

This alternative consists of installing a new well within 10 miles of the Greenwood Ventures PWS that would produce compliant water in place of water produced by the existing active well. 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. To address a range of solutions, three different well alternatives are developed, assuming the new well is located within 10 miles, 5 miles, and 1 mile from the existing intake point.

This alternative would require constructing a new 110-foot well, a new pump station with storage tank near the new well, and a pipeline from the new well/tank to a new storage tank and feed pump set for the Greenwood Ventures PWS. The pump station and storage tank would be necessary to overcome pipe friction and changes in land elevation. For this alternative, the pipeline is assumed to be approximately 10 miles long, and would be a 4-inch line that discharges to the new storage tank at Greenwood Ventures PWS. The pump station would include two 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 one or more nearby systems.

The estimated capital cost for this alternative includes installing the well and constructing the pipeline, pump station, and feed tank and pump set. The estimated O&M cost for this alternative includes the cost for O&M for the pipeline and pump station. The estimated capital cost for this alternative is $2.36 million, and the estimated annual O&M cost for this alternative is $33,151.

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 the Greenwood PWS Ventures, this alternative would be similar to the existing system in terms of operation. Greenwood Ventures PWS has experience with O&M of wells and pumps.

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 controlled by Greenwood Ventures Inc., so landowner cooperation would be required.

4.5.8 Alternative GVI-8: New Well at 5 miles

This alternative consists of installing a new well within 5 miles that would produce compliant water in place of the water produced by the Greenwood PWS Ventures well. 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 a new 110-foot well, a new pump station with storage tank near the new well, and a pipeline from the new well/tank to a new storage tank and feed pump set for the Greenwood Ventures PWS. The pump station and storage 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 line that discharges to the new storage tank at Greenwood Ventures PWS. The pump station would include two 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 one or more nearby systems.

The estimated capital cost for this alternative includes installing the well, and constructing the pipeline, pump station, and feed tank and pump set. The estimated O&M cost for this alternative includes the cost for O&M for the pipeline and pump station. The estimated capital cost for this alternative is $1.39 million, and the estimated annual O&M cost for this alternative is $32,090.

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 the Greenwood Ventures PWS, this alternative would be similar in terms of operation as the existing system. Greenwood Ventures PWS has experience with O&M of wells and pumps.

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 controlled by Greenwood Ventures Inc., so landowner cooperation would be required.

4.5.9 Alternative GVI-9: New Well at 1 mile

This alternative consists of installing a new well within 1 mile that would produce compliant water in place of the water produced by the existing well. 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 a new 110-foot well, and a pipeline from the new well to a new water storage tank and feed pump set for the Greenwood Ventures PWS. For this alternative, the pipeline is assumed to be approximately 1 mile long, and would be a 4-inch line that discharges to the new storage tank at the Greenwood Ventures PWS.

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 cost to install the well, storage tank, and construct the pipeline. The estimated O&M cost for this alternative includes the cost for O&M for the pipeline and storage tank. The estimated capital cost for this alternative is $330,902, and the estimated annual O&M cost for this alternative is $1,201.

The reliability of adequate amounts of compliant water under this alternative should be good, since water wells and pipelines are commonly employed. From the perspective of the Greenwood Ventures PWS, this alternative would be similar in terms of operation compared to the existing system. Greenwood Ventures PWS has experience with O&M of wells.

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 that an alternate groundwater source would not be found on land controlled by Greenwood Ventures Inc., so landowner cooperation may be required.

4.5.10 Alternative GVI-10: Central RO Treatment

This system would continue to pump water from the Greenwood Ventures PWS well field, and would treat the water through an RO system prior to distribution. Because of the high TDSs and the variety of contaminants in the groundwater, the RO system would treat all the raw water. The RO process concentrates impurities in the reject stream which would require disposal. It is estimated that the RO reject generation would be 10,000 gallons per day when the system is operated at full flow. This treatment would also be effective for removing TDSs.

This alternative consists of constructing the RO treatment plant near the existing Greenwood Ventures PWS service pumps. The plant is composed of a 500 square foot building with a paved driveway; a feed water tank, a skid with the pre-constructed RO plant; four transfer pumps, a 20,000-gallon tank for storing the treated water, and a 260,000-gallon pond for storing reject water. The treated water would be chlorinated and stored in the new treated water tank prior to being pumped into the six existing pressure tanks and into the distribution system. The entire facility is fenced. The capital cost includes purchase of a water truck-trailer to periodically haul reject water for disposal. The accumulated radioactivity level of the RO reject water is not expected to cause any significant problem for disposal.

The estimated capital cost for this alternative is $648,644, and the estimated annual O&M cost is $39,767.

The reliability of adequate amounts 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.

4.5.11 Alternative GVI-11: Point-of-Use Treatment

This alternative consists of the continued operation of the existing active Greenwood Ventures PWS well, plus treatment of water to be used for drinking or food preparation at the POU to remove nitrate, arsenic, and uranium. 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. Reverse osmosis POU treatment units would also be effective for reducing other potential contaminants such as TDS and sulfate.

This alternative would require installing the POU treatment units in dwellings and other buildings that provide drinking or cooking water. The Greenwood Ventures PWS would be responsible for purchasing and maintaining the treatment units, including membrane and filter replacement, periodic sampling, and necessary repairs. In residences, the most convenient point for installing treatment units is typically under the kitchen sink, with a separate tap installed for dispensing treated water. Installation of the treatment units in kitchens would require entry by Greenwood Ventures PWS or contract personnel into residences of customers. As a result, the cooperation of customers would be important for success in implementing this alternative. The treatment units could be installed so access could be made without entry into the residence, which would complicate the installation and increase costs.

POU RO treatment processes typically produce liquid waste streams that are equal in volume to the treated water and require disposal. These waste streams result in an increased 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 that the increase in water consumption is insignificant in terms of supply cost and that the waste stream can be recovered for reuse or discharged to the house sewer or septic 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 purchasing and replacing filters and membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $13,860, and the estimated annual O&M cost for this alternative is $13,616. For the cost estimate, it is assumed that one POU treatment unit would be required for each of the 21 existing connections to the Greenwood Ventures PWS. 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.

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 a single tap within a house. Additionally, the O&M efforts required for the POU systems will be significant, and Greenwood Ventures PWS personnel are inexperienced in this type of work. From the perspective of Greenwood

Ventures PWS, this alternative would be characterized as more difficult to operate due to the in-home requirements.

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

4.5.12 Alternative GVI-12: Point-of-Entry Treatment

This alternative consists of the continued operation of the existing active Greenwood Ventures PWS well, plus treatment of water to remove nitrate, arsenic, and uranium as it enters the residence. The purchase, installation, and maintenance of the treatment systems at the POE would be necessary for this alternative. Blending is not an option in this case. Reverse osmosis POE treatment units would also be effective for reducing other potential contaminants such as TDSs and sulfate.

This alternative would require installing the POE treatment units at dwellings and other buildings that provide water for drinking or cooking. Greenwood Ventures PWS would be responsible for purchasing and maintaining the treatment units, including membrane and filter replacement, periodic sampling, and necessary repairs. The plumbing in houses should be investigated to ensure that the aggressive water that would result from RO treatment would not cause damage. It may also be desirable to modify piping so that water for non-consumptive uses could be withdrawn upstream of the treatment unit. The POE treatment units would be installed outside the residence, so entry would not be necessary for O&M. Some cooperation from customers would be necessary for installation and maintenance of the treatment systems.

POE RO treatment processes typically produce liquid waste streams that are equal in volume to the treated water and require disposal. These waste streams result in an increased overall volume of water used. Point-of-entry systems treat a greater volume of water than POU systems. For this alternative, it is assumed that the increase in water consumption is insignificant in terms of supply cost and that the waste stream can be recovered for reuse or discharged to the house sewer or septic 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 purchasing and replacing filters and membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $242,550, and the estimated annual O&M cost for this alternative is $29,891. For the cost estimate, it is assumed that one POE treatment unit would be required for each of the 21 existing connections to the Greenwood Ventures PWS.

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 customers for system installation, use, and maintenance, and compliant water is supplied to all taps within a residence. Additionally, the O&M efforts required for the POE systems would be significant, and Greenwood Ventures PWS personnel are inexperienced in this type of work. From the perspective of Greenwood Ventures PWS, this alternative would be characterized as more difficult to operate due to the on-property requirements.

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

4.5.13 Alternative GVI-13: Public Dispenser for Treated Drinking Water

This alternative consists of the continued operation of the existing active Greenwood Ventures PWS well, 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 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.

