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

GREENWOOD ISD
PWS ID# 1650035

Prepared for:

THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Prepared by:

THE UNIVERSITY OF TEXAS BUREAU OF ECONOMIC GEOLOGY

AND

PARSONS

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

AUGUST 2005

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AUGUST 2005

EXECUTIVE SUMMARY

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

This feasibility report provides an evaluation of water supply alternatives for the Greenwood Independent School District (ISD) PWS located in Midland County approximately 10 miles from downtown Midland. Recent sample results from the Greenwood ISD PWS exceeded the MCL for arsenic of 10 micrograms per liter (µg/L) that go into effect January 23, 2006 (USEPA 2005; TCEQ 2004). Recent sample results also exceeded the MCL for total dissolved solids (TDS) of 1,000 milligrams per liter (mg/L) and the MCL for nitrate of 10 mg/L (USEPA 2005; TCEQ 2004).

Basic system information for the Greenwood ISD PWS is shown in Table ES.1.

Table ES.1
Greenwood ISD PWS
Basic System Information

Population served	1545
Connections (per person)	1545
Average daily flow rate	0.030 million gallons per day (mgd)
Peak demand flow rate	54.2 gallons per minute
Typical nitrate range	15.8 – 16.9 mg/L
Typical arsenic range	25.5 – 40.3 µg/L
Typical TDS	> 2000 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:

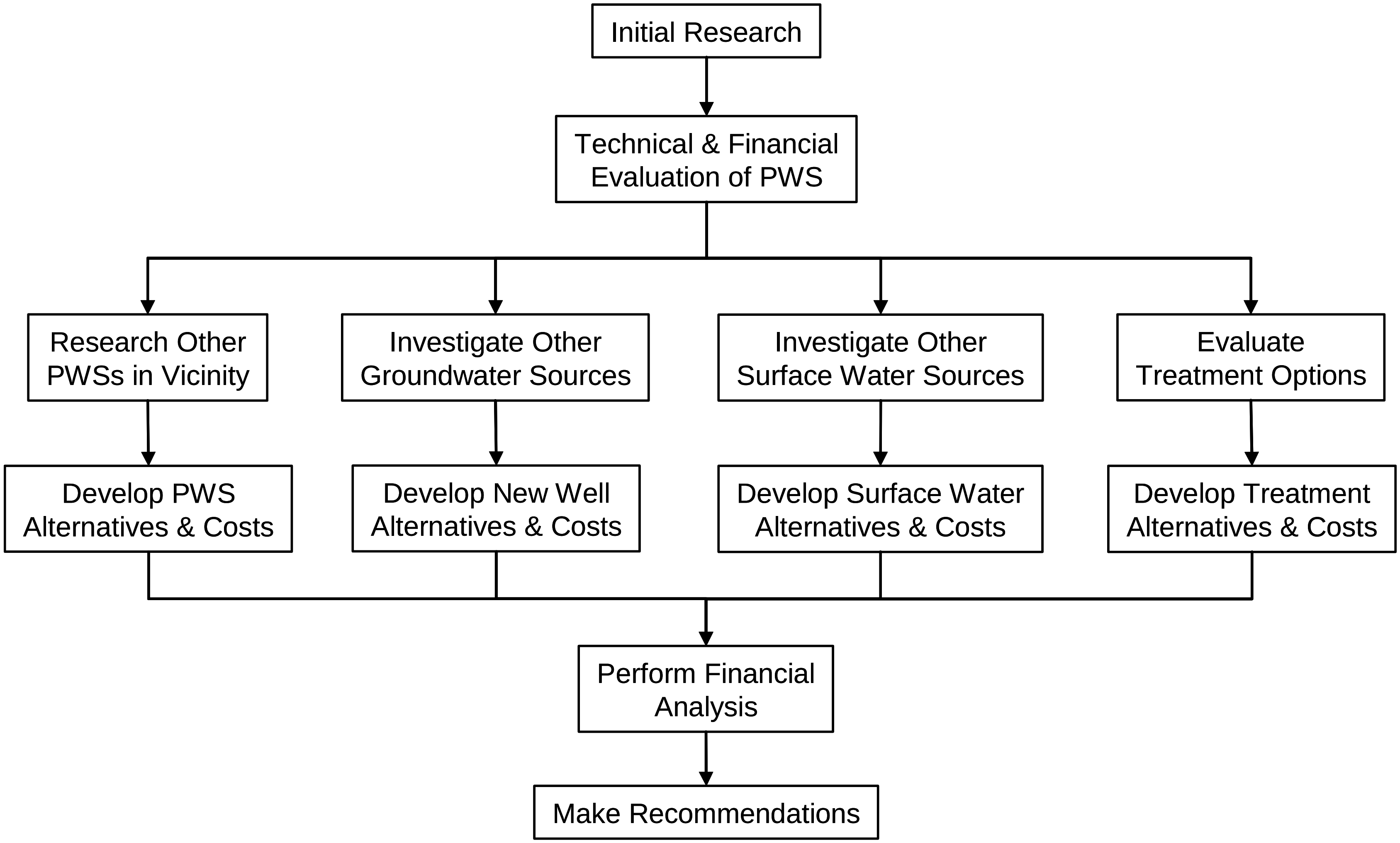
1. Gather data from the TCEQ and Texas Water Development Board databases, from TCEQ files, and from information maintained by the PWS;
2. Conduct financial, managerial, and technical (FMT) evaluations of the PWS;
3. Perform a geologic and hydrogeologic assessment of the study area;
4. Develop treatment 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 of the 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 ISD PWS obtains groundwater from four active wells completed in the Ogallala aquifer. Arsenic, nitrate, and TDS are commonly found in area wells at concentrations greater than the MCLs. The arsenic may be naturally occurring, but the nitrate may be the result of agricultural or other human activity. Arsenic, nitrate, and TDS concentrations can vary significantly over relatively short distances; as a result, there could be good quality groundwater nearby. However, the variability of arsenic, nitrate and TDS concentrations makes it difficult to determine where wells can be located to produce acceptable water. Additionally, systems with more than one well should

Figure ES-1
Summary of Project Methods



characterize the water quality of each well. If one of the wells is found to produce compliant water, as much production as possible should be shifted to that well as a method of achieving compliance. It may also be possible to do down-hole testing on non-compliant wells to determine the source of the contaminants. If the contaminants derive primarily from a single part of the formation, that part could be excluded by modifying the existing well, or avoided altogether by completing a new well.

COMPLIANCE ALTERNATIVES

The Greenwood ISD PWS has ongoing contracts with a certified operator for maintenance of five reverse osmosis (RO) treatment units. District maintenance staff operates and maintains the wells, tanks, and distribution system. Overall, the system had an adequate level of FMT capacity. The system had some areas that needed improvement to be able to address future compliance issues; however, the system does have many positive aspects, including dedicated and capable operator and staff and good communication. An area of concern for the system included the lack of capital improvement planning.

There are several PWSs within 30 miles of Greenwood ISD. Many of these nearby systems also have water quality issues, but there are several with good quality water. In general, feasibility alternatives were developed based on obtaining water from the nearest PWSs, either by directly purchasing water, or by expanding the existing well field. There is a minimum of surface water available in the area, and obtaining a new surface water source is considered through an alternative where treated surface water is obtained from the City of Odessa or the City of Stanton.

Centralized treatment alternatives for arsenic, nitrate, and TDS removal have been developed and were considered for this report. These included RO and electrodialysis reversal treatments.

Developing a new well close to Greenwood ISD is likely to be the best solution if compliant groundwater can be found. Having a new well close to Greenwood ISD 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. Like obtaining an alternate compliant water source, central treatment would provide compliant water to all water taps.

FINANCIAL ANALYSIS

Financial analysis of the Greenwood ISD PWS indicated that current water rates are estimated to be $31 or 0.08 percent of the 2000 median household income (MHI) for

Texas, which is $39,927. Table ES.2 provides a summary of the financial impact of implementing selected compliance alternatives, including the rate increase necessary to meet future 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	$31	0.08
To meet current expenses	NA	$30	0.08
Nearby well within approximately 1 mile	100% Grant	$43	0.11
	Loan/Bond	$237	0.60
Central treatment - RO	100% Grant	$184	0.50
	Loan/Bond	$242	0.60

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1 # ACRONYMS AND ABBREVIATIONS

°F	Degrees Fahrenheit
µg/L	Microgram per liter
AA	Activated Alumina
BAT	Best available technology
BEG	Bureau of Economic Geology
CA	Cellulose acetate
CCN	Certificate of Convenience and Necessity
CO	Correspondence
CPA	Cenozoic Pecos alluvium
CRMWD	Colorado River Municipal Water District
EDR	Electrodialysis reversal
FMT	Financial, managerial, and technical
GAM	Groundwater Availability Model
gpm	Gallons per minute
ISD	Independent School District
IX	Ion exchange
MCL	Maximum contaminant level
MF	Microfiltration
mg/L	Milligram per liter
mgd	Million gallons per day
MHI	Median household income
MOR	Monthly operating report
NF	Nanofiltration
NMEFC	New Mexico Environmental Financial Center
O&M	Operation and Maintenance
Parsons	Parsons Infrastructure and Technology Inc.
POE	Point-of-entry
POU	Point-of-use
psi	Pounds per square inch
PVC	Polyvinyl chloride
PWS	Public water system
RO	Reverse osmosis
SDWA	Safe Drinking Water Act
TCEQ	Texas Commission on Environmental Quality
TDS	Total dissolved solids
TFC	Thin film composite
TTHM	Total trihalomethane
TWDB	Texas Water Development Board

USEPA	U.S. Environmental Protection Agency
WAM	Water Availability Model

SECTION 1
INTRODUCTION

The University of Texas Bureau of Economic Geology (BEG) and its subcontractor, Parsons Infrastructure and Technology Group Inc. (Parsons), have been contracted by the Texas Commission on Environmental Quality (TCEQ) to assist with identifying and analyzing compliance alternatives for use by Public Water Systems (PWS) to meet and maintain Texas drinking water standards. A total of 15 PWSs were evaluated in this project and each is addressed in a separate report. The 15 systems evaluated for this project are listed below:

Public Water System	Texas County
City of Eden	Concho
City of Danbury	Brazoria
Rosharon Road Estates Subdivision	Brazoria
Mark V Estates	Brazoria
Rosharon Township	Brazoria
Sandy Meadows Estates Subdivision	Brazoria
Grasslands	Brazoria
City of Mason	Mason
Falling Water	Kerr
Greenwood Independent School District (ISD)	Midland
Country Village Mobile Home Estates	Midland
South Midland County Water Systems	Midland
Warren Road Subdivision Water Supply	Midland
Huber Garden Estates	Ector
Devilla Mobile Home Park	Ector

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

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

This feasibility report provides an evaluation of water supply compliance options for the Greenwood ISD, PWS ID# 1650035 located in Midland County. The Greenwood ISD water system has recorded the following nitrate, arsenic, and TDS concentrations in the last few years.

PARAMETER	2003 RESULTS	2004 RESULTS	2005 RESULTS	AVERAGE	MCL
Nitrate[1]	15.8	16.0	16.9	16.2	10
Arsenic[1]	0.0257	0.0255	0.0403	0.0305	0.010
TDS	2288	NA	NA	2288	1000

1 – The results shown in the table for each year may be an average if more than one sample result was available.
NA = not available.
All results are in mg/L.

Location of the Greenwood ISD PWS, also referred to as the "study area" in this report, is shown on Figure 1.1. Various water supply and planning jurisdictions are shown on Figure 1.2. These water supply and planning jurisdictions are used in the evaluation of alternate water supplies that may be available in the area.

1.1 PUBLIC HEALTH AND COMPLIANCE WITH MCLS

The goal of this project is to promote compliance by PWSs that supply drinking water exceeding regulatory MCLs. This project only addresses those contaminants and does not address any other violations that may exist for a PWS. As mentioned above, Greenwood ISD PWS had past sample results exceeding the MCL for nitrate, the future MCL for arsenic, and the secondary MCL for TDS.

In general, contaminant(s) in drinking water above the MCL(s) can have both short-term (acute) and long-term or lifetime (chronic) effects as briefly discussed below for nitrates, arsenic, and TDS.

1.1.1 Nitrate Health 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 most susceptible population to adverse nitrate health effects includes 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

Figure 1.1

Greenwood ISD Location Map

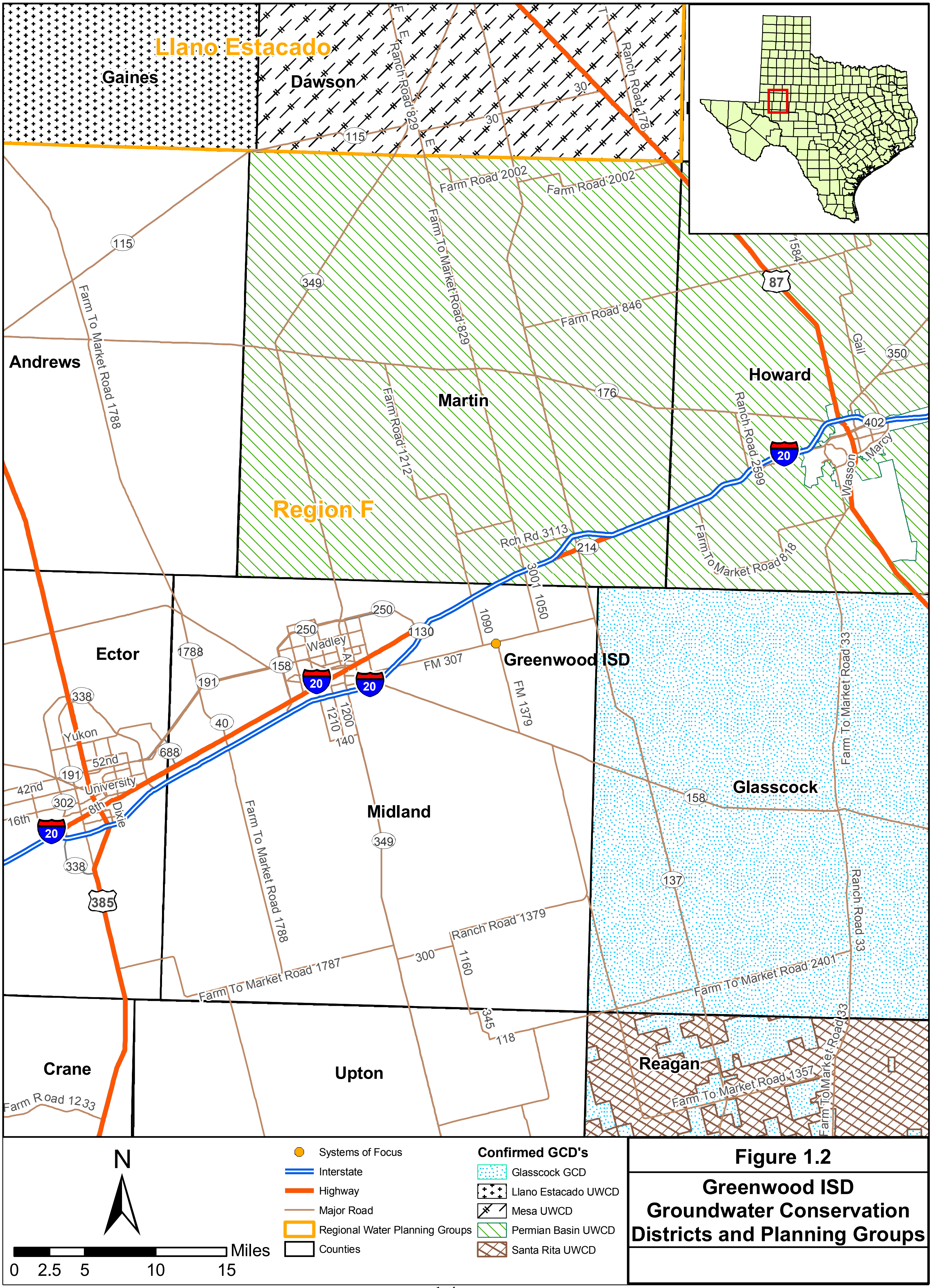


Figure 1.2

Greenwood ISD Groundwater Conservation Districts and Planning Groups

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).