Greenwood Ventures PWS would be responsible for maintenance of the treatment unit, including membrane and filter replacement, periodic sampling, and necessary repairs. A method for disposal of the reject waste stream produced by the treatment system will have to be found. This alternative relies on a great deal of cooperation and action from the customers 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 $11,600, and the estimated annual O&M cost for this alternative is $17,504.

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. Greenwood Ventures PWS has not provided this type of service in the past. From the perspective of Greenwood Ventures PWS, this alternative would be characterized as relatively easy to operate, since these types of treatment units are highly automated, and there is only one unit.

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

4.5.14 Alternative GVI-14: 100 Percent Bottled Water Delivery

This alternative consists of the continued operation of the existing active Greenwood Ventures PWS well, 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 Greenwood Ventures PWS would find it convenient and economical to contract a bottled water service. The bottle delivery program would have to be flexible enough to allow for 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 Greenwood Ventures 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 initial cost for this alternative is $25,807, and the estimated annual O&M cost for this alternative is $54,330. 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 Greenwood Ventures PWS.

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

4.5.15 Alternative GVI-15: Public Dispenser for Trucked Drinking Water

This alternative consists of continued operation of the existing active Greenwood PWS Ventures well, plus dispensing compliant water for drinking and cooking at a publicly accessible location. The compliant water would be purchased from a nearby system with compliant drinking water, 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 compliant water is required, 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.

Greenwood Ventures PWS 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. This alternative relies on 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 constructing the storage tank to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes the contract water delivery service, maintenance for the tank, water quality testing, and record keeping. The estimated capital cost for this alternative is $102,986, and the estimated annual O&M cost for this alternative is $16,883.

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. Greenwood Ventures PWS has not provided this type of service in the past. From the perspective of Greenwood Ventures PWS, 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.

4.5.16 Summary of Alternatives

Table 4.3 provides a summary of the key features of each alternative for the Greenwood Ventures PWS.

1 **Table 4.3 Summary of compliance Alternative for Greenwood Ventures Public Water System**

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
GVI-1	Purchase treated water from the City of Stanton	- Storage Tank - Pump station - 11.8-mile pipeline	$2,623,527	$28,720	$257,451	good	N	Agreement must be successfully negotiated with the City of Stanton. Blending may be possible. Costs could be shared with other nearby small systems.
GVI-2	New Well at Circle Six Ranch Baptist Camp	- New well - Storage Tank - Pump station - 19.2-mile pipeline	$4,194,225	$35,036	$400,708	Good	N	Agreement must be successfully negotiated with Circle Six Ranch Baptist Camp, or land must be purchased. Blending not possible. Costs could be shared with other nearby small systems.
GVI-3	Purchase treated water from the City of Midland	- Storage Tank - Pump station - 3-mile pipeline	$2,119,914	$28,261	$213,085	Good	N	Agreement must be successfully negotiated with the City of Midland. City currently requires annexation before it will do this. Blending may be possible.
GVI-4	New Well at Midland International Airport	- New well - Storage Tank - Pump station - 22.1-mile pipeline	$5,134,568	$35,607	$483,262	Good	N	Agreement must be successfully negotiated with Midland International Airport, or land must be purchased. Blending not possible. Costs could be shared with other nearby small systems.
GVI-5	Purchase treated water from the City of Odessa	- Storage Tank - Pump station - 34.8-mile pipeline	$7,881,386	$37,336	$724,472	Good	N	Agreement must be successfully negotiated with the City of Midland. Blending may be possible. Costs could be shared with other nearby small systems.
GVI-6	Install new compliant well at Greenwood Ventures PWS	- New well - Storage tank - Pump station	$48,445	$0	$4,224	Good	N	Investigation required to verify presence of compliant groundwater. Costs could be shared with other nearby small systems.
GVI-7	Install new compliant well within 10 miles	- New well - Storage tank - Pump station - 10-mile pipeline	$2,364,878	$33,151	$239,332	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.
GVI-8	Install new compliant well within 5 miles	- New well - Storage tank - Pump station - 5-mile pipeline	$1,389,586	$32,090	$153,241	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.
GVI-9	Install new compliant well within 1 mile	- New well - Storage tank - Pump station - 1-mile pipeline	$330,902	$1,201	$30,050	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.
GVI-10	Continue operation of current well field with central RO treatment	- Central RO treatment plant	$648,644	$39,767	$96,319	Good	T	Costs could possibly be shared with other nearby small systems.
GVI-11	Continue operation of current well field with POU treatment	- POU treatment units	$13,860	$13,616	$14,825	Fair	T, M	Only one compliant tap in home. Cooperation of residents required for installation, maintenance, and testing.
GVI-12	Continue operation of	- POE treatment units	$242,550	$29,891	$51,038	Fair	T, M	All home taps compliant and less resident

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
	current well field with POE treatment					(*better than POU*)		cooperation required.
GVI-13	Continue operation of current well field, but furnish public dispenser for treated drinking water	- Water treatment and dispenser unit	$11,600	$17,504	$18,515	Fair/interim measure	T	Does not provide compliant water to all taps, and requires a lot of effort by customers.
GVI-14	Continue operation of current well field, but furnish bottled drinking water for all customers	- Set up bottled water system	$25,807	$54,330	$56,580	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.
GVI-15	Continue operation of current well field, but furnish public dispenser for trucked drinking water.	- Construct storage tank and dispenser - Purchase potable water truck	$102,986	$16,883	$25,862	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 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.

Greenwood Ventures owns and operates a convenience store, a mobile home park, as well as its water supply system. The cost of water supply and service are included in the monthly lot rental fee. Separate financial records are not kept for O&M of the water system. Without tracking the revenues and expenses for the PWS, it is not possible to know if the money generated from the lot rental fees is sufficient to cover the cost of current O&M and compliance with the nitrate, arsenic, and uranium MCLs. This information was not available to complete the financial analysis.

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.

4.6.1 Greenwood Venture Financial Data

No separate financial data are maintained by the system operator for the Greenwood Ventures water system. Financial information on the water system is included in the consolidated financial data for the mobile home park and associated convenience store. Water usage does not constitute a separate monthly billing, but is included in the monthly rent for the mobile home pads. Other mobile home park facilities estimated their water usage per connection at approximately $15/month, or approximately 10 percent of monthly pad rental. Accordingly, this value was used in the financial model as the basic monthly charge for unlimited water usage with no additional rate structure tiers. No financial data for system expenditures for the Greenwood Ventures PWS were available.

4.6.2 Current Financial Condition

4.6.2.1 Cash Flow Needs

Based on estimates provided by the system operator, the current average annual water use by residential customers of Greenwood Ventures is estimated to be $180, or less than 1.0 percent of the Midland County MHI of $39,082, and also less than 1.0 percent of the MHI ($36,929) for the ZIP code block for the Greenwood PWS. Because of the lack of separate financial data exclusively for the water system, it is difficult to determine exact cash flow needs. However, it is anticipated that water usage revenues fall considerably short of expenditures with the system being subsidized by other revenues.

4.6.2.2 Ratio Analysis

Current Ratio

The Current Ratio for the Greenwood Ventures PWS could not be determined due to lack of necessary financial data to determine this ratio.

Debt to Net Worth Ratio

A Debt-to-Net-Worth Ratio also could not be determined owing to lack of the necessary financial data to determine this ratio.

Operating Ratio

Because of the lack of complete separate financial data on expenses specifically related to the Greenwood Ventures PWS, the Operating Ratio could not be accurately determined. However, based on expenditure estimates by the similar mobile home system operators, the Greenwood Venture system's estimated operating expenditures more than likely exceed the operating revenues.

4.6.3 Financial Plan Results

Each compliance alternative for the Greenwood PWS 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 Subsection 2.4.

For State Revolving Fund funding options, customer MHI compared to the state average determines the availability of subsidized loans. According to 2000 U.S. Census data, Midland County, where the Greenwood PWS is located, had an annual MHI of $39,082 or 98 percent of the statewide MHI of $39,927, and 93 percent of the MHI ($36,929) for the PWS ZIP code block for the Greenwood PWS. Since county incomes are in excess of 75 percent of the state average, Greenwood Ventures would not qualify for any discount to the interest rate of 3.8 percent. In the event SRFs are unavailable, a second funding option would be Revenue Bonds at an annual interest of 6 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 (2,250 gallons/month 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).

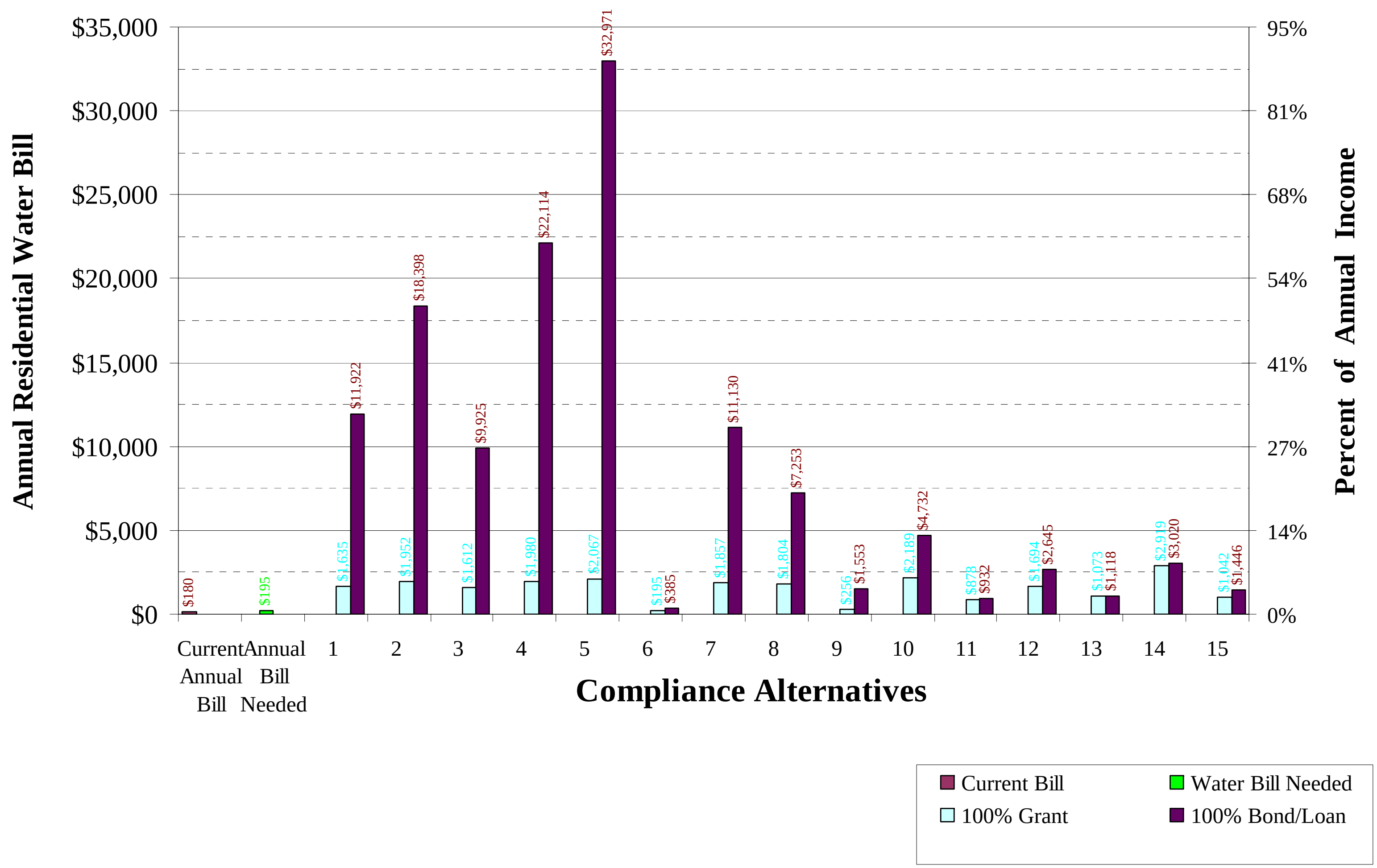
The two bars shown for each compliance alternative represent the rate changes necessary for revenues to match total expenditures assuming 100 percent grant funding and 100 percent loan/bond funding. Most funding options will fall between 100 percent grant and 100 percent loan/bond funding, with the exception 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 Financial Impact on Households

Alternative	Description		All Revenue	100% Grant	75% Grant	50% Grant	SRF	Bond
1	Purchase Water from City of Stanton	Max % of HH Income	362%	10%	24%	38%	59%	66%
		Max % Rate Increase Compared to Current	44428%	1128%	2843%	4558%	7158%	7987%
		Average Water Bill Required by Alternative	$ 124,921	$ 3,299	$ 8,028	$ 12,757	$ 19,930	$ 22,214
2	New Well at Circle Six Ranch Baptist Camp Inc.	Max % of HH Income	576%	12%	34%	57%	90%	101%
		Max % Rate Increase Compared to Current	70795%	1375%	4116%	6857%	11015%	12339%
		Average Water Bill Required by Alternative	$ 198,907	$ 3,954	$ 11,514	$ 19,074	$ 30,542	$ 34,194
3	Purchase Water from City of Midland	Max % of HH Income	293%	10%	21%	32%	49%	55%
		Max % Rate Increase Compared to Current	36004%	1111%	2496%	3881%	5983%	6652%
		Average Water Bill Required by Alternative	$ 101,281	$ 3,251	$ 7,072	$ 10,893	$ 16,690	$ 18,536
4	New Well at Midland International Airport	Max % of HH Income	704%	12%	39%	67%	108%	121%
		Max % Rate Increase Compared to Current	86518%	1397%	4753%	8108%	13198%	14819%
		Average Water Bill Required by Alternative	$ 243,031	$ 4,014	$ 13,268	$ 22,523	$ 36,562	$ 41,033
5	Purchase Water from City of Odessa	Max % of HH Income	1077%	13%	55%	96%	160%	180%
		Max % Rate Increase Compared to Current	132447%	1464%	6615%	11766%	19579%	22067%
		Average Water Bill Required by Alternative	$ 371,924	$ 4,193	$ 18,399	$ 32,605	$ 54,154	$ 61,016
6	New Well at GVI	Max % of HH Income	8%	1%	1%	2%	2%	2%
		Max % Rate Increase Compared to Current	843%	33%	65%	96%	144%	160%
		Average Water Bill Required by Alternative	$ 2,655	$ 383	$ 470	$ 558	$ 690	$ 732
7	New Well at 10 Miles	Max % of HH Income	327%	11%	24%	36%	56%	62%
		Max % Rate Increase Compared to Current	40193%	1301%	2847%	4392%	6737%	7483%
		Average Water Bill Required by Alternative	$ 113,026	$ 3,759	$ 8,021	$ 12,284	$ 18,750	$ 20,809
8	New Well at 5 Miles	Max % of HH Income	195%	11%	18%	26%	37%	41%
		Max % Rate Increase Compared to Current	23876%	1260%	2168%	3076%	4454%	4892%
		Average Water Bill Required by Alternative	$ 67,238	$ 3,649	$ 6,153	$ 8,658	$ 12,457	$ 13,667
9	New Well at 1 Mile	Max % of HH Income	46%	1%	3%	5%	7%	8%
		Max % Rate Increase Compared to Current	5585%	57%	273%	489%	817%	922%
		Average Water Bill Required by Alternative	$ 15,963	$ 446	$ 1,043	$ 1,639	$ 2,544	$ 2,832
10	Central Treatment - RO	Max % of HH Income	95%	13%	17%	20%	26%	27%
		Max % Rate Increase Compared to Current	11646%	1559%	1983%	2407%	3050%	3255%
		Average Water Bill Required by Alternative	$ 32,899	$ 4,445	$ 5,614	$ 6,783	$ 8,557	$ 9,122
11	Point-of-Use Treatment	Max % of HH Income	5%	5%	5%	5%	5%	5%
		Max % Rate Increase Compared to Current	540%	540%	549%	558%	571%	576%
		Average Water Bill Required by Alternative	$ 1,777	$ 1,732	$ 1,757	$ 1,782	$ 1,820	$ 1,832
12	Point-of-Entry Treatment	Max % of HH Income	39%	10%	12%	13%	15%	16%
		Max % Rate Increase Compared to Current	4668%	1174%	1333%	1491%	1732%	1808%
		Average Water Bill Required by Alternative	$ 13,335	$ 3,420	$ 3,858	$ 4,295	$ 4,958	$ 5,169
13	Public Dispenser for Treated Drinking Water	Max % of HH Income	6%	6%	6%	7%	7%	7%
		Max % Rate Increase Compared to Current	691%	691%	699%	706%	718%	721%
		Average Water Bill Required by Alternative	$ 2,173	$ 2,135	$ 2,156	$ 2,177	$ 2,209	$ 2,219
14	Supply Bottled Water to 100% of Population	Max % of HH Income	18%	18%	18%	18%	19%	19%
		Max % Rate Increase Compared to Current	2127%	2127%	2144%	2161%	2186%	2194%
		Average Water Bill Required by Alternative	$ 6,040	$ 5,956	$ 6,003	$ 6,049	$ 6,120	$ 6,142
15	Central Trucked Drinking Water	Max % of HH Income	18%	6%	7%	7%	8%	8%
		Max % Rate Increase Compared to Current	2083%	667%	734%	802%	904%	936%
		Average Water Bill Required by Alternative	$ 6,104	$ 2,071	$ 2,256	$ 2,442	$ 2,724	$ 2,813

1

Figure 4-2 Alternative Cost Summary



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

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 2006 RS Means Building Construction 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 gate valves and flush valves would be installed, on average, every 5,000 feet along the pipeline. Pipeline cost estimates are based on 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. Construction cost of a storage tank is based on 2006 RS Means Building Construction Cost Data.