1.1.2 Arsenic Health Effects

According to the USEPA, potential health effects from long-term ingestion of water with levels of arsenic above the MCL of 10 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 prostrate cancer (USEPA 2005b).

1.2 METHODOLOGY

The methodology for this project follows 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 USEPA and Texas drinking water standards. Three PWSs were evaluated in the pilot study to develop the methodology (*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 financial, managerial, and technical (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 and arsenic abatement options. Section 2 describes the methodology used to develop and assess compliance alternatives. The groundwater sources of nitrate and arsenic are addressed in Section 3. Findings for the Greenwood ISD water system, along with compliance alternatives development and evaluation, can be found in Section 4. Section 5 references the sources used in this report.

1.3 REGULATORY PERSPECTIVE

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

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

This project was conducted to assist in achieving these responsibilities.

1.4 ABATEMENT OPTIONS

Past analytical results for nitrate and TDS prior to point-of-use (POU) treatment indicate violations of drinking water regulations. In addition, arsenic concentrations in the raw water prior to POU treatment will not meet the new arsenic MCL that goes into effect in January 2006. Greenwood ISD has taken corrective action by installing POU reverse osmosis (RO) treatment at five locations throughout the campus, which consists of an elementary school, an intermediate school, a middle school, and a high school. Treated water is provided in the cafeterias, at water fountains, and for other miscellaneous uses such as coffee pots. For other sinks and faucets throughout the facility, signs are posted that say not to drink the water. The following subsections explore alternatives considered as potential options for obtaining/providing compliant drinking water.

1.4.1 Existing Public Water Supply Systems

A common approach to achieve compliance is for the PWS to make arrangements with a neighboring PWS to supply water. 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, flow rate, 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 usage. Peak instantaneous demands can be met through proper sizing of storage facilities. Furthermore, the potential for obtaining the appropriate quantity of water to blend to achieve compliance should be considered. The concept of blending involves combining water with low levels of contaminants with non-compliant water in sufficient quantity that the resulting blended water is compliant. The exact blend ratio would depend on the quality of the water a potential supplier PWS can provide, and would likely vary over time. If high quality water is purchased, produced or otherwise obtained, blending can reduce the amount of high quality water required. Implementation of blending will require a control system to ensure the blended water is compliant.

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

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

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

1.4.1.2 Quality

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

Surface water sources may offer a potential higher-quality source. Facilities for the treatment of surface water may be unreasonably expensive for smaller PWSs. Connecting to large neighboring PWSs or regional authorities for treated surface water may be more cost effective.

1.4.2 Potential for New Groundwater Sources

1.4.2.1 Existing Non-Public Supply Wells

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

- Use existing data sources to identify wells in the areas that have satisfactory quality. For Midland County, the following standards could be used in a rough screening to identify compliant groundwater:
    - Nitrate (measured as nitrogen) concentrations less than 8 mg/L (below the MCL of 10 mg/L);
    - Arsenic concentrations less than 8 µg/L (below the future MCL of 10 µg/L); and
    - TDS concentrations less than 1,000 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 which 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. Owners are probably the best source of information regarding the latest test dates, who tested the water, well flow rates, and other well characteristics.
- After collecting as much information as possible from cooperative owners, the PWS would then narrow the selection of wells and sample and analyze them for quality. Wells with good quality would then be potential candidates for test pumping. In some cases, a particular well may need to be refurbished before test pumping. Information obtained from test pumping would then be used in combination with information about the

general characteristics of the aquifer to determine whether a well at this location would be suitable as a supply source.

- It is recommended that new wells be installed instead of using existing wells to ensure the well characteristics are known and the well meets construction standards.
- 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.

1.4.3 Potential for Surface Water Sources

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

1.4.3.1 Existing Surface Water Sources

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

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

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 this could require negotiations, contracts, 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 water 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 also investigated as compliance alternatives for treatment of nitrate and arsenic to regulatory levels (*i.e.*, MCLs). Numerous options have been identified by the USEPA as best available technologies (BAT) for non-compliant constituents. Identification and descriptions of the various BATs are provided in the following sections. Several other treatment options are also described but were not further considered in the feasibility study (*e.g.*, because of lack of commercial applications or other limitations).

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 regulation applies to all community water systems and non-transient, non-community water systems, regardless of size.

The new arsenic MCL of 0.01 mg/L becomes 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 POU treatment can be instituted in place of centralized treatment. All surface water 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 Small System Compliance Technologies:

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

1.4.5 Treatment Technologies Description

Reverse osmosis, IX, and EDR are identified by USEPA as BATs for removal of nitrates. These three treatment technologies are also applicable to arsenic, and are the only three technologies common to both nitrate and arsenic treatment. RO and IX are also viable options for point-of-entry (POE) and POU systems. A description of these technologies 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) or polyamide thin film composite (TFC). The TFC membrane operates at much lower pressure and can achieve higher salt rejection than the CA membranes but is less chlorine resistant. Common membrane construction includes spiral wound or hollow fine fiber. Each material and construction method has specific benefits and limitations depending on the raw water characteristics and pre-treatment. Spiral wound has been the dominant configuration in common RO systems. A newer, lower pressure type membrane which is similar in operation to RO, is nanofiltration (NF) which has higher rejection for divalent ions than mono-valent ions. 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 nitrate and arsenic while NF has a lower nitrate and arsenic rejection efficiency. The treatment process is relatively insensitive to pH. Water recovery is 60-80 percent, depending on raw water characteristics. The concentrate volume for disposal can be significant. The conventional RO treatment train for well water uses anti-scalant addition, cartridge filtration, RO membranes, chlorine disinfection, and clearwell storage.

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

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

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

Advantages (RO)

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

Disadvantages (RO)

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

A concern with RO for treatment of inorganics is that if the full stream is treated, then most of the alkalinity and hardness would also be removed. In that event, post-treatment may be necessary to avoid corrosion problems. If feasible, a way to avoid this issue is to treat a slip stream of raw water and blend the slip stream back with the raw water rather than treat the full stream. The amount of water rejected is also an issue with RO. Discharge concentrate can be between 10 and 50 percent of the influent flow.

1.4.5.2 Ion Exchange

Process**.** In solution, salts separate into positively charged cations and negatively charged anions. Ion exchange is a reversible chemical process in which ions from an insoluble, permanent, solid resin bed are exchanged for ions in water. The process relies on the fact that certain ions are preferentially adsorbed on the IX resin. Operation begins with a fully recharged cation or anion resin bed, having enough positively or negatively charged ions to carry out the cation or anion exchange. Usually a polymer resin bed is composed of millions of spherical beads about the size of medium sand grains. As water passes through the resin bed, the positively or negatively charged ions are released into the water, being substituted or replaced with the contaminant ions in the water (ion exchange). When the resin becomes exhausted of positively or negatively charged ions, the bed must be regenerated by passing a strong, usually sodium chloride, solution over the resin bed, displacing the contaminant ions with sodium ions for cation exchange and chloride ions for anion exchange. Many different types of resins can be used to reduce dissolved contaminant concentrations. The IX treatment train for groundwater typically includes cation or anion resin beds, chlorine disinfection, and clearwell storage. Treatment trains for surface water may also include raw water pumps, debris screens, and gravity filters for pre-treatment. Additional treatment or management of the concentrate and the removed solids will be necessary prior to disposal. For nitrate and arsenic removal, a strong base anion exchange resin in the chloride form can remove 99 percent of the nitrate and arsenic. Sulfate is a strong competing anion for nitrate and arsenic adsorption by IX. Regeneration is accomplished with sodium chloride.

<u>Pre-treatment</u>. There are pretreatment requirements for pH, organics, turbidity, and other raw water characteristics. Pre-treatment may be required to reduce excessive amounts of total suspended solids, iron, and manganese, which could plug the resin bed, and typically includes media or carbon filtration. Pre-treatment may also be required to remove sulfate that can interfere with nitrate and arsenic removal.

<u>Maintenance</u>. The IX resin requires regular on-site regeneration, the frequency of which depends on raw water characteristics, the contaminant concentration, and the size and number of IX vessels. Many systems have undersized the IX vessels only to realize higher than necessary operating costs. Preparation of the sodium chloride solution is required. If used, filter replacement and backwashing would be required.

<u>Waste Disposal</u>. Approval from local authorities is usually required for disposal of concentrate from the regeneration cycle (highly concentrated salt solution); occasional solid waste (in the form of broken resin beads) which are backwashed during regeneration; and if used, spent filters and backwash wastewater.

Advantages (IX)

- Acid addition, degasification, and repressurization are not required.
- Ease of operation; highly reliable.
- Lower initial cost; resins will not wear out with regular regeneration.
- Effective; widely used.
- Suitable for small and large installations.
- A variety of specific resins are available for removing specific contaminants.

Disadvantages (IX)

- Requires salt storage; regular regeneration.

- Concentrate disposal.
- Usually not feasible with high levels of TDS.
- Resins are sensitive to the presence of competing ions.

In considering application of IX for inorganics removal, it is important to understand what the effect of competing ions would be, and to what extent the brine can be recycled. Similar to AA treatment, IX exhibits a selectivity sequence, which refers to an order in which ions are preferred. Barium, lead, and copper are highly preferred cations. Sulfate competes with both nitrate and arsenic, but more aggressively with arsenic in anion exchange. Source waters with TDS levels above 500 mg/L and sulfate levels above 120 mg/L are not amenable to IX treatment. Spent regenerant is produced during IX bed regeneration, and this spent regenerant may have high concentrations of sorbed contaminants which can be expensive to treat and/or dispose. Research has been conducted to minimize this effect; recent research on arsenic removal shows that the brine can be reused as many as 25 times.

1.4.5.3 Electrodialysis Reversal

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

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

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

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

Advantages (EDR)

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

Disadvantages (EDR)

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

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

1.4.5.4 Distillation

Distillation heats water until it turns to steam. The steam travels through a condenser coil where it is cooled and returned to liquid. The nitrate and arsenic remain in the boiler section. Distillation is energy-intensive in relation to the other processes, but is not well suited for production of drinking water for the centralized-treatment, POU, or POE applications.

Owing to the lack of commercial applications for this technology, it will be eliminated from further consideration.

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

Point-of-entry (POE) and point-of-use (POU) treatment systems can be used to provide compliant drinking water. For nitrate, arsenic, and TDS removal, these systems typically use small RO treatment units that are installed "under the sink" in the case of point-of-use, and where water enters a house or building in the case of point-of-entry. It should be noted that the POU treatment units would need to be more complex than units typically found in commercial retail outlets in order to meet regulatory requirements, making purchase and installation more expensive. Greenwood ISD has already installed five POU reverse osmosis treatment units at various locations throughout the school campus.

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 are:

- POU and POE treatment units must be owned, controlled, and maintained by the water system, although the utility may hire a contractor to ensure proper operation and maintenance (O&M) and MCL compliance. The water system must retain unit ownership and oversight of unit installation, maintenance and sampling; the utility ultimately is the responsible party when it comes to 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.
- POU and POE units must have mechanical warning systems to automatically notify 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.