Labor costs are estimated based on RS Means Building Construction Data specific to each region.

Electrical power cost is estimated to be $0.128 per kiloWatt hours (kWH). 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 2006 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* (1978). Costs from the 1978 report are adjusted to 2006 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 2006 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 R.S. Means Construction 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. It is assumed that new wells located more than 1 mile from the intake point of an existing system would require at least one storage tank and pump station.

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.

References:

USEPA 1978. Technical Report, *Innovative and Alternate Technology Assessment Manual* MCD 53

USEPA. 1992. Standardized Costs for Water Supply Distribution Systems. EPA/600/R-92/009.

Table B.1
Summary of General Data
Greenwood Ventures Inc.
PWS #1650006
General PWS Information

Service Population	50	**Number of Connections**	21
Total PWS Daily Water Usage	0.004 (mgd)	**Source**	Calculated using assumed

Unit Cost Data
West Texas

General Items	**Unit**	**Unit Cost**
Treated water purchase cost	*See alternative*	
Water purchase cost (trucked)	$/1,000 gals	$ 1.80
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	$ 60
Open cut and encasement, 10"	LF	$ 30
Gate valve and box, 04"	EA	$ 340
Air valve	EA	$ 1,000
Flush valve	EA	$ 750
Metal detectable tape	LF	$ 0.15
Bore and encasement, length	Feet	200
Open cut and encasement, length	Feet	50
Pump Station Unit Costs	**Unit**	**Unit Cost**
Pump	EA	$ 7,500
Pump Station Piping, 04"	EA	$ 4,000
Gate valve, 04"	EA	$ 370
Check valve, 04"	EA	$ 430
Electrical/Instrumentation	EA	$ 10,000
Site work	EA	$ 2,000
Building pad	EA	$ 4,000
Pump Building	EA	$ 10,000
Fence	EA	$ 5,870
Tools	EA	$ 1,000
Well Installation Unit Costs	**Unit**	**Unit Cost**
Well installation	*See alternative*	
Water quality testing	EA	$ 1,500
Well pump	EA	$ 7,500
Well electrical/instrumentation	EA	$ 5,000
Well cover and base	EA	$ 3,000
Piping	EA	$ 2,500
Storage Tank - 5,000 gals	EA	$ 7,025
Electrical Power	$/kWH	$ 0.128
Building Power	kWH	11,800
Labor	$/hr	$ 32
Materials	EA	$ 1,200
Transmission main O&M	$/mile	$ 200
Tank O&M	EA	$ 1,000
POU/POE Unit Costs		
POU treatment unit purchase	EA	$ 250
POU treatment unit installation	EA	$ 150
POE treatment unit purchase	EA	$ 3,000
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	$ 1,000
Contaminant analysis	$/year	$ 100
POU/POE labor support	$/hr	$ 32
Dispenser/Bottled Water Unit Costs		
Treatment unit purchase	EA	$ 3,000
Treatment unit installation	EA	$ 5,000
Treatment unit O&M	EA	$ 500
Administrative labor	hr	$ 43
Bottled water cost (inc. delivery)	gallon	$ 1.60
Water use, per capita per day	gpcd	1.0
Bottled water program materials	EA	$ 5,000
Storage Tank - 5,000 gals	EA	$ 7,025
Site improvements	EA	$ 4,000
Potable water truck	EA	$ 60,000
Water analysis, per sample	EA	$ 100
Potable water truck O&M costs	$/mile	$ 1.00

Central Treatment Unit Costs	**Unit**	**Unit Cost**
General		
Site preparation	acre	$ 4,000
Slab	CY	$ 1,000
Building	SF	$ 60
Building electrical	SF	$ 8.00
Building plumbing	SF	$ 8.00
Heating and ventilation	SF	$ 7.00
Fence	LF	$ 15
Paving	SF	$ 2.00
Reject pond, excavation	CYD	$ 3
Reject pond, compacted fill	CYD	$ 7
Reject pond, lining	SF	$ 0.50
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/yr	$ 0.128
Equipment power	kwh/yr	$ 0.128
Labor, O&M	hr	$ 40
Analyses	test	$ 200
Reverse Osmosis		
Electrical	JOB	$ 50,000
Piping	JOB	$ 20,000
RO package plant	UNIT	$ 80,000
Transfer pumps (5 hp)	EA	$ 5,000
Permeate tank	gal	$ 3
RO materials	year	$ 2,000
RO chemicals	year	$ 1,500
Backwash disposal mileage cost	miles	$ 1.00
Backwash disposal fee	1,000 gal/yr	$ 5.00

Appendix C
Compliance Alternative Conceptual Cost Estimates

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.15. 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	***Greenwood Ventures Inc.***
Alternative Name	***Purchase Water from City of Stanton***
Alternative Number	***GVI-1***

Distance from Alternative to PWS (along pipe)	11.8	miles
Total PWS annual water usage	1.369	MG
Treated water purchase cost	$ 1.65	per 1,000 gals
Number of Pump Stations Needed	1	
Number of feed tanks/pump sets needed	1	

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"	62,324	LF	$ 26.00	$ 1,620,424
Bore and encasement, 10"	200	LF	$ 60.00	$ 12,000
Open cut and encasement, 10"	650	LF	$ 30.00	$ 19,500
Gate valve and box, 04"	12	EA	$ 340.00	$ 4,238
Air valve	12	EA	$ 1,000.00	$ 12,000
Flush valve	12	EA	$ 750.00	$ 9,349
Metal detectable tape	62,324	LF	$ 0.15	$ 9,349
Subtotal				**$ 1,686,859**
Pump Station(s) Installation				
Pump, 3hp	4	EA	$ 7,500	$ 30,000
Pump Station Piping, 04"	2	EA	$ 4,000	$ 8,000
Gate valve, 04"	8	EA	$ 370	$ 2,960
Check valve, 04"	4	EA	$ 430	$ 1,720
Electrical/Instrumentation	2	EA	$ 10,000	$ 20,000
Site work	2	EA	$ 2,000	$ 4,000
Building pad	2	EA	$ 4,000	$ 8,000
Pump Building	2	EA	$ 10,000	$ 20,000
Fence	2	EA	$ 5,870	$ 11,740
Tools	2	EA	$ 1,000	$ 2,000
Storage Tank - 5,000 gals	2	EA	$ 7,025	$ 14,050
Subtotal				**$ 122,470**
Subtotal of Component Costs				**$ 1,809,329**
Contingency	20%			$ 361,866
Design & Constr Management	25%			$ 452,332
TOTAL CAPITAL COSTS				**$ 2,623,527**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	11.8	mile	$ 200	$ 2,361
Subtotal				**$ 2,361**
Water Purchase Cost				
From City of Stanton	1,369	1,000 gal	$ 1.65	$ 2,258
Subtotal				**$ 2,258**
Pump Station(s) O&M				
Building Power	23,600	kWH	$ 0.128	$ 3,021
Pump Power	771	kWH	$ 0.128	$ 99
Materials	2	EA	$ 1,200	$ 2,400
Labor	730	Hrs	$ 32	$ 23,608
Tank O&M	2	EA	$ 1,000	$ 2,000
Subtotal				**$ 31,128**
O&M Credit for Existing Well Closure				
Pump power	47	kWH	$ 0.128	$ (6)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 32	$ (5,821)
Subtotal				**$ (7,027)**
TOTAL ANNUAL O&M COSTS				**$ 28,720**

Table C.2

PWS Name *Greenwood Ventures Inc.*
Alternative Name *New Well at Circle Six Ranch Baptist Camp Inc.*
Alternative Number *GVI-2*

Distance from PWS to new well location	19.21	miles
Estimated well depth	110	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	
Number of feed tanks/pump sets needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	2	n/a	n/a	n/a
Number of Crossings, open cut	19	n/a	n/a	n/a
PVC water line, Class 200, 04"	101,443	LF	$ 26.00	$ 2,637,518
Bore and encasement, 10"	400	LF	$ 60.00	$ 24,000
Open cut and encasement, 10"	950	LF	$ 30.00	$ 28,500
Gate valve and box, 04"	20	EA	$ 340.00	$ 6,898
Air valve	19	EA	$ 1,000.00	$ 19,000
Flush valve	20	EA	$ 750.00	$ 15,216
Metal detectable tape	101,443	LF	$ 0.15	$ 15,216
Subtotal				**$ 2,746,349**
Pump Station(s) Installation				
Pump	4	EA	$ 7,500	$ 30,000
Pump Station Piping, 04"	2	EA	$ 4,000	$ 8,000
Gate valve, 04"	8	EA	$ 370	$ 2,960
Check valve, 04"	4	EA	$ 430	$ 1,720
Electrical/Instrumentation	2	EA	$ 10,000	$ 20,000
Site work	2	EA	$ 2,000	$ 4,000
Building pad	2	EA	$ 4,000	$ 8,000
Pump Building	2	EA	$ 10,000	$ 20,000
Fence	2	EA	$ 5,870	$ 11,740
Tools	2	EA	$ 1,000	$ 2,000
Storage Tank - 5,000 gals	2	EA	$ 7,025	$ 14,050
Subtotal				**$ 122,470**
Well Installation				
Well installation	110	LF	$ 25	$ 2,750
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 23,750**
Subtotal of Component Costs				**$ 2,892,569**
Contingency	20%			$ 578,514
Design & Constr Management	25%			$ 723,142
TOTAL CAPITAL COSTS				**$ 4,194,225**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	19.2	mile	$ 200	$ 3,843
Subtotal				**$ 3,843**
Pump Station(s) O&M				
Building Power	23,600	kWH	$ 0.128	$ 3,021
Pump Power	1,280	kWH	$ 0.128	$ 164
Materials	2	EA	$ 1,200	$ 2,400
Labor	730	Hrs	$ 32	$ 23,608
Tank O&M	2	EA	$ 1,000	$ 2,000
Subtotal				**$ 31,193**
Well O&M				
Pump power	53	kWH	$ 0.128	$ 7
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 32	$ 5,821
Subtotal				**$ 7,028**
O&M Credit for Existing Well Closure				
Pump power	47	kWH	$ 0.128	$ (6)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 32	$ (5,821)
Subtotal				**$ (7,027)**
TOTAL ANNUAL O&M COSTS				**$ 35,036**

Table C.3

PWS Name *Greenwood Ventures Inc.*
Alternative Name *Purchase Water from City of Midland*
Alternative Number *GVI-3*

Distance from Alternative to PWS (along pipe)	9.3	miles
Total PWS annual water usage	1.369	MG
Treated water purchase cost	$ 1.65	per 1,000 gals
Number of Pump Stations Needed	1	
Number of feed tanks/pump sets needed	1	

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	15	n/a	n/a	n/a
PVC water line, Class 200, 04"	49,152	LF	$ 26.00	$ 1,277,952
Bore and encasement, 10"	200	LF	$ 60.00	$ 12,000
Open cut and encasement, 10"	750	LF	$ 30.00	$ 22,500
Gate valve and box, 04"	10	EA	$ 340.00	$ 3,342
Air valve	9	EA	$ 1,000.00	$ 9,000
Flush valve	10	EA	$ 750.00	$ 7,373
Metal detectable tape	49,152	LF	$ 0.15	$ 7,373
Subtotal				**$ 1,339,540**
Pump Station(s) Installation				
Pump, 5 hp	4	EA	$ 7,500	$ 30,000
Pump Station Piping, 04"	2	EA	$ 4,000	$ 8,000
Gate valve, 04"	8	EA	$ 370	$ 2,960
Check valve, 04"	4	EA	$ 430	$ 1,720
Electrical/Instrumentation	2	EA	$ 10,000	$ 20,000
Site work	2	EA	$ 2,000	$ 4,000
Building pad	2	EA	$ 4,000	$ 8,000
Pump Building	2	EA	$ 10,000	$ 20,000
Fence	2	EA	$ 5,870	$ 11,740
Tools	2	EA	$ 1,000	$ 2,000
Storage Tank - 5,000 gals	2	EA	$ 7,025	$ 14,050
Subtotal				**$ 122,470**
Subtotal of Component Costs				**$ 1,462,010**
Contingency	20%			$ 292,402
Design & Constr Management	25%			$ 365,502
TOTAL CAPITAL COSTS				**$ 2,119,914**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	9.3	mile	$ 200	$ 1,862
Subtotal				**$ 1,862**
Water Purchase Cost				
City of Midland	1,369	1,000 gal	$ 1.65	$ 2,258
Subtotal				**$ 2,258**
Pump Station(s) O&M				
Building Power	23,600	kWH	$ 0.128	$ 3,021
Pump Power	1,084	kWH	$ 0.128	$ 139
Materials	2	EA	$ 1,200	$ 2,400
Labor	730	Hrs	$ 32	$ 23,608
Tank O&M	2	EA	$ 1,000	$ 2,000
Subtotal				**$ 31,168**
O&M Credit for Existing Well Closure				
Pump power	47	kWH	$ 0.128	$ (6)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 32	$ (5,821)
Subtotal				**$ (7,027)**
TOTAL ANNUAL O&M COSTS				**$ 28,261**

Table C.4

PWS Name ***Greenwood Ventures Inc.***
Alternative Name ***New Well at Midland International Airport***
Alternative Number ***GVI-4***

Distance from PWS to new well location	22.07	miles
Estimated well depth	100	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	
Number of feed tanks/pump sets needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	20	n/a	n/a	n/a
Number of Crossings, open cut	40	n/a	n/a	n/a
PVC water line, Class 200, 04"	116,547	LF	$ 26.00	$ 3,030,222
Bore and encasement, 10"	4,000	LF	$ 60.00	$ 240,000
Open cut and encasement, 10"	2,000	LF	$ 30.00	$ 60,000
Gate valve and box, 04"	23	EA	$ 340.00	$ 7,925
Air valve	22	EA	$ 1,000.00	$ 22,000
Flush valve	23	EA	$ 750.00	$ 17,482
Metal detectable tape	116,547	LF	$ 0.15	$ 17,482
Subtotal				**$ 3,395,111**
Pump Station(s) Installation				
Pump	4	EA	$ 7,500	$ 30,000
Pump Station Piping, 04"	2	EA	$ 4,000	$ 8,000
Gate valve, 04"	8	EA	$ 370	$ 2,960
Check valve, 04"	4	EA	$ 430	$ 1,720
Electrical/Instrumentation	2	EA	$ 10,000	$ 20,000
Site work	2	EA	$ 2,000	$ 4,000
Building pad	2	EA	$ 4,000	$ 8,000
Pump Building	2	EA	$ 10,000	$ 20,000
Fence	2	EA	$ 5,870	$ 11,740
Tools	2	EA	$ 1,000	$ 2,000
Storage Tank - 5,000 gals	2	EA	$ 7,025	$ 14,050
Subtotal				**$ 122,470**
Well Installation				
Well installation	100	LF	$ 25	$ 2,500
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 23,500**

Subtotal of Component Costs			**$ 3,541,081**
Contingency	20%		$ 708,216
Design & Constr Management	25%		$ 885,270
TOTAL CAPITAL COSTS			**$ 5,134,568**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	22.1	mile	$ 200	$ 4,415
Subtotal				**$ 4,415**
Pump Station(s) O&M				
Building Power	23,600	kWH	$ 0.128	$ 3,021
Pump Power	1,280	kWH	$ 0.128	$ 164
Materials	2	EA	$ 1,200	$ 2,400
Labor	730	Hrs	$ 32	$ 23,608
Tank O&M	2	EA	$ 1,000	$ 2,000
Subtotal				**$ 31,193**
Well O&M				
Pump power	42	kWH	$ 0.128	$ 5
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 32	$ 5,821
Subtotal				**$ 7,027**
O&M Credit for Existing Well Closure				
Pump power	47	kWH	$ 0.128	$ (6)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 32	$ (5,821)
Subtotal				**$ (7,027)**

TOTAL ANNUAL O&M COSTS **$ 35,607**

Table C.5

PWS Name ***Greenwood Ventures Inc.***
Alternative Name ***Purchase Water from City of Odessa***
Alternative Number ***GVI-5***