SECTION 2
EVALUATION METHODOLOGY

2.1 DECISION TREE

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

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

2.2 DATA SOURCES AND DATA COLLECTION

2.2.1 Data Search

2.2.1.1 Water Supply Systems

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

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

Figure 2.1
TREE 1 – EXISTING FACILITY ANALYSIS

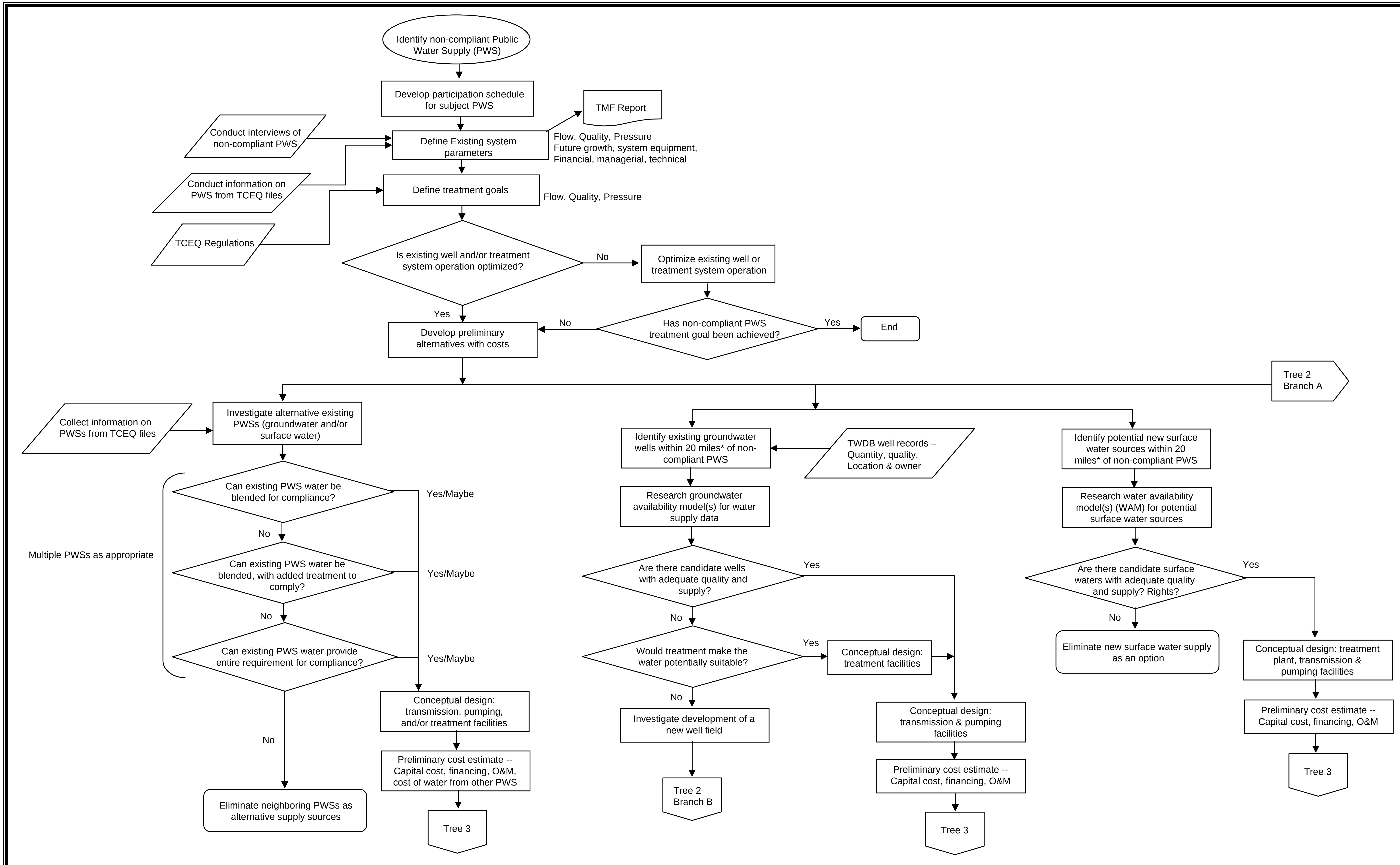
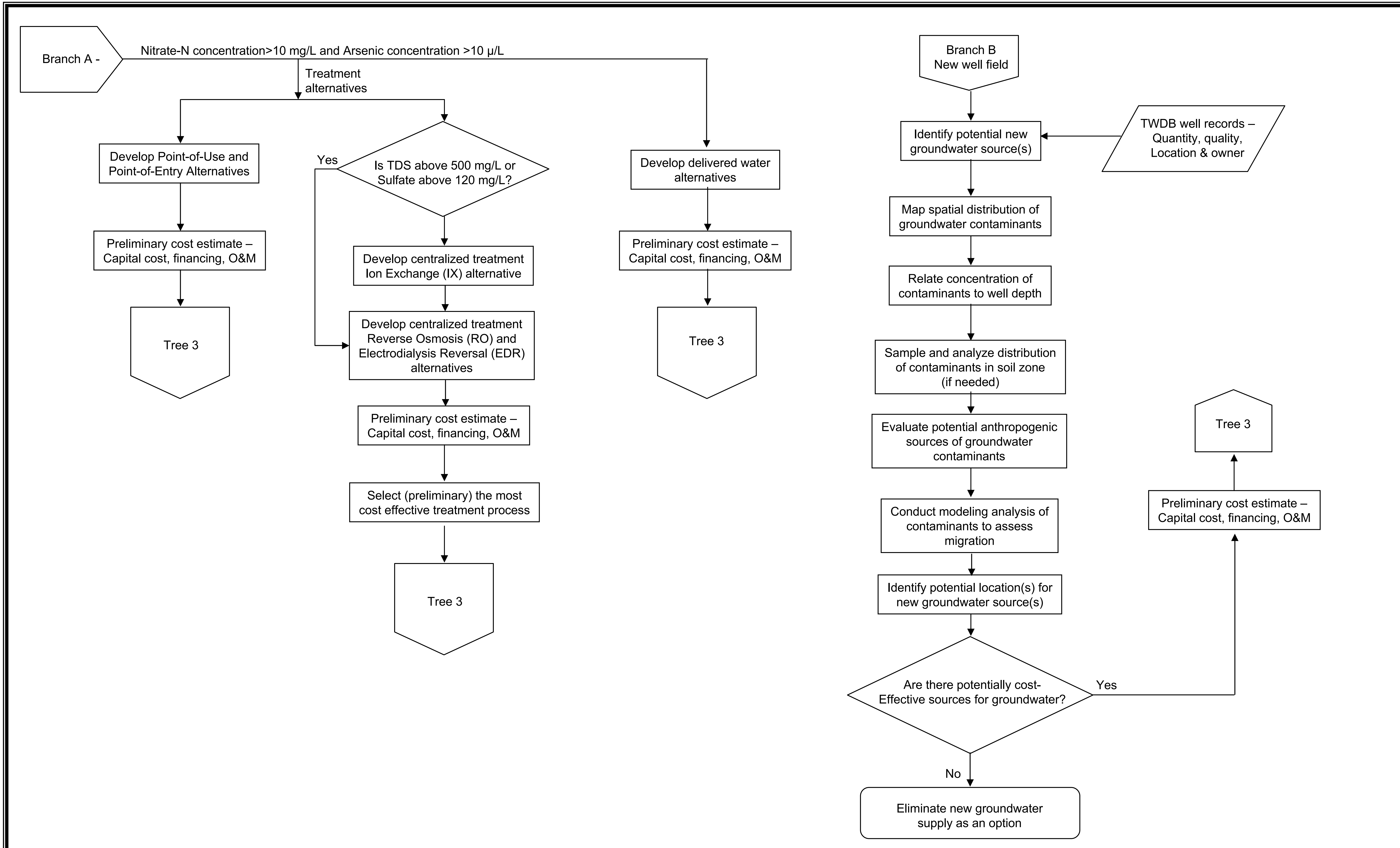


Figure 2.2
TREE 2 – DEVELOP TREATMENT ALTERNATAIVES



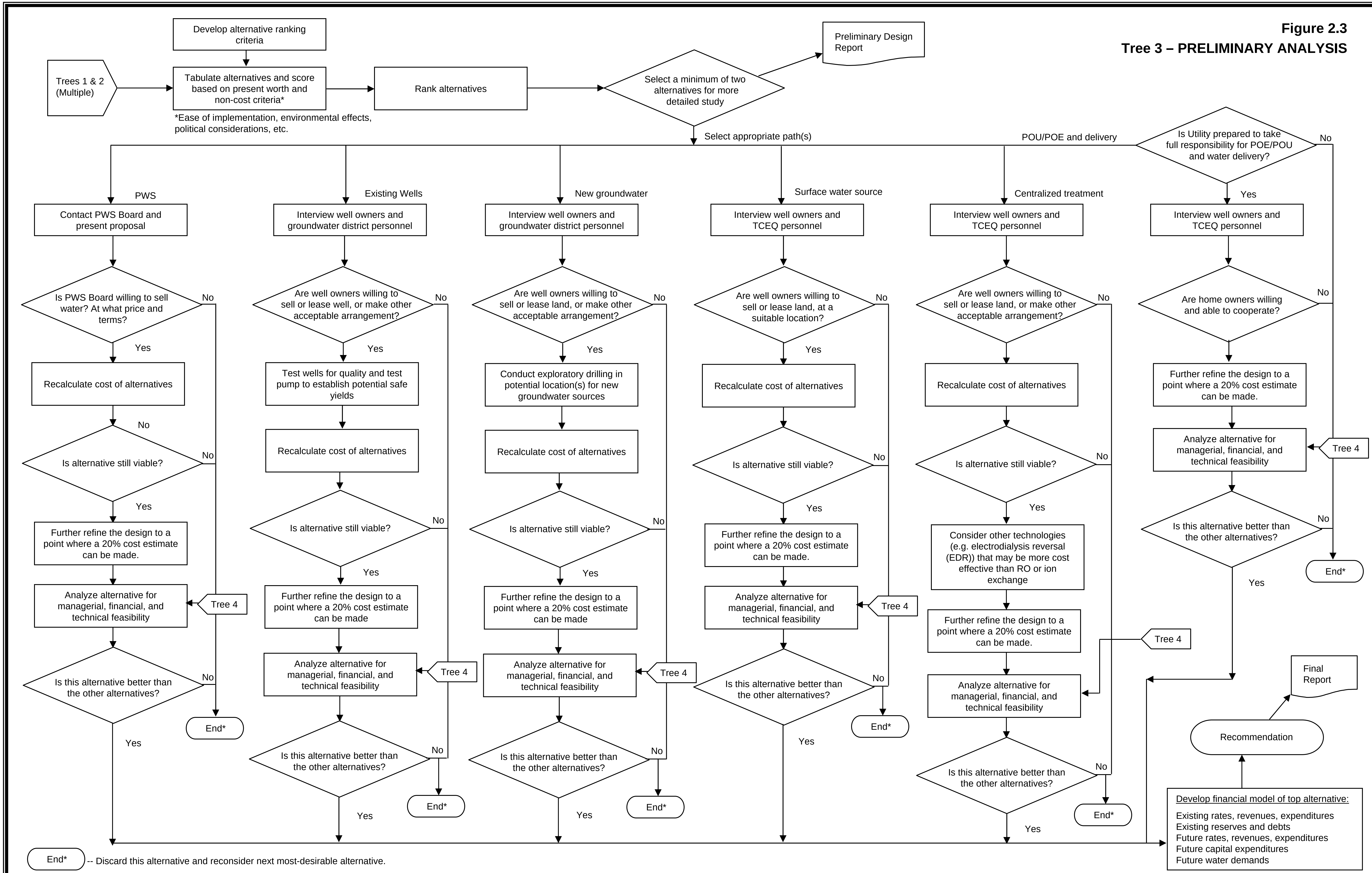
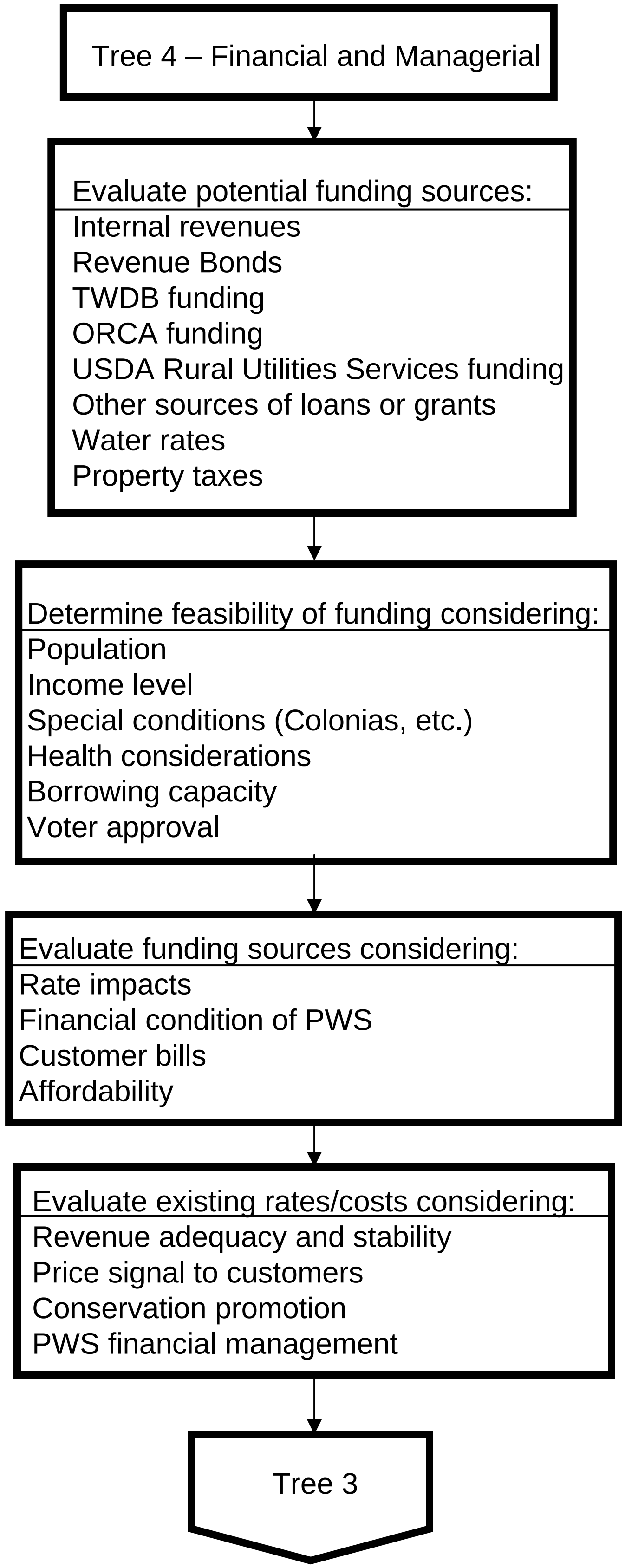


Figure 2.3
Tree 3 – PRELIMINARY ANALYSIS
Trees 1 & 2 (Multiple)
Develop alternative ranking criteria
Tabulate alternatives and score based on present worth and non-cost criteria*
*Ease of implementation, environmental effects, political considerations, etc.
Rank alternatives
Select a minimum of two alternatives for more detailed study
Preliminary Design Report
Select appropriate path(s)
POU/POE and delivery
Is Utility prepared to take full responsibility for POE/POU and water delivery?
PWS
Existing Wells
New groundwater
Surface water source
Centralized treatment
Contact PWS Board and present proposal
Interview well owners and groundwater district personnel
Interview well owners and TCEQ personnel
Is PWS Board willing to sell water? At what price and terms?
Are well owners willing to sell or lease well, or make other acceptable arrangement?
Are well owners willing to sell or lease land, or make other acceptable arrangement?
Are well owners willing to sell or lease land, at a suitable location?
Are home owners willing and able to cooperate?
Recalculate cost of alternatives
Test wells for quality and test pump to establish potential safe yields
Conduct exploratory drilling in potential location(s) for new groundwater sources
Is alternative still viable?
Further refine the design to a point where a 20% cost estimate can be made.
Consider other technologies (e.g. electrodialysis reversal (EDR)) that may be more cost effective than RO or ion exchange
Analyze alternative for managerial, financial, and technical feasibility
Is this alternative better than the other alternatives?
Tree 4
Yes
No
End*
Final Report
Recommendation
Develop financial model of top alternative:
Existing rates, revenues, expenditures
Existing reserves and debts
Future rates, revenues, expenditures
Future capital expenditures
Future water demands
End* -- Discard this alternative and reconsider next most-desirable alternative.

Figure 2.4
TREE 4 – FINANCIAL AND MANAGERIAL



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.tceq.state.tx.us/iwud/pws/index.cfm. Under "Advanced Search", type in the name(s) of the Counties 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 flow rate, and nature of the surrounding formation. The "Water Quality Table" provides information on the aquifer and the various chemical concentrations in the water. The database contained both total and dissolved metals. Water samples analyzed for dissolved metals are filtered to remove suspended solids. Since the suspended solids in drinking water are near zero, the values reported for total and dissolved metals was considered equivalent.

2.2.1.3 Surface Water Sources

The 2002 Texas Water Plan published by the TWDB divides the state into regional planning areas. Midland County falls within Region F. The Region F Water Management Plan planning documents were consulted for lists of surface water sources. Greenwood ISD falls within the Colorado River Basin.

2.2.1.4 Groundwater Availability Model

Groundwater Availability Models (GAM), developed by the TWDB, are planning tools and should be consulted as part of a search for new or supplementary water sources. The GAMs for the Ogallala and Edwards-Trinity Plateau aquifers were investigated as a potential tool for identifying available and suitable groundwater resources.

2.2.1.5 Water Availability Model

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

2.2.1.6 Financial Data

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

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

2.2.1.7 Demographic Data

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

2.2.2 PWS Interviews

2.2.2.1 PWS Financial Capacity Assessment Process

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

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

Financial capacity is a water system's ability to acquire and manage sufficient financial resources to allow the system to achieve and maintain compliance with the Safe Drinking Water Act (SDWA) requirements. 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 regulations. 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 the adequacy of the source water, treatment, storage, and distribution infrastructure. It also refers to the ability of system personnel to effectively operate and maintain the system and to otherwise implement essential technical knowledge.

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

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

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

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

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

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

2.2.2.2 Interview Process

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

2.3 ALTERNATIVE DEVELOPMENT AND ANALYSIS

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

2.3.1 Existing PWS

The neighboring PWSs were identified, and the extents of their systems were investigated. PWSs farther than 30 miles from the non-compliant PWS were generally not considered because the length of pipelines 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 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

Treatment technologies considered potentially applicable to both nitrate and arsenic removal are RO, IX, and EDR since they are proven technologies with numerous successful installations. However, all systems with elevated nitrate and arsenic also have TDS levels higher than 1,000 mg/L and thus, IX is not economically feasible. Both RO and EDR treatment are considered for central treatment alternatives. Both RO and EDR treatment produce a liquid waste: a reject stream from RO treatment and a concentrate stream from EDR treatment. As a result, the treated volume of water is less than the volume of raw water that enters the treatment system. The amount of raw water used increases to produce the same amount of treated water if RO or EDR treatment is implemented. 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 was to determine the financial impact of implementing compliance alternatives. The current financial situation was also reviewed to determine what rate increases were necessary for the PWS to achieve or maintain financial viability.

2.4.1 Financial Feasibility

A key financial metric is comparison of the average annual household water bill for a PWS customer to the MHI for the area. MHI data from the 2000 Census were 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 were determined for existing base conditions and included consideration of additional rate increases needed under current conditions. Annual water bills were 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 provided 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 Census was used as the basis for MHI. In addition to consideration of affordability, 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, correspond to census tract data.

2.4.3 Average Cost per Student

An average cost per student was estimated for the existing system and the various compliance alternatives. The estimates were generated from a long-term financial planning model that detailed annual revenue, expenditure and cash reserve requirements over a 30-year period.

2.4.4 Financial Plan Development

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

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

2.4.5 Financial Plan Results

Results from the financial planning model were summarized in two ways: by percentage of household income and by average cost per student necessary to implement the alternatives and maintain financial viability.

2.4.5.1 Funding Options

Results, summarized in Table 4.5, show the following according to alternative and funding source:

- The first year in which a water rate increase would be required; and
- The total required increase in cost per student, compared to current estimated costs.

Water rates resulting from the incremental capital costs of the alternative solutions were examined under a number of funding options. The first alternative examined was always funded 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 was only responsible for the associated O&M costs.
- Grant funds for 75 percent of required capital, with the balance treated as if revenue bond funded.
- Grant funds for 50 percent of required capital, with the balance treated as if revenue bond funded.
- State revolving fund loan at the most favorable available rates and terms applicable to the communities.
- If local MHI > 75 percent of state MHI, standard terms, currently at 3.8 percent interest for non-rated entities. Additionally:
  - ➢ 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 included:

- No account growth (either positive or negative).
- Average consumption per student unchanged over time.
- No change in unaccounted for water as a percentage of total (more efficient water use would lower total water requirements and costs).
- No inflation included in the analyses (although the model had 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).
- 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, as presented in Table 4.4, show the increases in average cost per student necessary to maintain financial viability over time.

2.4.5.4 Potential Funding Sources

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

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

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

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

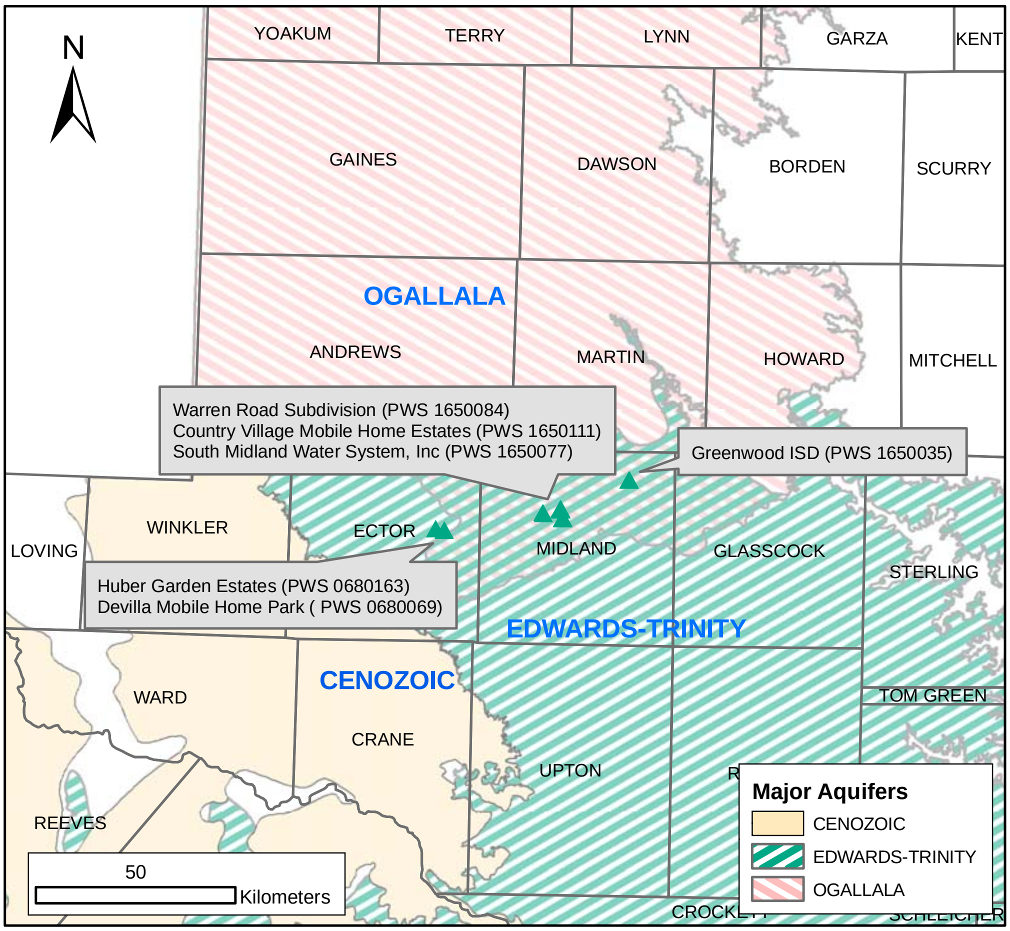
- United States Department of Agriculture, Rural Utilities Service; and
- United States Housing and Urban Development.

SECTION 3
UNDERSTANDING SOURCES OF CONTAMINANTS

3.1 NITRATE AND ARSENIC IN THE SOUTHERN HIGH PLAINS AND EDWARDS TRINITY PLATEAU AQUIFERS

The major aquifers in the vicinity of the evaluated public water systems include the Ogallala aquifer (Miocene–Pliocene age), the Edwards Trinity (Plateau) aquifer (Cretaceous age), and the Cenozoic Pecos Alluvium (CPA) aquifer (Tertiary and Quaternary age) (Ashworth and Hopkins 1995). Figure 3.1 shows assessed public water supplies and major aquifers in the study area.

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



The Ogallala Formation consists of coarse sandstone and conglomerates of late Tertiary (Miocene-Pliocene) age (Nativ 1988). The sediments consist of coarse fluvial clastics that were deposited in paleovalleys in a mid-Tertiary erosional surface with eolian sands in intervening upland areas. The Ogallala Formation is ~ 30m thick in the south (Ector-Midland Counties). The top of the Ogallala Formation is marked by a resistant calcite layer termed the “caprock” caliche.

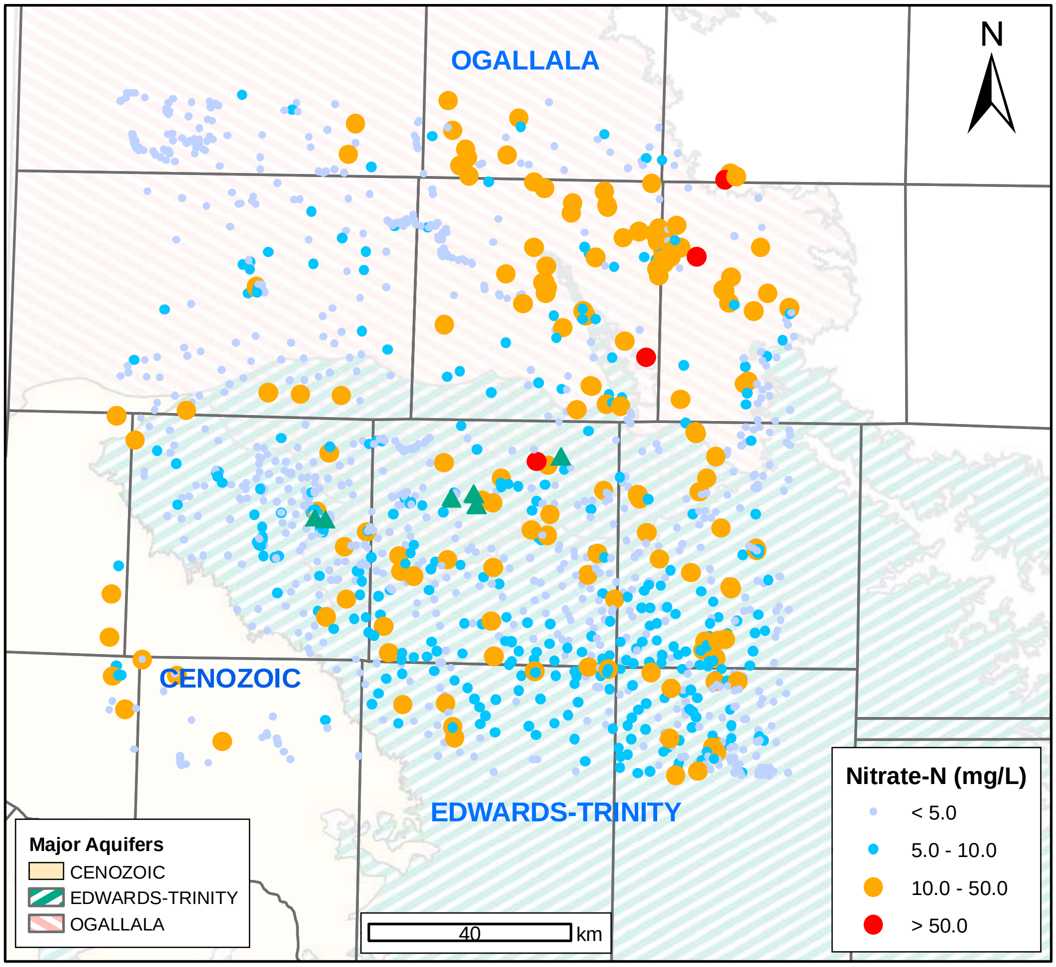
The Edwards Trinity (Plateau) aquifer underlies the Ogallala aquifer in Andrews, Martin, Ector, Midland, and Glasscock Counties and crops out south of this region. This aquifer consists predominantly of the Trinity Group (Early Cretaceous age) and includes the Antlers Sandstone in Ector and Midland Counties, which is overlain by the Washita and Fredericksburg Divisions in Glasscock County (Barker and Ardis 1996). 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 overlying Washita and Fredericksburg Divisions are carbonate dominated with interbedded sandstones. The Lower Cretaceous formations were karstified before deposition of the Upper Cretaceous formations. These units are divided into several formations with complicated terminology: Walnut Formation, Comanche Peak Limestone, and Edwards Limestone transitioning laterally in name to Fort Terrett Formation (base) and Fort Lancaster Formation in some places, and Segovia Formation in other places. The most prolific producing unit is the Fort Terrett Formation. When overlain by the Ogallala Formation, both formations are hydrologically connected and form the High Plains aquifer. However, in some areas only the Cretaceous unit is saturated, and the Ogallala sediments are in the unsaturated zone.

The CPA aquifer consists of up to 1,500 feet of alluvial fill and occupies two separate basins: the Pecos Trough to the west, and the Monument Draw Trough in the east (E. Ector, Winkler, Ward, Crane, and Pecos Counties). These troughs formed as a result of dissolution of underlying evaporites (rock salt, anhydrite, gypsum) in the Permian units. Groundwater occurs under unconfined (water table) or semiconfined conditions. The alluvium consists of unconsolidated or poorly cemented clay, sand, gravel, and caliche (White 1971). North of the Pecos River the alluvium is overlain by windblown sand deposited in dunes. The sand dunes are up to 250 feet thick.

3.2 GENERAL TRENDS IN NITRATE CONCENTRATIONS

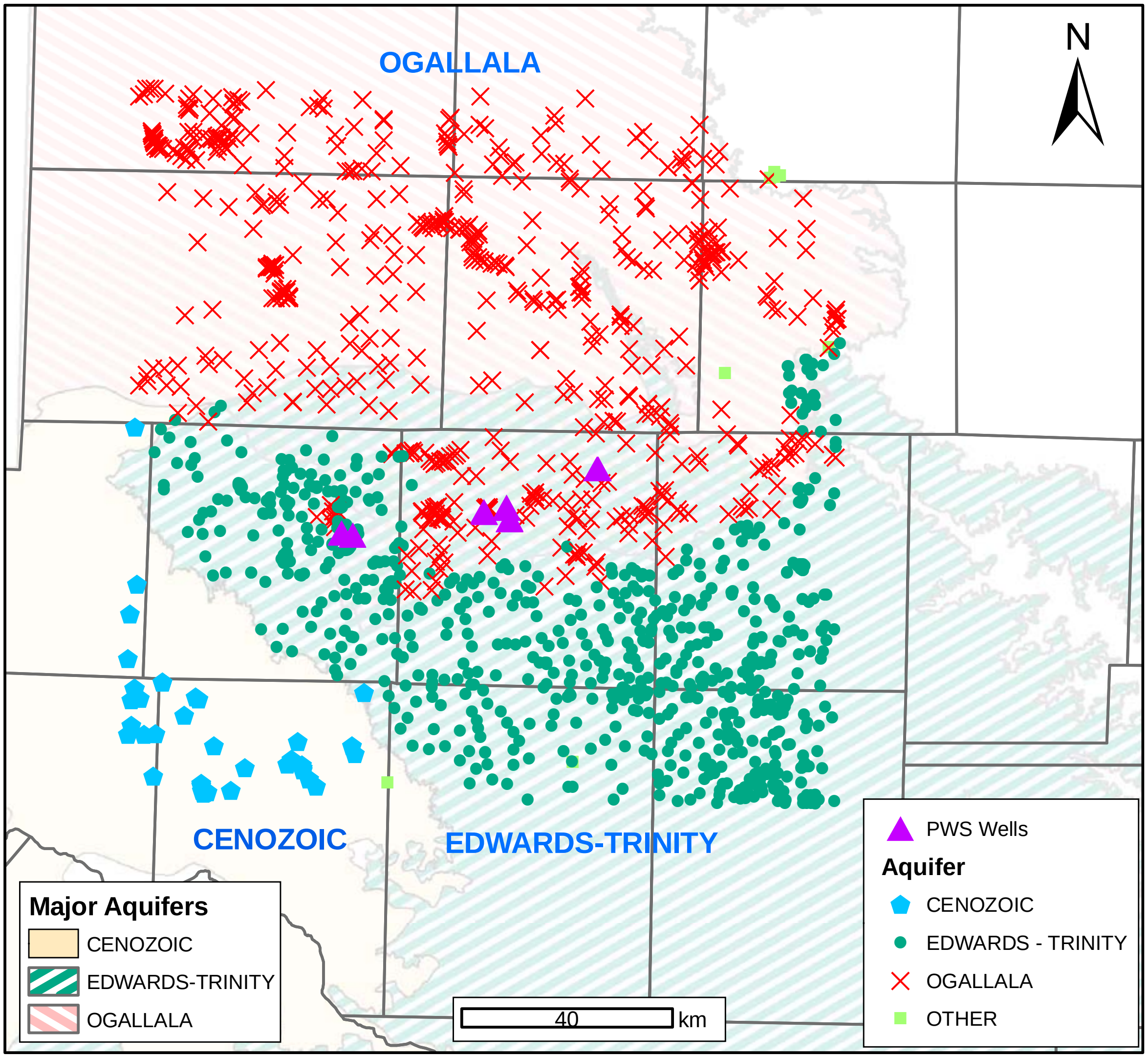
The geochemistry of nitrate is described in Appendix E. Nitrate trends in the vicinity of the assessed PWSs were examined to assess spatial trends, as well as correlations with other water quality parameters. Nitrate measurements are from the TWDB database. Figure 3.2 shows spatial distribution of nitrate concentrations from the TWDB database.