Distance from Alternative to PWS (along pipe)	34.8	miles
Total PWS annual water usage	1.369	MG
Treated water purchase cost	$ 1.60	per 1,000 gals
Number of Pump Stations Needed	2	
Number of feed tanks/pump sets needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	23	n/a	n/a	n/a
Number of Crossings, open cut	61	n/a	n/a	n/a
PVC water line, Class 200, 04"	183,906	LF	$ 26.00	$ 4,781,556
Bore and encasement, 10"	4,600	LF	$ 60.00	$ 276,000
Open cut and encasement, 10"	3,050	LF	$ 30.00	$ 91,500
Gate valve and box, 04"	37	EA	$ 340.00	$ 12,506
Air valve	35	EA	$ 1,000.00	$ 35,000
Flush valve	37	EA	$ 750.00	$ 27,586
Metal detectable tape	183,906	LF	$ 0.15	$ 27,586
Subtotal				**$ 5,251,733**
Pump Station(s) Installation				
Pump, 5 hp	6	EA	$ 7,500	$ 45,000
Pump Station Piping, 04"	3	EA	$ 4,000	$ 12,000
Gate valve, 04"	12	EA	$ 370	$ 4,440
Check valve, 04"	6	EA	$ 430	$ 2,580
Electrical/Instrumentation	3	EA	$ 10,000	$ 30,000
Site work	3	EA	$ 2,000	$ 6,000
Building pad	3	EA	$ 4,000	$ 12,000
Pump Building	3	EA	$ 10,000	$ 30,000
Fence	3	EA	$ 5,870	$ 17,610
Tools	3	EA	$ 1,000	$ 3,000
Storage Tank - 5,000 gals	3	EA	$ 7,025	$ 21,075
Subtotal				**$ 183,705**
Subtotal of Component Costs				**$ 5,435,438**
Contingency	20%			$ 1,087,088
Design & Constr Management	25%			$ 1,358,860
TOTAL CAPITAL COSTS				**$ 7,881,386**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	34.8	mile	$ 200	$ 6,966
Subtotal				**$ 6,966**
Water Purchase Cost				
City of Odessa	1,369	1,000 gal	$ 1.60	$ 2,190
Subtotal				**$ 2,190**
Pump Station(s) O&M				
Building Power	35,400	kWH	$ 0.128	$ 4,531
Pump Power	3,657	kWH	$ 0.128	$ 468
Materials	3	EA	$ 1,200	$ 3,600
Labor	730	Hrs	$ 32	$ 23,608
Tank O&M	3	EA	$ 1,000	$ 3,000
Subtotal				**$ 35,207**
O&M Credit for Existing Well Closure				
Pump power	47	kWH	$ 0.128	$ (6)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 32	$ (5,821)
Subtotal				**$ (7,027)**
TOTAL ANNUAL O&M COSTS				**$ 37,336**

Table C.6

PWS Name *Greenwood Ventures Inc.*
Alternative Name *New Well at GVI*
Alternative Number *GVI-6*

Distance from PWS to new well location	0.1	miles
Estimated well depth	140	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	0	
Number of feed 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	-	n/a	n/a	n/a
PVC water line, Class 200, 04"	300	LF	$ 26.00	$ 7,800
Bore and encasement, 10"	-	LF	$ 60.00	$ -
Open cut and encasement, 10"	-	LF	$ 30.00	$ -
Gate valve and box, 04"	0	EA	$ 340.00	$ 20
Air valve	1.00	EA	$ 1,000.00	$ 1,000
Flush valve	0	EA	$ 750.00	$ 45
Metal detectable tape	300	LF	$ 0.15	$ 45
Subtotal				**$ 8,910**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 370	$ -
Check valve, 04"	-	EA	$ 430	$ -
Electrical/Instrumentation	-	EA	$ 10,000	$ -
Site work	-	EA	$ 2,000	$ -
Building pad	-	EA	$ 4,000	$ -
Pump Building	-	EA	$ 10,000	$ -
Fence	-	EA	$ 5,870	$ -
Tools	-	EA	$ 1,000	$ -
Storage Tank - 5,000 gals	-	EA	$ 7,025	$ -
Subtotal				**$ -**
Well Installation				
Well installation	140	LF	$ 25	$ 3,500
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 24,500**
Subtotal of Component Costs				**$ 33,410**
Contingency	20%			$ 6,682
Design & Constr Management	25%			$ 8,353
TOTAL CAPITAL COSTS				**$ 48,445**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	0.1	mile	$ 200	$ 11
Subtotal				**$ 11**
Pump Station(s) O&M				
Building Power	-	kWH	$ 0.128	$ -
Pump Power	-	kWH	$ 0.128	$ -
Materials	-	EA	$ 1,200	$ -
Labor	-	Hrs	$ 32	$ -
Tank O&M	-	EA	$ 1,000	$ -
Subtotal				**$ -**
Well O&M				
Pump power	68	kWH	$ 0.128	$ 9
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 32	$ 5,821
Subtotal				**$ 7,030**
O&M Credit for Existing Well Closure				
Pump power	47	kWH	$ 0.128	$ (6)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 32	$ (5,821)
Subtotal				**$ (7,027)**
TOTAL ANNUAL O&M COSTS				**$0.00**

Table C.7

PWS Name *Greenwood Ventures Inc.*
Alternative Name *New Well at 10 Miles*
Alternative Number *GVI-7*

Distance from PWS to new well location	10.0	miles
Estimated well depth	110	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	
Number of feed tanks/pump sets needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	5	n/a	n/a	n/a
Number of Crossings, open cut	15	n/a	n/a	n/a
PVC water line, Class 200, 04"	52,800	LF	$ 26.00	$ 1,372,800
Bore and encasement, 10"	1,000	LF	$ 60.00	$ 60,000
Open cut and encasement, 10"	750	LF	$ 30.00	$ 22,500
Gate valve and box, 04"	11	EA	$ 340.00	$ 3,590
Air valve	10	EA	$ 1,000.00	$ 10,000
Flush valve	11	EA	$ 750.00	$ 7,920
Metal detectable tape	52,800	LF	$ 0.15	$ 7,920
Subtotal				**$ 1,484,730**
Pump Station(s) Installation				
Pump, 5 hp	4	EA	$ 7,500	$ 30,000
Pump Station Piping, 04"	2	EA	$ 4,000	$ 8,000
Gate valve, 04"	8	EA	$ 370	$ 2,960
Check valve, 04"	4	EA	$ 430	$ 1,720
Electrical/Instrumentation	2	EA	$ 10,000	$ 20,000
Site work	2	EA	$ 2,000	$ 4,000
Building pad	2	EA	$ 4,000	$ 8,000
Pump Building	2	EA	$ 10,000	$ 20,000
Fence	2	EA	$ 5,870	$ 11,740
Tools	2	EA	$ 1,000	$ 2,000
Storage Tank - 5,000 gals	2	EA	$ 7,025	$ 14,050
Subtotal				**$ 122,470**
Well Installation				
Well installation	110	LF	$ 25	$ 2,750
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 23,750**
Subtotal of Component Costs				**$ 1,630,950**
Contingency	20%			$ 326,190
Design & Constr Management	25%			$ 407,738
TOTAL CAPITAL COSTS				**$ 2,364,878**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	10.0	mile	$ 200	$ 2,000
Subtotal				**$ 2,000**
Pump Station(s) O&M				
Building Power	23,600	kWH	$ 0.128	$ 3,021
Pump Power	945	kWH	$ 0.128	$ 121
Materials	2	EA	$ 1,200	$ 2,400
Labor	730	Hrs	$ 32	$ 23,608
Tank O&M	2	EA	$ 1,000	$ 2,000
Subtotal				**$ 31,150**
Well O&M				
Pump power	53	kWH	$ 0.128	$ 7
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 32	$ 5,821
Subtotal				**$ 7,028**
O&M Credit for Existing Well Closure				
Pump power	47	kWH	$ 0.128	$ (6)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 32	$ (5,821)
Subtotal				**$ (7,027)**
TOTAL ANNUAL O&M COSTS				**$ 33,151**

Table C.8

PWS Name *Greenwood Ventures Inc.*
Alternative Name *New Well at 5 Miles*
Alternative Number *GVI-8*