Figure 3.2 Detectable Nitrate-N Concentrations in Groundwater (TWDB Database, Analyses from 1937 through 2004)



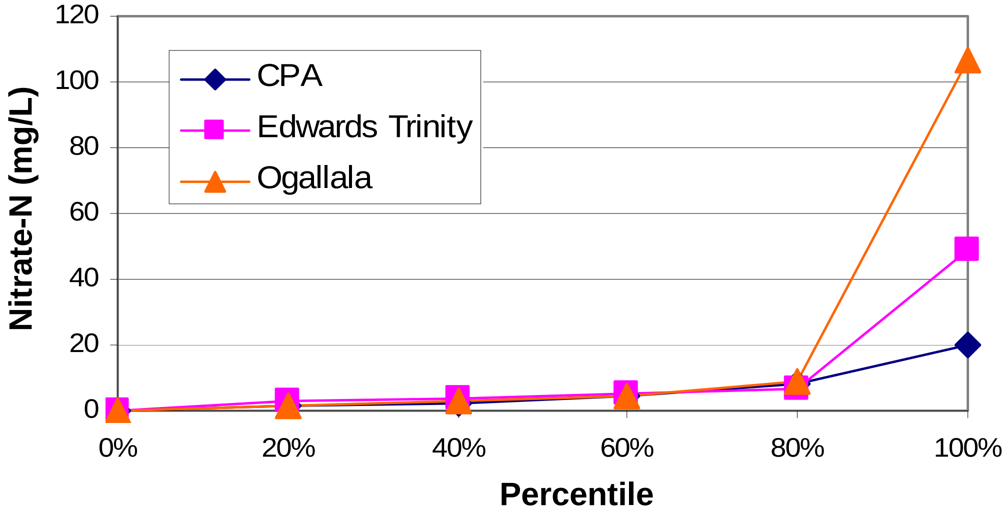
From the TWDB database, 1,410 measurements were extracted, representing the most recent nitrate measurements taken at a specific well (if more than one sample existed for 1 day the average for the day was calculated). Samples were limited to an area delimited by the following coordinates: bottom left 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). Figure 3.3 shows wells with nitrate samples categorized by aquifers.

Figure 3.3 Wells with Nitrate Samples Categorized by Aquifer



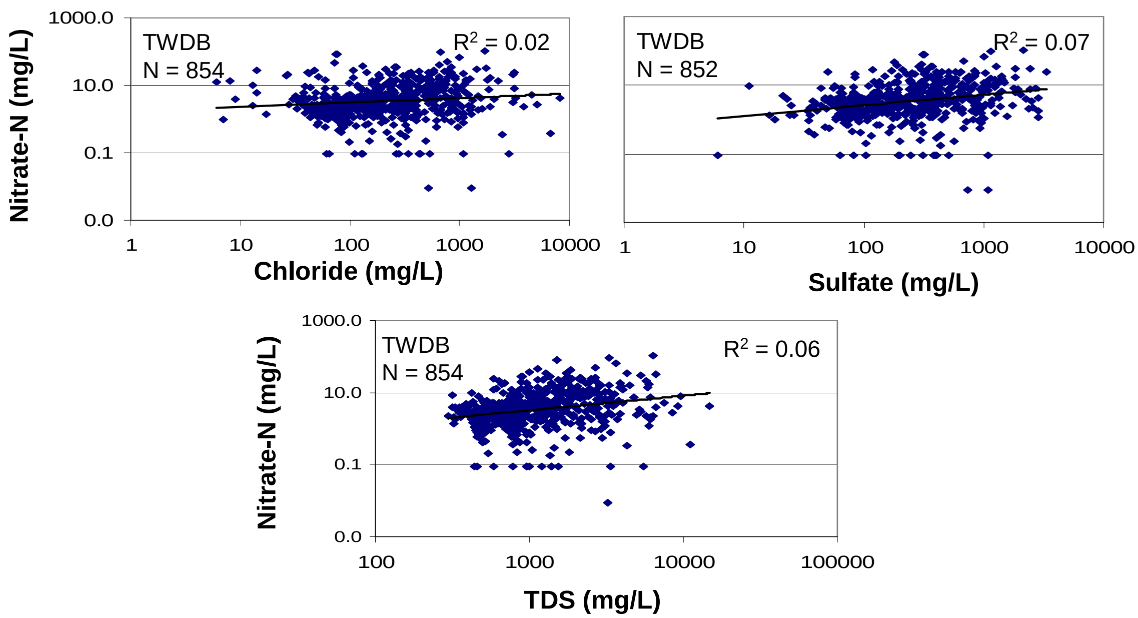
The above map (Figure 3.3) shows 1,410 wells that have nitrate measurements from the TWDB database: 774 are in the Edwards Trinity (Plateau) aquifer, 584 in the Ogallala aquifer, 43 in the CPA aquifer, and 9 in other aquifers. The distribution of nitrate-N concentrations within the three aquifers (CPA, Edwards Trinity (Plateau), and Ogallala) is similar (Figure 3.4). The similarity in nitrate-N levels among the aquifers suggests the source of nitrate is not a particular geologic unit but probably anthropogenic in origin.

Figure 3.4 Distribution of Nitrate-N Concentrations



Nitrate-N is not strongly related to general water quality parameters (sulfate, chloride, and total dissolved solids (TDS)) in the Ogallala aquifer (Figure 3.5). Similar results were found for the Edwards-Trinity (Plateau) aquifer where the coefficient of determination or R-squared (R^2) is less than 0.1 (*i.e.*, little to no correlation), strengthening the conclusion that nitrate-N sources are anthropogenic rather than geologic in origin.

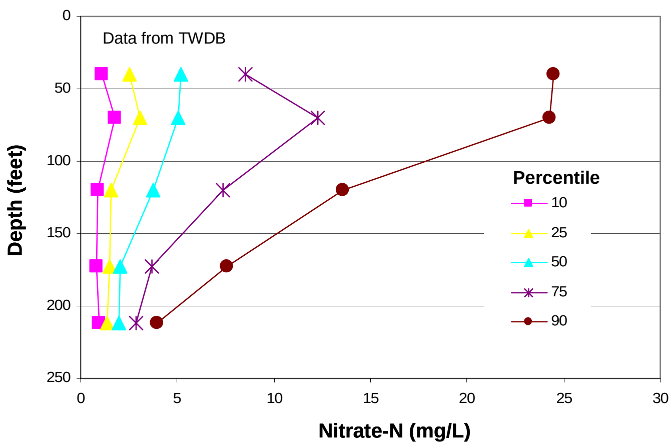
Figure 3.5 Correlation of Nitrate with Chloride, Sulfate, and TDS in the Ogallala Aquifer



Note: 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 in 1 day the average concentration is calculated; only seven wells had more than one sample for the most recent day).

Nitrate-N concentrations are 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).

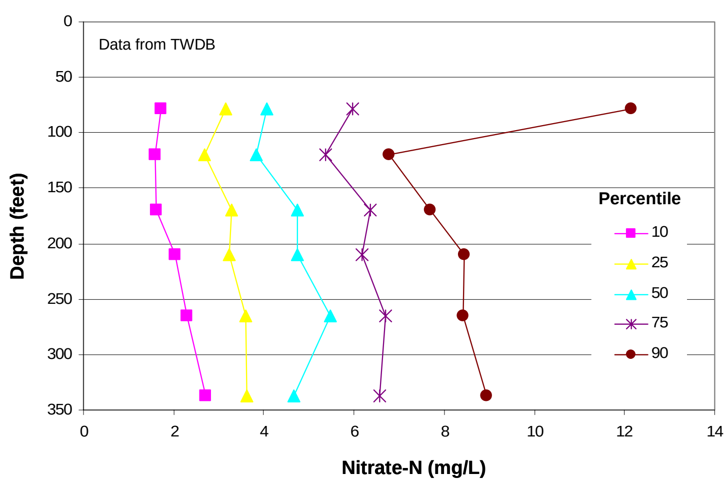
Figure 3.6 Relationship Between Nitrate-N Concentrations and Well Depth in the Ogallala Aquifer



Depth interval (feet)	Min. depth (feet)	Max. depth (feet)	Median depth (feet)	Num. 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

For Figure 3.6, wells are 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.

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



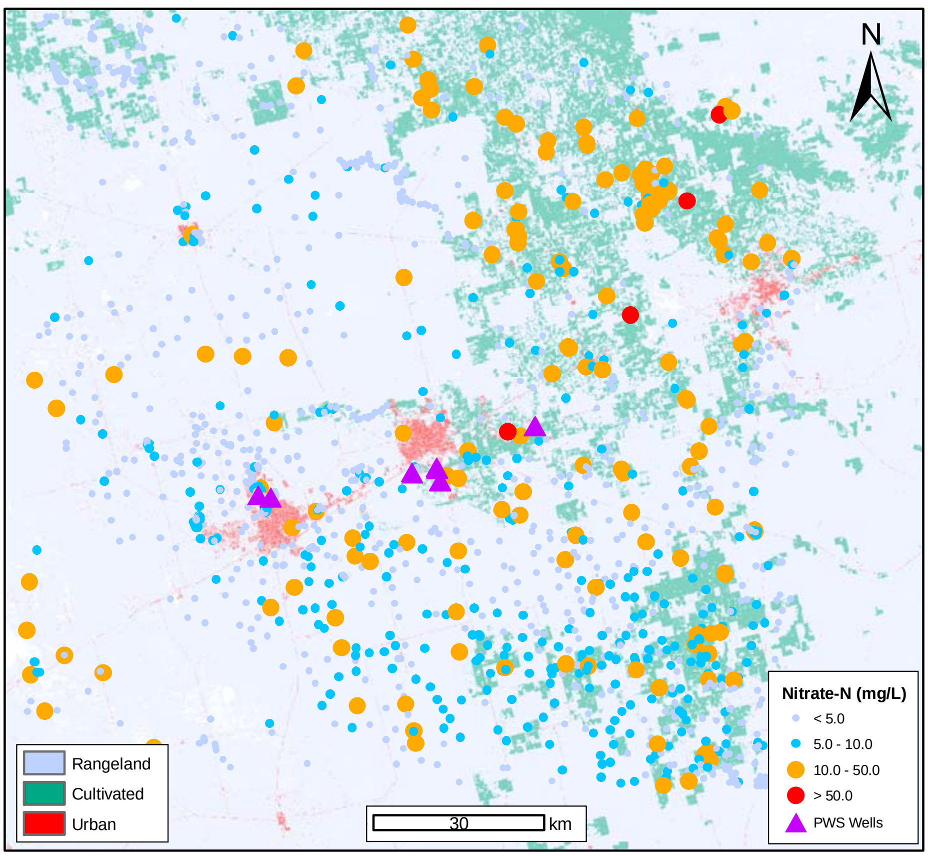
Depth range (feet)	Min. depth (feet)	Max. depth (feet)	Median depth (feet)	Num. of wells
< 100	37	99	79	77
100-150	100	149	120	170
150-200	150	197	170	143
200-250	200	248	211	106
250-300	250	297	265	72
> 300	300	495	337	116

Figure 3.7 shows the relationship between nitrate-N concentrations and depth within the Edwards-Trinity (Plateau) aquifer. Wells are divided into depth bins, and for each bin, nitrate-N concentrations are shown with respect to median depth. The table on

the right summarizes the depth values for each bin and gives the number of wells in the analysis for that depth range. 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 shallower wells (< 100 feet) have higher concentrations.

Nitrate-N concentrations from the TWDB database were compared with land use from the National Land Cover Dataset (NLCD 1992). Land-use datasets are categorized into three groups (rangeland, cultivated, and urban) and compared with nitrate-N concentrations within the study area. Figure 3.8 shows the spatial distribution of nitrate-N and land use; high concentrations of nitrate-N are generally found in cultivated areas. Figure 3.9 shows the correlation between land-use types and nitrate-N concentrations.

Figure 3.8 Spatial Relationship Between Land Cover (NLCD) and Nitrate-N Concentrations



Note: Nitrate concentrations are from the TWDB database, and the most recent nitrate measurement is shown for each well.

Figure 3.9 Relationship Between Nitrate-N Concentrations and Land Use

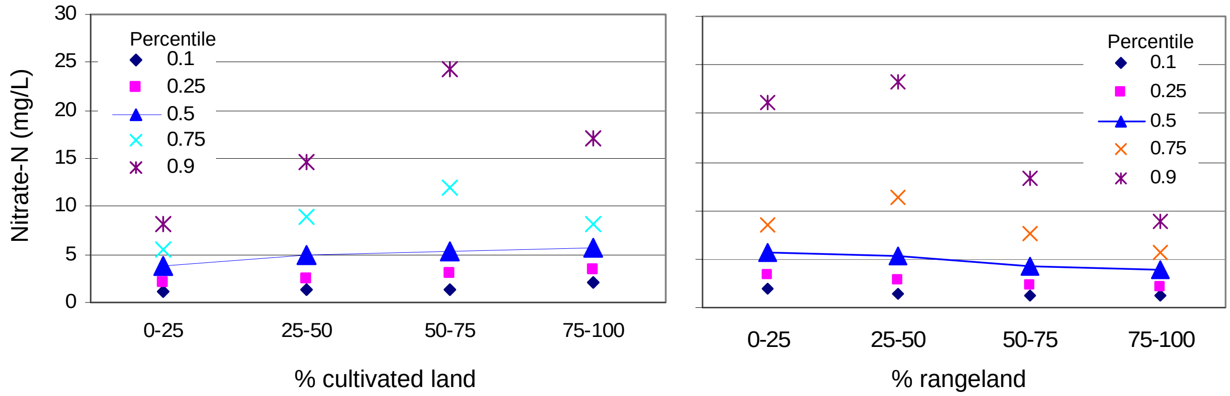


Figure 3.9 shows nitrate-N concentrations in groundwater in relation to land use within a 1-km radius of well locations. Land use was obtained from the NLCD and was categorized into the following land-use types: rangeland (NLCD codes 51, 71, 41, 42, and 43), cultivated (NLCD codes 81, 82, 83, and 61), and urban (NLCD codes 21, 22, 23, and 85). The complementary analysis accounts for more than 90 percent of the land use related to over 95 percent of the wells. Nitrate-N concentrations are from the TWDB database, and the most recent measurement is used for each well. Nitrate-N concentrations generally increase with percentage of cultivated land (left plot) and decrease with percentage of rangeland (right plot). The two plots are generally complementary with increases in nitrate-N with cultivation and decreases in nitrate-N with rangeland. The greatest increases in nitrate-N with cultivation occur in the upper 75^{th} and 90^{th} percentiles. Population means of the land-use groups (percentage bins) are statistically different ($P < 1e^{-9}$) for both land-use categories.

3.3 GENERAL TRENDS IN ARSENIC CONCENTRATIONS

The geochemistry of arsenic is described in Appendix E. Arsenic trends in the vicinity of the analyzed PWSs were examined to assess spatial trends, as well as correlations with other water quality parameters. Arsenic measurements 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. Figure 3.10 shows spatial distribution of arsenic concentrations from the TWDB database, and Figure 3.11 shows percentages of wells in each aquifer that exceed the MCL of arsenic of 10 µg/L.

Figure 3.10 Spatial Distribution of Arsenic Concentrations (TWDB Database)

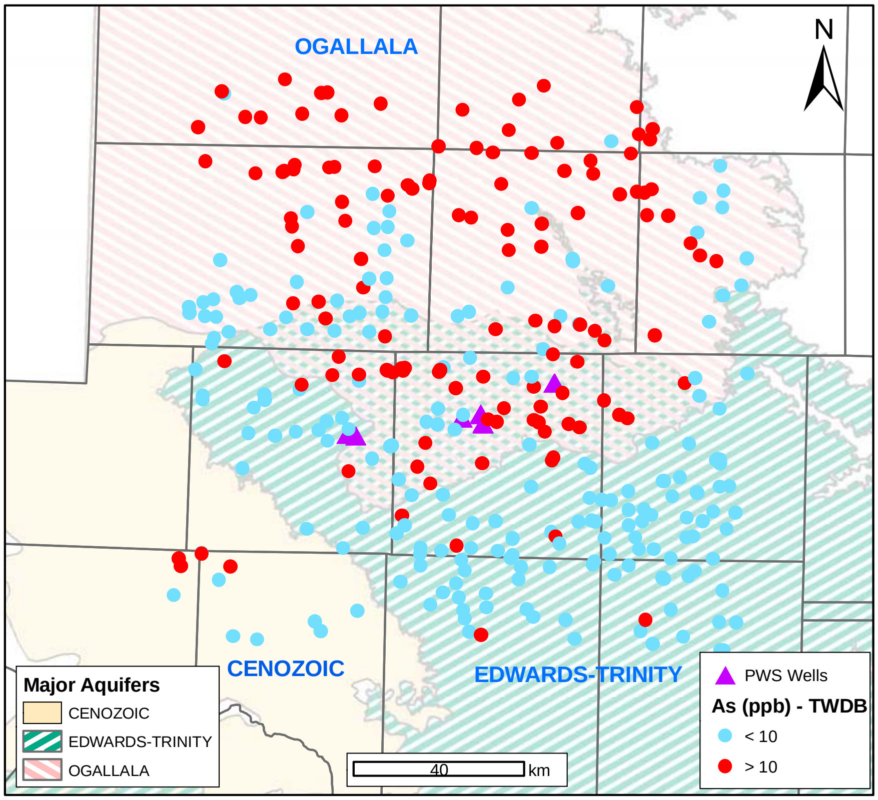
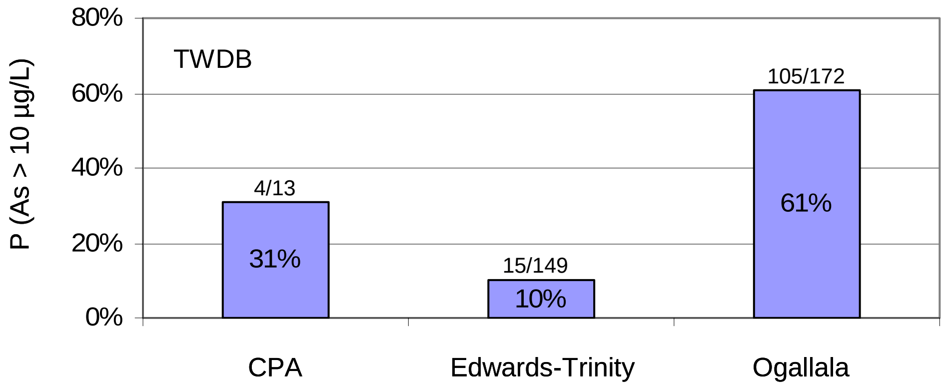


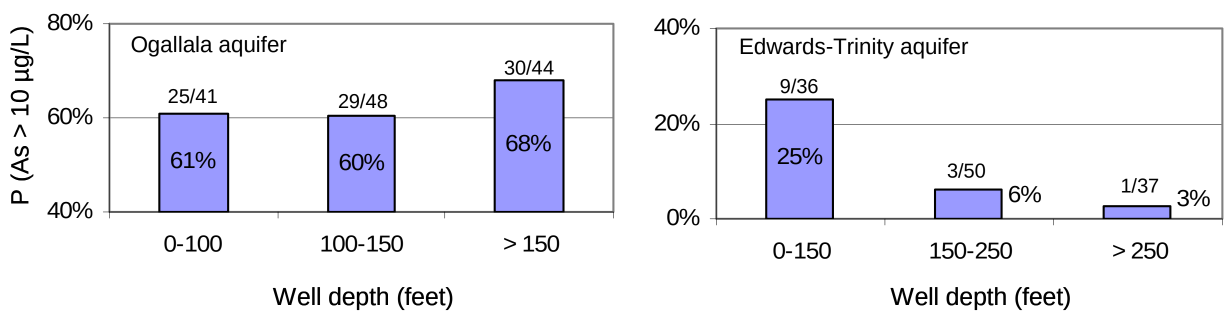
Figure 3.11 Probabilities of Arsenic Concentrations Exceeding 10 µg/L MCL for Aquifers in the Study Area



Data in Figures 3.10 and 3.11 are from the TWDB database. The most recent arsenic measurement was used for each well. The Ogallala aquifer has a percentage of wells with arsenic concentrations >10 µg/L which is higher than the other aquifers (Figure 3.11). Within the Ogallala aquifer, 61 percent of the wells had arsenic concentrations >10 µg/L, in comparison with the CPA (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 boundary of the Ogallala aquifer (only seven wells with high arsenic are outside the aquifer boundary, and three of those seven are within 5 km of the boundary). It is possible 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 has a secondary aquifer (Dockum) designated 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 were not strongly correlated with well depth. Within the Edwards-Trinity (Plateau) aquifers the shallower wells (<150 feet) have higher probabilities of arsenic concentrations exceeding 10 µg/L. 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 strengthens the assumption that the source of contamination for wells within the Edwards-Trinity (Plateau) aquifers is actually from the Ogallala aquifer.

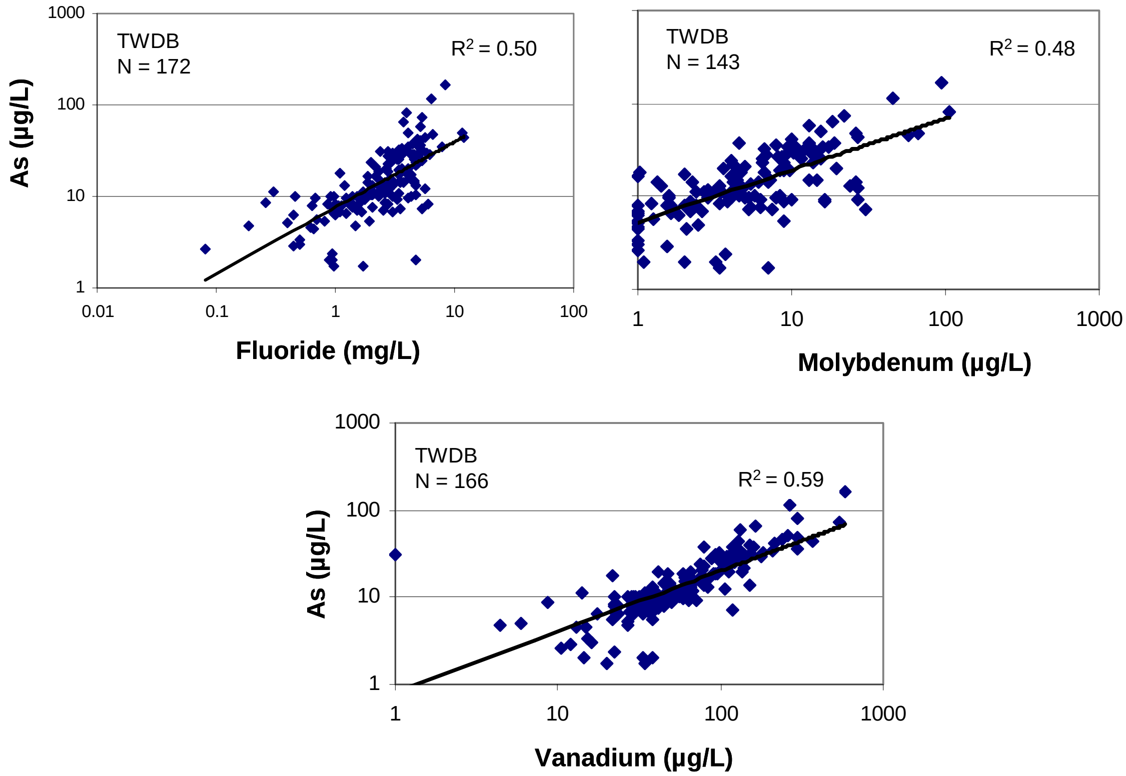
Figure 3.12 Relationship Between Arsenic Concentrations and Well Depth



Data are from the TWDB database, and the most recent arsenic measurement was used for analysis for each well. Numbers above each column represent numbers of arsenic measurements that are >10 µg/L and total number of analyses in the bin. For example, 25/41 represents 24 samples >10 µg/L out of 41 analyses at a well depth between 0 and 100 feet.

Relationships between arsenic and pH, SO_4, fluoride, chloride, TDS, vanadium, and molybdenum were evaluated using data from the TWDB database. Data from the NURE database were used to evaluate the relationship between arsenic concentrations and dissolved oxygen concentrations. Strong coefficients of determination or R-squared values (R^2 >0.48) were found between arsenic and fluoride, arsenic and vanadium, and arsenic and molybdenum 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 are from the TWDB database, and the most recent arsenic sample was used in the analysis for each well. Fluoride, molybdenum, and vanadium concentrations were measured the same day as those of the most recent arsenic measurements. A total of nine arsenic measurements within the database were below the detection limit of 10 µg/L, and two samples are below the detection limit of 2 µg/L. These samples are plotted as equal to detection limits (10 and 2, respectively). Vanadium samples have a detection limit of 1 µg/L 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 µg/L. Values below detection limits of 50 and 20 were excluded from analysis, and remaining values 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 between 6.7 and 14.3 mg/L. No aquifer designation is within 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). Depths for these wells range from 6 to 70 feet, also suggesting they are in the shallow Ogallala aquifer. Dissolved oxygen values show that groundwater is oxidizing and that arsenic should be present as arsenate and may have been mobilized under high pH (see Appendix E).

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 the source of arsenic is from the Ogallala aquifer overlying the Edwards-Trinity (Plateau) aquifer.

3.4 DETAILED ASSESSMENT FOR GREENWOOD ISD (PWS 1650035)

Four active wells (G1650035A, G1650035B, G1650035C, and G1650035D) and one emergency well (G1650035E) are in this water supply system. All wells except well G1650035E have a depth of 120 feet; well G1650035E has a depth of 94 feet. All wells are within the Ogallala aquifer. Screen depth information is not available. All wells are related to one entry point in the water supply system, making it difficult to trace contaminants to a specific well. Table 3.1 summarizes nitrate-N concentrations measured at the Greenwood ISD PWS.

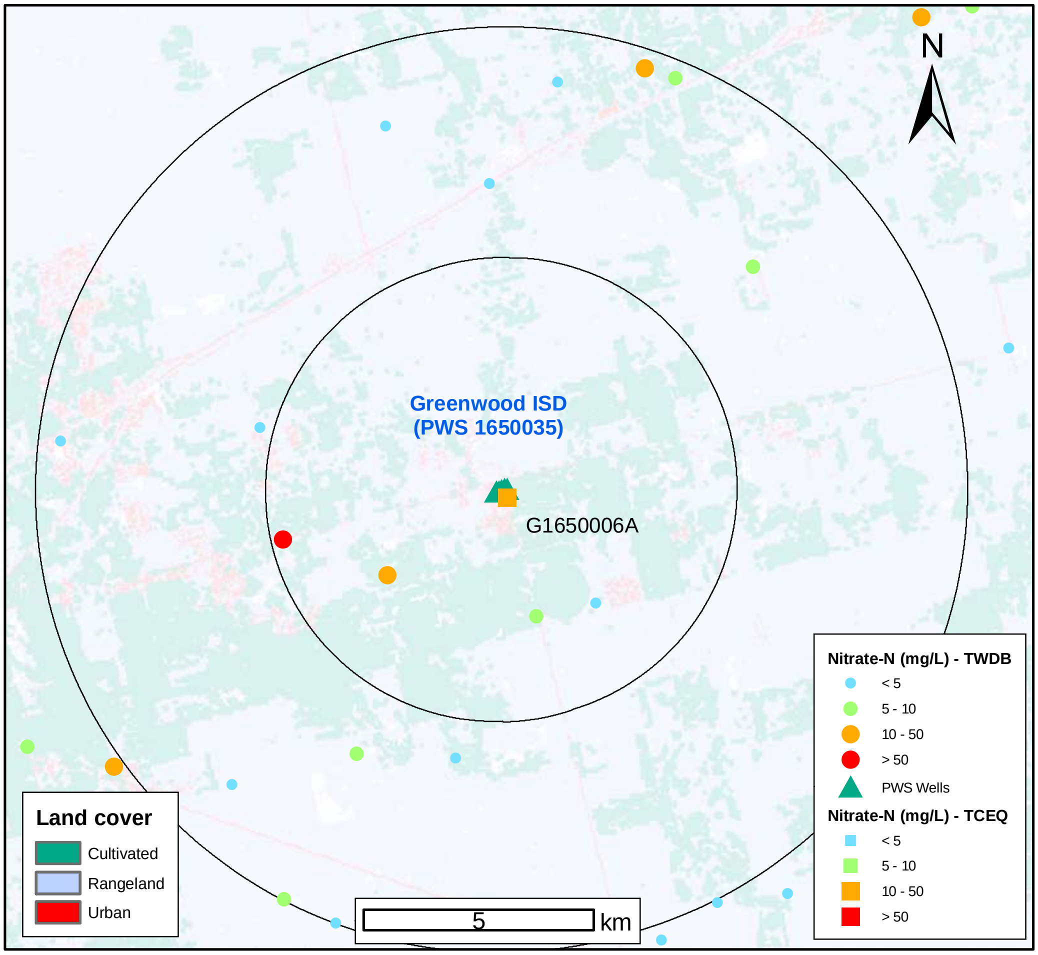
Groundwater nitrate and arsenic concentrations can have a high degree of spatial variability. Because of this variability, an investigation of the existing wells should be conducted to determine whether one, several or all five wells produce non-compliant water. If one well is found to produce compliant water, as much production as possible should be shifted to the compliant well. Also, if one well is found to produce compliant water, the wells should be compared in terms of depths and well logs to try and identify differences that could be responsible for the elevated concentration of arsenic in the other well. Then if blending of water from the existing wells does not produce a sufficient quantity of compliant water, it may be possible to install a new well similar to the existing compliant well that also would provide compliant water.

Table 3.1 Nitrate-N Concentrations in the Greenwood ISD PWS (TCEQ Database)

Date	Nitrate-N (mg/L)	Source
3/19/1997	13	TCEQ
7/8/1997	12.99	TCEQ
9/24/1997	15.01	TCEQ
12/10/1997	14.54	TCEQ
2/3/1998	13.91	TCEQ
4/15/1998	13.66	TCEQ
8/4/1998	12.23	TCEQ
8/4/1998	12.23	TCEQ
6/30/1999	14.41	TCEQ
8/17/1999	13.29	TCEQ
11/1/1999	13.42	TCEQ
2/8/2000	13.3	TCEQ
6/22/2000	13.48	TCEQ
7/26/2000	13.81	TCEQ
11/16/2000	14.62	TCEQ
2/26/2001	13.74	TCEQ
6/25/2001	14.19	TCEQ
9/25/2001	15.33	TCEQ
12/4/2001	14.29	TCEQ
2/20/2002	13.24	TCEQ
6/24/2002	14.69	TCEQ
8/29/2002	14.76	TCEQ
11/6/2002	14.08	TCEQ
4/24/2003	16.12	TCEQ
4/24/2003	15.89	TCEQ
7/24/2003	15.24	TCEQ
2/10/2004	16.17	TCEQ
5/5/2004	0.75	TCEQ
11/29/2004	15.9	TCEQ
2/28/2005	16.9	TCEQ

Thirty nitrate samples were collected at the PWS between 1997 and 2005. All samples except for one are above the nitrate-N MCL (10 mg/L). Figure 3.14 shows the spatial distribution of nitrate-N concentrations within 5- and 10-km buffers of the PWS wells.