Distance from PWS to new well location	5.0	miles
Estimated well depth	110	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	
Number of feed tanks/pump sets needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	2	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	$ 26.00	$ 686,400
Bore and encasement, 10"	1,800	LF	$ 60.00	$ 108,000
Open cut and encasement, 10"	100	LF	$ 30.00	$ 3,000
Gate valve and box, 04"	5	EA	$ 340.00	$ 1,795
Air valve	5	EA	$ 1,000.00	$ 5,000
Flush valve	5	EA	$ 750.00	$ 3,960
Metal detectable tape	26,400	LF	$ 0.15	$ 3,960
Subtotal				**$ 812,115**
Pump Station(s) Installation				
Pump, 5 hp	4	EA	$ 7,500	$ 30,000
Pump Station Piping, 04"	2	EA	$ 4,000	$ 8,000
Gate valve, 04"	8	EA	$ 370	$ 2,960
Check valve, 04"	4	EA	$ 430	$ 1,720
Electrical/Instrumentation	2	EA	$ 10,000	$ 20,000
Site work	2	EA	$ 2,000	$ 4,000
Building pad	2	EA	$ 4,000	$ 8,000
Pump Building	2	EA	$ 10,000	$ 20,000
Fence	2	EA	$ 5,870	$ 11,740
Tools	2	EA	$ 1,000	$ 2,000
Storage Tank - 5,000 gals	2	EA	$ 7,025	$ 14,050
Subtotal				**$ 122,470**
Well Installation				
Well installation	110	LF	$ 25	$ 2,750
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 23,750**
Subtotal of Component Costs				**$ 958,335**
Contingency	20%			$ 191,667
Design & Constr Management	25%			$ 239,584
TOTAL CAPITAL COSTS				**$ 1,389,586**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	5.0	mile	$ 200	$ 1,000
Subtotal				**$ 1,000**
Pump Station(s) O&M				
Building Power	23,600	kWH	$ 0.128	$ 3,021
Pump Power	473	kWH	$ 0.128	$ 61
Materials	2	EA	$ 1,200	$ 2,400
Labor	730	Hrs	$ 32	$ 23,608
Tank O&M	2	EA	$ 1,000	$ 2,000
Subtotal				**$ 31,090**
Well O&M				
Pump power	53	kWH	$ 0.128	$ 7
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 32	$ 5,821
Subtotal				**$ 7,028**
O&M Credit for Existing Well Closure				
Pump power	47	kWH	$ 0.128	$ (6)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 32	$ (5,821)
Subtotal				**$ (7,027)**
TOTAL ANNUAL O&M COSTS				**$ 32,090**

Table C.9

PWS Name *Greenwood Ventures Inc.*
Alternative Name *New Well at 1 Mile*
Alternative Number *GVI-9*

Distance from PWS to new well location	1.0	miles
Estimated well depth	110	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	0	
Number of feed tanks/pump sets needed	1	

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	$ 26.00	$ 137,280
Bore and encasement, 10"	-	LF	$ 60.00	$ -
Open cut and encasement, 10"	100	LF	$ 30.00	$ 3,000
Gate valve and box, 04"	1	EA	$ 340.00	$ 359
Air valve	1.00	EA	$ 1,000.00	$ 1,000
Flush valve	1	EA	$ 750.00	$ 792
Metal detectable tape	5,280	LF	$ 0.15	$ 792
Subtotal				**$ 143,223**
Pump Station(s) Installation				
Pump, 5 hp	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 370	$ 1,480
Check valve, 04"	2	EA	$ 430	$ 860
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 61,235**
Well Installation				
Well installation	110	LF	$ 25	$ 2,750
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 23,750**
Subtotal of Component Costs				**$ 228,208**
Contingency	20%			$ 45,642
Design & Constr Management	25%			$ 57,052
TOTAL CAPITAL COSTS				**$ 330,902**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	1.0	mile	$ 200	$ 200
Subtotal				**$ 200**
Pump Station(s) O&M				
Building Power	-	kWH	$ 0.128	$ -
Pump Power	-	kWH	$ 0.128	$ -
Materials	-	EA	$ 1,200	$ -
Labor	-	Hrs	$ 32	$ -
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 1,000**
Well O&M				
Pump power	53	kWH	$ 0.128	$ 7
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 32	$ 5,821
Subtotal				**$ 7,028**
O&M Credit for Existing Well Closure				
Pump power	47	kWH	$ 0.128	$ (6)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 32	$ (5,821)
Subtotal				**$ (7,027)**
TOTAL ANNUAL O&M COSTS				**$ 1,201**

Table C.10

PWS Name *Greenwood Ventures Inc.*
Alternative Name *Central Treatment - RO*
Alternative Number *GVI-10*

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Reverse Osmosis Unit Purchase/Installation				
Site preparation	0.50	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	$ 80,000	$ 80,000
Transfer pumps	4	EA	$ 5,000	$ 20,000
Feed tank	10,000	gal	$ 3	$ 30,000
Permeate tank	20,000	gal	$ 3	$ 60,000
Reject pond:				
Excavation	1,500	CYD	$ 3.00	$ 4,500
Compacted fill	1,250	CYD	$ 7.00	$ 8,750
Lining	21,750	SF	$ 0.50	$ 10,875
Vegetation	2,500	SY	$ 1.00	$ 2,500
Access road	625	LF	$ 30.00	$ 18,750
Subtotal of Design/Construction Costs				**$ 378,375**
Contingency	20%			$ 75,675
Design & Constr Management	25%			$ 94,594
Reject water haulage truck	1	EA	$ 100,000	$ 100,000
TOTAL CAPITAL COSTS				**$ 648,644**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Reverse Osmosis Unit O&M				
Building Power	7,500	kwh/yr	$ 0.128	$ 960
Equipment power	1,500	kwh/yr	$ 0.128	$ 192
Labor	600	hrs/yr	$ 32	$ 19,200
Materials	1	year	$ 2,000	$ 2,000
Chemicals	1	year	$ 1,500	$ 1,500
Analyses	24	test	$ 200	$ 4,800
Subtotal				**$ 28,652**
Backwash Disposal				
Disposal truck mileage	10,000	miles	$ 1.00	$ 10,000
Backwash disposal fee	223	kgal/yr	$ 5.00	$ 1,115
Subtotal				**$ 11,115**
TOTAL ANNUAL O&M COSTS				**$ 39,767**

Table C.11

PWS Name ***Greenwood Ventures Inc.***
Alternative Name ***Point-of-Use Treatment***
Alternative Number ***GVI-11***

Number of Connections for POU Unit Installation 21

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POU-Treatment - Purchase/Installation				
POU treatment unit purchase	21	EA	$ 250	$ 5,250
POU treatment unit installation	21	EA	$ 150	$ 3,150
Subtotal				**$ 8,400**
Subtotal of Component Costs				**$ 8,400**
Contingency	20%			$ 1,680
Design & Constr Management	25%			$ 2,100
Procurement & Administration	20%			$ 1,680
TOTAL CAPITAL COSTS				**$ 13,860**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POU materials, per unit	21	EA	$ 225	$ 4,725
Contaminant analysis, 1/yr per unit	21	EA	$ 100	$ 2,100
Program labor, 10 hrs/unit	210	hrs	$ 32	$ 6,791
Subtotal				**$ 13,616**
TOTAL ANNUAL O&M COSTS				**$ 13,616**

Table C.12

PWS Name ***Greenwood Ventures Inc.***
Alternative Name ***Point-of-Entry Treatment***
Alternative Number ***GVI-12***

Number of Connections for POE Unit Installation 21

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POE-Treatment - Purchase/Installation				
POE treatment unit purchase	21	EA	$ 3,000	$ 63,000
Pad and shed, per unit	21	EA	$ 2,000	$ 42,000
Piping connection, per unit	21	EA	$ 1,000	$ 21,000
Electrical hook-up, per unit	21	EA	$ 1,000	$ 21,000
Subtotal				**$ 147,000**
Subtotal of Component Costs				**$ 147,000**
Contingency	20%			$ 29,400
Design & Constr Management	25%			$ 36,750
Procurement & Administration	20%			$ 29,400
TOTAL CAPITAL COSTS				**$ 242,550**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POE materials, per unit	21	EA	$ 1,000	$ 21,000
Contaminant analysis, 1/yr per unit	21	EA	$ 100	$ 2,100
Program labor, 10 hrs/unit	210	hrs	$ 32	$ 6,791
Subtotal				**$ 29,891**
TOTAL ANNUAL O&M COSTS				**$ 29,891**

Table C.13

PWS Name ***Greenwood Ventures Inc.***
Alternative Name ***Public Dispenser for Treated Drinking Water***
Alternative Number ***GVI-13***

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	$ 3,000	$ 3,000
Unit installation costs	1	EA	$ 5,000	$ 5,000
Subtotal				**$ 8,000**
Subtotal of Component Costs				**$ 8,000**
Contingency	20%			$ 1,600
Design & Constr Management	25%			$ 2,000
TOTAL CAPITAL COSTS				**11,600**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Treatment unit O&M, 1 per unit	1	EA	$ 500	$ 500
Contaminant analysis, 1/wk per u	52	EA	$ 100	$ 5,200
Sampling/reporting, 1 hr/day	365	HRS	$ 32	$ 11,804
Subtotal				**$ 17,504**
TOTAL ANNUAL O&M COSTS				**$ 17,504**

Table C.14

PWS Name *Greenwood Ventures Inc.*
Alternative Name *Supply Bottled Water to Population*
Alternative Number *GVI-14*

Service Population	50	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	18,250	gallons

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Implementation				
Initial program set-up	500	hours	$ 43	$ 21,506
Subtotal				**$ 21,506**
Subtotal of Component Costs				**$ 21,506**
Contingency	20%			$ 4,301
TOTAL CAPITAL COSTS				**$ 25,807**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water purchase costs	18,250	gals	$ 1.60	$ 29,200
Program admin, 9 hrs/wk	468	hours	$ 43	$ 20,130
Program materials	1	EA	$ 5,000	$ 5,000
Subtotal				**$ 54,330**
TOTAL ANNUAL O&M COSTS				**$ 54,330**

Table C.15

PWS Name	***Greenwood Ventures Inc.***
Alternative Name	***Central Trucked Drinking Water***
Alternative Number	***GVI-15***

Service Population	50	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	18,250	gallons
Travel distance to compliant water source (roundtrip)	30	miles

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Storage Tank Installation				
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Site improvements	1	EA	$ 4,000	$ 4,000
Potable water truck	1	EA	$ 60,000	$ 60,000
Subtotal				**$ 71,025**
Subtotal of Component Costs				**$ 71,025**
Contingency	20%			$ 14,205
Design & Constr Management	25%			$ 17,756
TOTAL CAPITAL COSTS				**$ 102,986**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water delivery labor, 4 hrs/wk	208	hrs	$ 32	$ 6,727
Truck operation, 1 round trip/wk	1560	miles	$ 1.00	$ 1,560
Water purchase	18	1,000 gals	$ 1.80	$ 33
Water testing, 1 test/wk	52	EA	$ 100	$ 5,200
Sampling/reporting, 2 hrs/wk	104	hrs	$ 32	$ 3,363
Subtotal				**$ 16,883**
TOTAL ANNUAL O&M COSTS				**$ 16,883**

Appendix D
Example Financial Model

Table D.1 Example Financial Model

Water System	Greenwood
Funding Alternative	Bond
Alternative Description	Purchase Water from City of Midland

Sum of Amount		Year																					
Group	Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Capital Expenditures	Capital Expenditures-Funded from Bond	$ -	$ -	$ -	########	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from Grant	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from Reve	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from SRF I	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Expenditures Sum		$ -	$ -	$ -	########	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt Service	Revenue Bonds				$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834
	State Revolving Funds				$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt Service Sum					$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834	$ 165,834
Operating Expenditures	Chemicals, Treatment			$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300
	Contract Labor			$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200
	Repairs			$ 900	$ 900	$ 900	$ 900	$ 900	$ 900	$ 900	$ 900	$ 900	$ 900	$ 900	$ 900	$ 900	$ 900	$ 900	$ 900	$ 900	$ 900	$ 900	$ 900
	Supplies			$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400
	Utilities			$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450
	O&M Associated with Alternative					$ 28,261	$ 28,261	$ 28,261	$ 28,261	$ 28,261	$ 28,261	$ 28,261	$ 28,261	$ 28,261	$ 28,261	$ 28,261	$ 28,261	$ 28,261	$ 28,261	$ 28,261	$ 28,261	$ 28,261	$ 28,261
	Maintenance			$ 650	$ 650	$ 650	$ 650	$ 650	$ 650	$ 650	$ 650	$ 650	$ 650	$ 650	$ 650	$ 650	$ 650	$ 650	$ 650	$ 650	$ 650	$ 650	$ 650
Operating Expenditures Sum				$ 3,900	$ 3,900	$ 32,161	$ 32,161	$ 32,161	$ 32,161	$ 32,161	$ 32,161	$ 32,161	$ 32,161	$ 32,161	$ 32,161	$ 32,161	$ 32,161	$ 32,161	$ 32,161	$ 32,161	$ 32,161	$ 32,161	$ 32,161
Residential Operating Revenues	Residential Base Monthly Rate			$ 3,591	$ 3,591	$ 172,343	$ 372,607	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119
	Residential Tier 1 Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier2 Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier3 Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier4 Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Unmetered Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Residential Operating Revenues Sum				$ 3,591	$ 3,591	$ 172,343	$ 372,607	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119

Location_Name	Greenwood
Alt_Desc	Purchase Water from City of Midland

		Current_Year																					
Funding_Alt	Data	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Bond	Sum of Beginning_Cash_Bal	$ -	$ (1,459)	$(168,752)	$(200,264)	$ (31,512)	$168,752	$369,016	$569,280	$769,544	$ 969,808	$1,170,072	$1,370,336	$1,570,600	$1,770,865	$1,971,129	$2,171,393	$2,371,657	$2,571,921	$2,772,185	$2,972,449	$3,172,713	$3,372,977
	Sum of Total_Expenditures	$ 3,900	$2,289,648	$ 197,995	$ 197,995	$197,995	$197,995	$197,995	$197,995	$197,995	$ 197,995	$ 197,995	$ 197,995	$ 197,995	$ 197,995	$ 197,995	$ 197,995	$ 197,995	$ 197,995	$ 197,995	$ 197,995	$ 197,995	$ 197,995
	Sum of Total_Receipts	$ 3,591	$2,123,505	$ 172,343	$ 372,607	$404,119	$404,119	$404,119	$404,119	$404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119	$ 404,119
	Sum of Net_Cash_Flow	$ (309)	$ (166,143)	$ (25,652)	$ 174,612	$206,124	$206,124	$206,124	$206,124	$206,124	$ 206,124	$ 206,124	$ 206,124	$ 206,124	$ 206,124	$ 206,124	$ 206,124	$ 206,124	$ 206,124	$ 206,124	$ 206,124	$ 206,124	$ 206,124
	Sum of Ending_Cash_Bal	$ (309)	$ (167,602)	$(194,404)	$ (25,652)	$174,612	$374,876	$575,140	$775,404	$975,668	$1,175,932	$1,376,197	$1,576,461	$1,776,725	$1,976,989	$2,177,253	$2,377,517	$2,577,781	$2,778,045	$2,978,309	$3,178,573	$3,378,837	$3,579,101
	Sum of Working_Cap	$ 650	$ 650	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360	$ 5,360
	Sum of Repl_Resv	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
	Sum of Total_Reqd_Resv	$ 1,150	$ 1,150	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860	$ 5,860
	Sum of Net_Avail_Bal	$ (1,459)	$ (168,752)	$(200,264)	$ (31,512)	$168,752	$369,016	$569,280	$769,544	$969,808	$1,170,072	$1,370,336	$1,570,600	$1,770,865	$1,971,129	$2,171,393	$2,371,657	$2,571,921	$2,772,185	$2,972,449	$3,172,713	$3,372,977	$3,573,241
	Sum of Add_Resv_Needed	$ (1,459)	$ (168,752)	$(200,264)	$ (31,512)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Sum of Rate_Inc_Needed	0%	4699%	116%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0
	Sum of Percent_Rate_Increase	-40%	-40%	2780%	6126%	6652%	6652%	6652%	6652%	6652%	6652%	6652%	6652%	6652%	6652%	6652%	6652%	6652%	6652%	6652%	6652%	6652%	6652%

Appendix E
General Nitrate Geochemistry

Appendix E
General Nitrate Geochemistry

Nitrate contamination occurs when nitrate-N concentrations exceed 10 mg/L nitrate-N (MCL for nitrate-N). Nitrate is negatively charged and behaves conservatively; i.e. it does not sorb onto soils, 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 soils in Dawson County 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 soils.

Appendix F
General Arsenic Geochemistry

Appendix F
General Arsenic Geochemistry

On January 22, 2001 USEPA adopted a new standard for arsenic in drinking water at 10 ppb, replacing the old standard of 50 ppb. The rule became effective on February 22, 2002. The date by which systems must comply with the new 10 µg/L standard was January 23, 2006. 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.

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