Figure 3.14 Nitrate-N Concentrations in 5- and 10-km Buffers of Greenwood ISD PWS Wells (TWDB and TCEQ Databases)



Data are from the TCEQ and TWDB databases. Maximum nitrate-N concentration is shown for each well. Two types of samples were included in the analysis from the TCEQ database: raw samples that can be related to a single well and entry-point samples taken from a single entry point, which can be related to a single well.

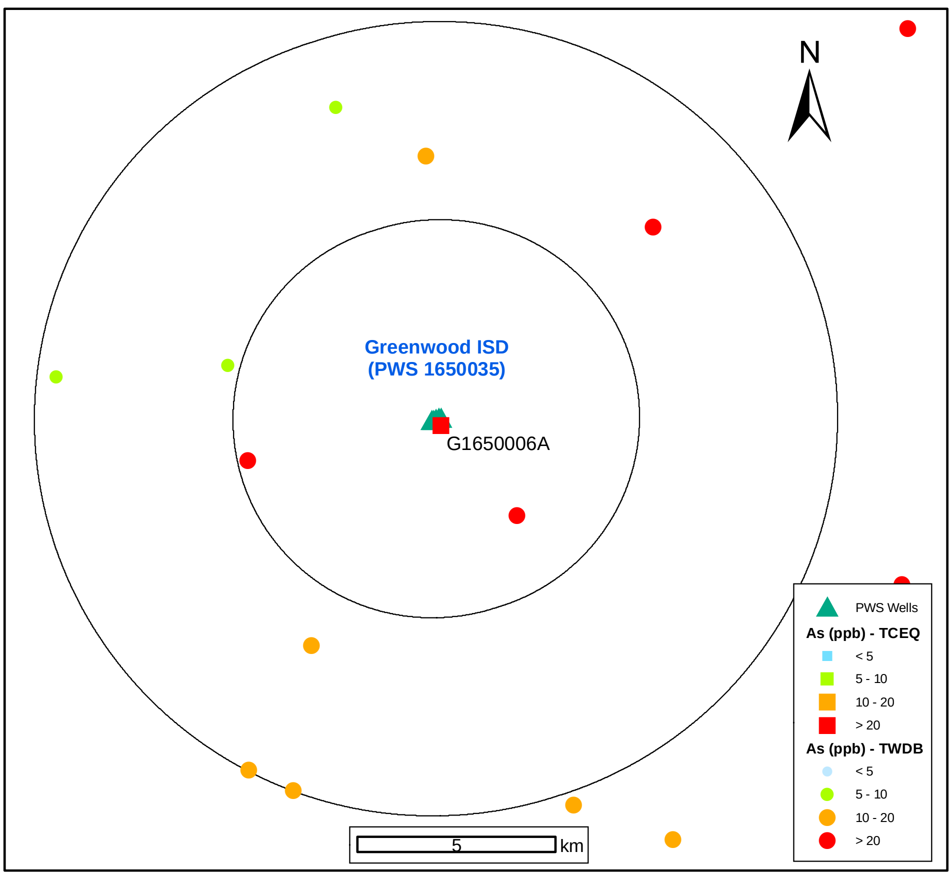
Only one well had nitrate-N samples from the TCEQ database within the buffers (G1650006A), and it had nitrate-N concentrations >10 mg/L. Three wells from the TWDB database within buffers of the PWS wells had high (>10 mg/L) nitrate-N concentrations. Table 3.2 summarizes arsenic concentrations measured at the Greenwood ISD PWS.

Table 3.2 Arsenic Concentrations in the Greenwood ISD PWS (TCEQ Database)

Date	As (µg/L)	Source
3/19/1997	28.1	TCEQ
2/8/2000	27	TCEQ
4/24/2003	25.7	TCEQ
2/10/2004	25.5	TCEQ
2/28/2005	40.3	TCEQ

Five arsenic measurements from the TCEQ database were collected at the PWS between 1997 and 2005. All measurements are above the arsenic MCL (10 µg/L). Figure 3.15 shows the spatial distribution of arsenic concentrations within 5- and 10-km buffers of the PWS wells.

Figure 3.15 Arsenic Concentrations in 5- and 10-km Buffers of Greenwood ISD PWS Wells (TWDB and TCEQ Databases)



Data are from the TCEQ and TWDB databases. Maximum arsenic concentration is shown for each well. Two types of samples were included in the analysis from the TCEQ database: raw samples that can be related to a single well and entry-point samples taken from a single entry point, which can be related to a single well. Only one PWS well from the TCEQ database had arsenic measurements within the buffers (well G1650006A), and it had arsenic concentrations above the MCL. Seven TWDB wells are within the buffers with arsenic concentrations >10 µg/L and three with arsenic concentrations <10 µg/L.

SECTION 4
ANALYSIS OF GREENWOOD ISD PWS

4.1 DESCRIPTION OF EXISTING SYSTEM

4.1.1 Existing System

The location of the Greenwood ISD PWS is shown on Figure 4.1. The PWS has four active groundwater wells supplying water to the entire school campus. In addition, Greenwood ISD completed two new wells to provide an adequate source of water for irrigating sports fields on the campus. These new wells may be used to supplement the potable water wells on an emergency basis once the TCEQ approves a Temporary Water Use Permit. Information on the four potable water wells completed in the Ogallala aquifer is provided in the following table.

WELL NO.	SOURCE NO.	DEPTH (FT)	RATED GPM
1	G1650035A	120	48
2	G1650035B	120	42
3	G1650035C	120	38
4	G1650035D	120	38

Water from the wells is injected with sodium hypochlorite and pumped into two 40,000-gallon storage tanks. Water is pumped from the storage tanks to pressure tanks located inside a building for distribution throughout the campus. The system is equipped with an emergency generator in the event of a power failure.

Information on the two new irrigation water wells completed in the Ogallala Aquifer is provided in the following table. These wells are located approximately 3 miles south of the school campus. Water from the irrigation wells is pumped into a 40,000-gallon storage tank located adjacent to the potable water tanks and a storage tank located next to the bus barn. This water is not chlorinated since its intended use is for irrigation only.

WELL NO.	WELL NAME	DEPTH (FT)	RATED GPM
5	South Well	160	120
6	Middle Well	150	100

Basic system information is as follows:

- Population served: 1545 (faculty, staff, and students)
- Connections: 2; however, cost based on per capita
- Average daily flow rate: 0.030 mgd*
- Peak demand flow rate: 0.06 mgd**
- Typical nitrate range: 15.8 – 16.9 mg/L (before RO treatment)

- Typical arsenic range: 25.5 – 40.3 µg/L (before RO treatment)
- Typical TDS: > 2000 mg/L (before RO treatment)

* *Estimated at 19.5 gallons per capita per day (gpcd).*
** *Estimated at 2 times average daily flow.*

Greenwood ISD installed RO treatment units at each of the four campus cafeterias and in the field house. RO-treated water is piped to the water fountains and ice machines, and drops are provided in the cafeteria for food preparation and at coffee pots.

4.1.2 Capacity Assessment for Greenwood ISD

The project team conducted a capacity assessment of the Greenwood ISD PWS to evaluate the system's FMT capabilities. The evaluation process involved interviews with staff and management who have a responsibility for either operations or management of the system. The questions were designed to be open ended to provide a better assessment of overall capacity. In general, the technical aspects of capacity are discussed elsewhere in this report. This section focuses on the managerial and financial components of capacity.

The capacity assessment is separated into four categories: general assessment of capacity, positive aspects of capacity, capacity deficiencies, and capacity concerns. The general assessment of capacity describes the overall impression of FMT capability of the water system. The positive aspects of capacity describe those factors which the system is doing well. Those factors should provide opportunities for the system to build upon in order to improve capacity deficiencies. The capacity deficiencies noted are those aspects that are creating a particular problem for the system. 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 ensure proper operation of the system. The last category is titled capacity concerns. These are items that, in general, are not causing significant problems for the system at this time. However, the system may want to address them before these concerns have the opportunity to cause problems.

The following personnel involved with the Greenwood ISD PWS were interviewed:

- Glenn Barber, School Superintendent
- Cindy King, PWS Operator

All interviews were conducted in person.

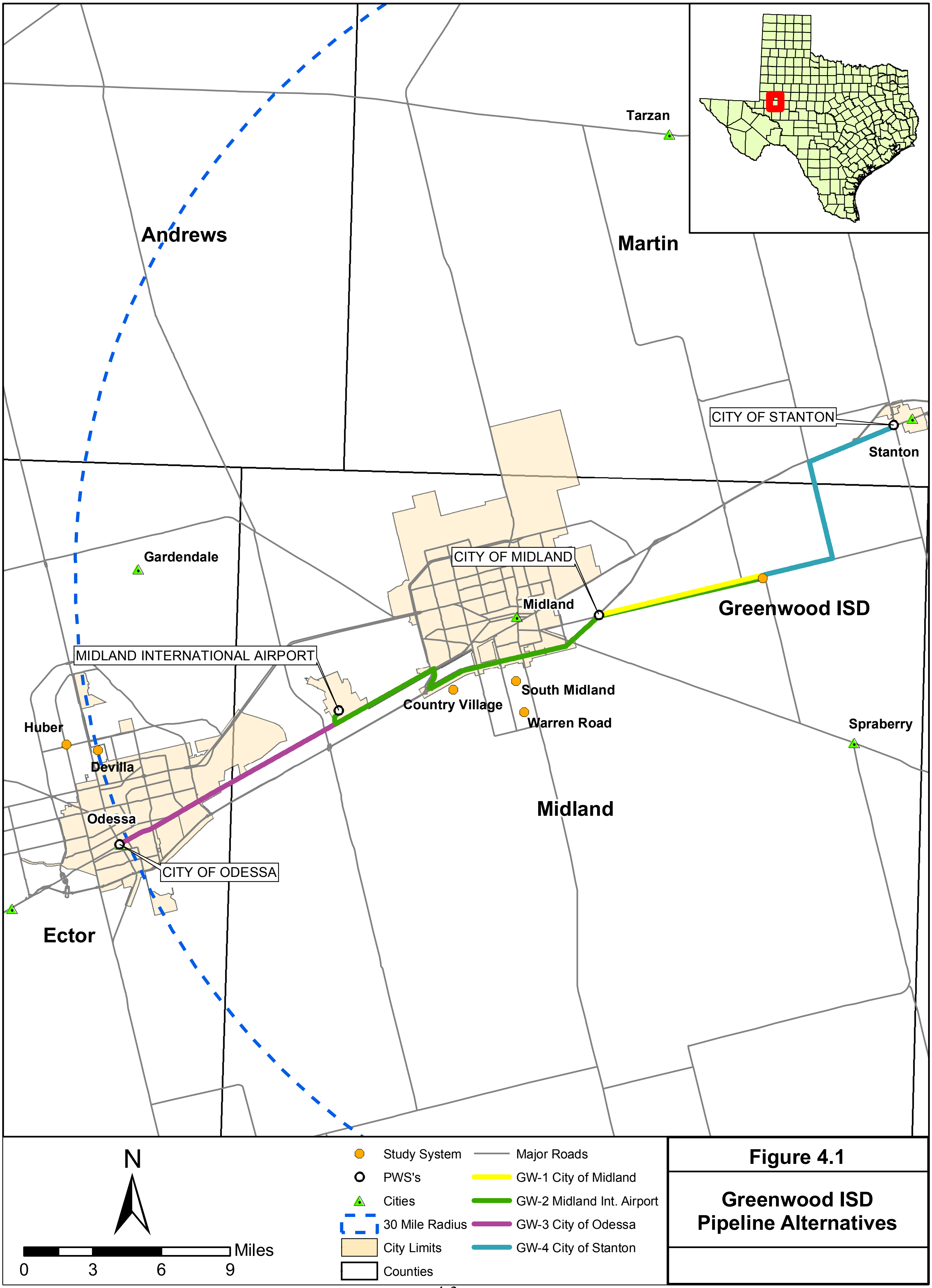


Figure 4.1

Greenwood ISD Pipeline Alternatives

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4.1.2.1 General Structure

The Greenwood ISD PWS serves the campus, providing water to approximately 1,545 students during the school year and to minimal staff during the summer months. The campus is located in the eastern part of Midland County, approximately 10 miles from downtown Midland. There are no retail businesses in the community of Greenwood. The District Superintendent reports to a seven-member School Board. The District has ongoing contracts with a certified operator for maintenance of five RO treatment units. District maintenance staff operates and maintains the wells, tanks, and distribution system.

4.1.2.2 General Assessment of Capacity

While the District's primary function is to provide an education to its students, it is also responsible for providing safe drinking water to students and staff. Overall, the system has an adequate level of capacity.

4.1.2.3 Positive Aspects of Capacity

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

- **Dedicated and Capable Operator and Staff -** The certified operator and the maintenance staff for the system are very dedicated to the school and committed to providing safe drinking water. The operator and her family have strong ties to the community and are willing to take whatever actions necessary to ensure the drinking water is safe. The District maintenance staff are also very capable and hardworking and seem to take responsibility for whatever needs to be done.
- **Communication** - There seems to be good communication as well as a high level of trust between the operator, District maintenance staff, and Superintendent. In addition, the Superintendent has kept the School Board apprised of the nitrate and arsenic concerns, so it is aware of the issues involved.

4.1.2.4 Capacity Deficiencies

The following capacity deficiencies were noted in conducting the assessment.

- **Lack of Long-Term Capital Improvements Planning –** While there is some future planning, the District does not have a 20-year capital improvements planning process. The lack of planning may negatively impact the ability of the PWS to plan and finance long-term needs.

4.1.2.5 Potential Capacity Concerns

The following items are concerns regarding capacity but there are no particular operational, managerial, or financial problems that can be attributed to these items. The system should focus on the deficiencies noted above in the capacity deficiency section. Addressing the items listed below will help in further improving FMT capabilities.

- **Separate Budget for Water Operations –** There is no separate operating budget for the water system. Costs are only allocated to the Plant Maintenance & Operation Category of the budget. It is important to have some method of determining the actual cost of providing water service.
- **Reserve Account –** While there seems to be an adequate amount of money in the Fund Balance, no amount has been strictly dedicated to the water system. If possible, it would be good to allocate an appropriate amount for water system emergencies.
- **Source Water Protection Program –** The District does not have a source water protection plan in place. While some measures have already been taken for the new wells and pump house, an overall plan has not be implemented.
- **Written Operational Procedures –** There are no written procedures for standard O&M. At this time, the staff know what tasks need to done and are able to operate the system without written procedures. The lack of written procedures may cause problems if new staff members are hired or current staff members leave.
- **Knowledge of Safe Drinking Water Regulations** - The District Superintendent relies on the contract operator to be familiar with current Safe Drinking Water Regulations. However, responsibility for complying with the regulations lies with the owner of the system.

4.2 ALTERNATIVE WATER SOURCE DEVELOPMENT

4.2.1 Identification of Alternative Existing Public Water Supply Sources

Table 4.1 is a list of the existing groundwater-supplied PWSs within approximately 30 miles of the Greenwood ISD. Selected sources are shown on Figure 4.1.

Table 4.1 Existing Groundwater-Supplied Public Water Supply Systems

System Name	Distance from Greenwood ISD (miles)	Comments / Issues
Greenwood Ventures Inc.	0.1	Small system with WQ issues: As, TDS, NO3, gross alpha; marginal exceedances: fluoride, Se
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 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
South Midland County Water Systems	11.6	Small system with WQ issues: As, TDS, NO3
Warren Road Subdivision	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
City of Midland	13.0	Large system (>1 mgd) with WQ issues: As, TDS, fluoride
Country Village Mobile Home Estates	14.4	Small system with WQ issues: As, TDS, NO3
Westgate Mobile Home Park	14.7	Small system with water quality issues: trichloroethylene (TCE) and methyl t-butyl ether (MTBE) have been detected
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	19.6	Small system with WQ issues: As, TDS, NO3
Midland International Airport	19.6	Large system (>1 mgd) with marginal As exceedances
City of Odessa	30.4	Large system (>1 mgd) with WQ issues: TDS, SO4

Table 4.2 Public Water Systems within 30 miles of Greenwood ISD Selected for Further Evaluation

Colorado River Municipal Water District
City of Midland
Midland International Airport
City of Odessa
City of Stanton

4.2.1.1 Colorado River Municipal Water District

The Colorado River Municipal Water District (CRMWD) supplies water to both the Cities of Midland and Odessa and, while it would not supply water directly to

Greenwood ISD, 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 full combined capacity of these reservoirs is 1.272 million acre-feet. Additionally, CRMWD operates five well fields for water supply. Three of these 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 mgd. CRMWD primarily uses these well fields to supplement surface water deliveries during the summer months.

4.2.1.2 City of Midland

The City of Midland is located approximately 8 miles west of Greenwood ISD. The City of Midland purchases approximately 75 to 80 percent of its water from the CRMWD through a 1966 contract agreement. 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 million-gallon reservoir located at the water purification plant, and the 100 million gallon 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 located approximately 2 miles west of the City's water treatment plant. In addition to 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 million gallons from Lake Ivie and 16 million gallons 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 a 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 million gallon 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 constituents. The third well field is the T-Bar Ranch, which is 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 35,500 connections, about 32,000 of which are metered. The major users of water in Midland include the 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 of water and $2.75 for each additional 1,000 gallons.

In the fall of 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 town to be annexed must submit a petition signed by at least 50 percent of the community residents wanting to be annexed. The commission representing the community then appoints 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.

4.2.1.3 Midland International Airport

Midland International Airport is located approximately 19 miles west of Greenwood ISD. 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 ground water consulting firm with an office in Midland, Arcadis, is currently evaluating the ability for the Midland International Airport well field to continue meeting the demands of the airport. Data for this report were collected during the summer 2005, and the evaluation report will be completed in the fall 2005.

Currently the operators of the PWS do not consider that there is sufficient excess capacity to provide water to offsite facilities or areas. However, based on the available water quality data, the location may be a suitable point for a new groundwater well.

4.2.1.4 City of Odessa

The intake point for the City of Odessa is located approximately 26 miles west of Greenwood ISD. 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. Groundwater is pumped from a well field in Ward County.

Raw water is delivered to a treatment facility where it is filtered and chlorinated, and then stored in a 4.3-million gallon concrete storage tank prior to distribution to the City of Odessa. In addition to the water delivered via the CRMWD pipeline, a relatively small amount of water (less than 10 percent) 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-million gallon storage tank.

In 2004, approximately 6.7 billion gallons of water was delivered to Odessa from San Angelo via the CRMWD pipeline, and 4.5 percent or 0.31 billion gallons originated from the Ward County Well Field. The 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 does have an excess capacity of treated water and may be willing to sell water to other PWSs. A community that wishes 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 they would have to fund the cost of the connecting pipeline.

4.2.1.5 City of Stanton

The City of Stanton is located approximately 9 miles northwest of Greenwood ISD. Stanton is under contract with the CRMWD to receive 90 million gallons 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 million gallons 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 groundwater 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 that treated water be piped to it 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, but that may change if gambling casinos are approved in Texas. Stanton is currently identified as a candidate site for a casino.

4.2.2 Potential for New Groundwater Sources

4.2.2.1 Installing New Compliant Wells

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

Since the PWS is already familiar with well operation, 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. As a result, existing wells identified with good water quality should be investigated. Re-sampling and test pumping would be required to verify and determine the quality and quantity of water at those wells.

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

4.2.2.2 Results of Groundwater Availability Modeling

Regional groundwater withdrawal in the vicinity of the Greenwood ISD is extensive and likely to remain near current levels over the next decades. In northern Midland County, where the study system is located, two aquifers are potential groundwater sources for public supplies: the Ogallala aquifer, and the downdip of the Edwards-Trinity Plateau aquifer.

Supply wells for Greenwood ISD and its vicinity withdraw groundwater primarily from the Southern Ogallala aquifer. The aquifer outcrop extends over most of the Texas panhandle and into eastern New Mexico, reaching northern and central Midland County. According to the 2002 Texas Water Plan, a 24 percent depletion in the Ogallala supply is anticipated over the next several decades, from 5,000,097 acre-feet per year 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, 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 ISD 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

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

Greenwood ISD 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 TWDB's 2002 Texas Water Plan anticipates an 11 percent reduction in surface water availability in the Colorado River Basin over the next 50 years, from 879,400 acre-feet per year in 2002 to 783,641 acre-feet per year in 2050.

The vicinity of the Greenwood ISD has a minimum availability of surface water for new users as indicated by the TCEQ's availability maps for the Colorado Basin. In the site vicinity, and over the entire Midland County, unappropriated flows for new uses are available at most 50 percent of the time. This supply is inadequate as the TCEQ requires a 100 percent supply availability for a municipal water supply.

4.2.4 Options for Detailed Consideration

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

1. City of Midland. Obtain treated CRMWD water through the City of Midland system. A pipeline and pump station would be constructed to transfer the water to the Greenwood ISD storage tanks (Alternative GW-1).

2. Midland International Airport. Obtain compliant groundwater from Midland International Airport. A pipeline and pump station would be constructed to transfer the water to the Greenwood ISD storage tanks (Alternative GW-2).

3. City of Odessa. Obtain treated CRMWD water through the City of Odessa system. A pipeline and pump station would be constructed to transfer the water to the Greenwood ISD storage tank (Alternative GW-3).

4. City of Stanton. Obtain treated CRMWD water through the City of Stanton system. A pipeline and pump station would be constructed to transfer the water to the Greenwood ISD storage tank (Alternative GW-4).

In addition to the location-specific alternatives above, three hypothetical alternatives are considered in which new wells would be installed 10-, 5-, and 1-miles from the Greenwood ISD PWS. Under each of these alternatives, it is assumed that a source of compliant water can be located and then a new well would be completed and a pipeline would be constructed to transfer the compliant water to Greenwood ISD. These alternatives are GW-7, GW-8, and GW-9.

4.3 TREATMENT OPTIONS

4.3.1 Blending with Other PWSs

There are opportunities to blend with other PWSs in the areas with well fields or water treatment plants that are producing compliant water. Blending is discussed in alternatives GW-1 through GW-6.

4.3.2 Centralized Treatment Systems

Centralized treatment of the well field water is identified as a potential alternative for Greenwood ISD. RO and EDR are potential applicable processes. RO and EDR can reduce nitrate, TDS, and arsenic to produce compliant water. The central RO treatment alternative is Alternative GW-5, and the central EDR treatment alternative is Alternative GW-6.

4.3.3 New Groundwater Wells

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. New wells are discussed in alternatives GW-7, GW-8 and GW-9.

4.4 ALTERNATIVE DEVELOPMENT AND ANALYSIS

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

4.4.1 Alternative GW-1: 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 ISD. 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 ISD 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 the existing storage tank for the Greenwood ISD. A pump station would also be required to overcome pipe friction and elevation differences between Midland and the Greenwood ISD. The required pipeline would be approximately 7.5 miles long and would be constructed of 4-inch polyvinyl chloride (PVC) pipe.

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 ISD, since the incremental cost would be relatively small, and would provide operational flexibility.

This alternative involves regionalization by definition, since Greenwood ISD would be obtaining drinking water from an existing larger supplier. Also, other PWSs near Greenwood ISD 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 and pump station. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost related to current operation of the Greenwood ISD wells, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $1.72 million, and the alternatives' estimated annual O&M cost is $100,600.

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 Greenwood ISD's perspective, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is 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.

4.4.2 Alternative GW-2: Purchase Groundwater from Midland International Airport

This alternative consists of drilling a new well in the Midland International Airport area that would replace Greenwood ISD's wells. Records indicate nitrate levels in a range of 4 to 6 mg/L in the Midland International Airport wells, which is not low enough to provide a high confidence level that blending would be possible. As a result, for this alternative, it is assumed that Greenwood ISD 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, and a pipeline to the Greenwood ISD. One of the two pumps in the pump station is for backup in case the other pump fails. The 4-inch PVC pipeline would be approximately 22 miles long, would primarily follow I-20W, Business Route I-20W, and County Road 307.

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, and a pipeline to the Greenwood ISD. The estimated O&M cost for this alternative is related to taking the existing well field out of service, 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 $5.04 million, and the estimated annual O&M cost for this alternative is $36,700.

The reliability of adequate amounts of compliant water under this alternative should be good. Greenwood ISD has a well field with adequate capacity. From Greenwood ISD's perspective, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pumps stations is well understood, and Greenwood ISD currently operates pumps.

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

4.4.3 Alternative GW-3: 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 ISD. 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 ISD 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 the existing storage tank for the Greenwood ISD. A pump station would also be required to overcome pipe friction and the elevation differences between Odessa and Greenwood ISD. The 4-inch PVC pipeline would primarily follow I-20W, Business Route I-20W, and County Road 307. The pipeline would be approximately 32 miles long.

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 ISD, since the incremental cost would be relatively small, and it would provide operational flexibility.

This alternative involves regionalization by definition, since Greenwood ISD would be obtaining drinking water from an existing larger supplier. It is possible that the Greenwood ISD could turn over provision of drinking water to the City of Odessa instead of purchasing water. Also, other PWSs near Greenwood ISD 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 and pump station. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost related to current operation of the Greenwood ISD wells, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $7.08 million, and the alternatives' estimated annual O&M cost is $118,600.

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

4.4.4 Alternative GW-4: Purchase Treated Water from the City of Stanton

This alternative involves purchasing treated surface water from the City of Stanton, which will be used to supply the Greenwood ISD. 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 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 Stanton also has a history of not reporting MCL exceedances to the public. These issues would need to be resolved before this alternative is viable. It is not known if these issues had been resolved since the time they were reported.

This alternative would require constructing a pipeline from the City of Stanton water main to the existing storage tank for the Greenwood ISD. A pump station would also be required to overcome pipe friction and the elevation differences between Stanton and Greenwood ISD. The 4-inch PVC pipeline would primarily follow I-20W, County Road 1050, and County Road 307. The pipeline would be approximately 12 miles long.

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 ISD, since the incremental cost would be relatively small, and it would provide operational flexibility.

This alternative involves regionalization by definition, since Greenwood ISD would be obtaining drinking water from an existing larger supplier. It is possible the Greenwood ISD could turn over provision of drinking water to the City of Stanton instead of purchasing water. Also, other PWSs near Greenwood ISD 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 and pump station. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost related to current operation of the Greenwood ISD wells, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $2.8 million, and the alternatives' estimated annual O&M cost is $26,900.

The reliability of adequate amounts of compliant water under this alternative is fair based on compliance history. From Greenwood ISD's perspective, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood. If the decision was 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 Stanton to purchase treated drinking water.

4.4.5 Alternative GW-5: Reverse Osmosis Treatment

This system would continue to pump water from the Greenwood ISD well field, and would treat the water through an RO system prior to distribution. For this option, a fraction of the raw water would be treated and then blended with the untreated stream to obtain overall compliant water. The RO process concentrates impurities in the reject stream which would require disposal. It is estimated that the RO reject generation would be 33,600 gpd when the system is operated at full flow.

This alternative consists of constructing the RO treatment plant near the existing Greenwood service pumps. The plant is composed of a 500 square foot building with a paved driveway; a skid with the pre-constructed RO plant; two 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 distribution system. The existing above-grade storage tank would continue to be used to accumulate feed water from the well field. The entire facility is fenced. The capital cost includes purchase of a water truck-trailer to periodically haul reject water for disposal.

The estimated capital cost for this alternative is $692,100, and the estimated annual O&M cost is $130,200.

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.

4.4.6 Alternative GW-6: Central EDR Treatment

The system would continue to pump water from the Greenwood ISD well field, and would treat the water through an EDR system prior to distribution. For this option the EDR would treat the full flow without bypass as the EDR operation can be tailored for desired removal efficiency. It is estimated that the EDR reject generation would be 22,000 gpd when the system is operated at full flow.

This alternative consists of constructing the EDR treatment plant near the existing Greenwood ISD service pumps. The plant is composed of a 600 square foot building with a paved driveway; a skid with the pre-constructed EDR system; two 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 distribution system. The existing above-grade storage tank would continue to be used to accumulate feed water from the well field. The entire facility is fenced. The capital cost includes purchase of a water truck-trailer to periodically haul reject water for disposal.

The estimated capital cost for this alternative is $964,300, and the estimated annual O&M cost is $115,800.

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

4.4.7 Alternative GW-7: New Well at 10 miles

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

This alternative would require constructing one new 300-foot well, a new pump station with storage tank near the new wells, and a pipeline from the new well/tank to the existing intake point for the Greenwood ISD system. 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 PVC line that discharges to the existing Greenwood ISD storage tank. 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 options for a more regional solution. It may be possible to share water and costs with another nearby system.

The estimated capital cost for this alternative includes installing the well and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the cost for O&M for the pipeline and pump station, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing well. The estimated capital cost for this alternative is $2.49 million, and the estimated annual O&M cost for this alternative is $26,000.

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 Greenwood ISD, this alternative would be similar to operate as the existing system. Greenwood ISD has experience with O&M of wells, pipelines and pump stations.

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

4.4.8 Alternative GW-8: New Well at 5 miles

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

This alternative would require constructing one new 300-foot well, a new pump station with storage tank near the new well, and a pipeline from the new well/tank to the existing intake point for the Greenwood ISD system. 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 PVC line that discharges to the existing Greenwood ISD storage tank. 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 options for a more regional solution. It may be possible to share water and costs with another nearby system.

The estimated capital cost for this alternative includes installing the well, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes O&M for the pipeline and pump station, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing wells. The estimated capital cost for this alternative is $1.39 million, and the estimated annual O&M cost for this alternative is $21,700.

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

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

4.4.9 Alternative GW-9: New Well at 1 mile

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

This alternative would require constructing one new 300-foot well, a new pump station with storage tank near the new well, and a pipeline from the new well/tank to the existing intake point for the Greenwood ISD system. 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 1 mile long, and would be a 4-inch PVC line that discharges to the existing Greenwood ISD storage tank. 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 options for a more regional solution. It may be possible to share water and costs with another nearby system.

The estimated capital cost for this alternative includes installing the well, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes O&M for the pipeline and pump station, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing wells. The estimated capital cost for this alternative is $533,500, and the estimated annual O&M cost for this alternative is $18,300 less than current costs.

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 Greenwood ISD, this alternative would be similar to operate as the existing system. Greenwood ISD has experience with O&M of wells, pipelines, and pump stations.

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

4.4.10 Summary of Alternatives

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

1 **Table 4.3 Summary of Compliance Alternatives for Greenwood ISD**

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost[2]	Reliability	System Impact	Remarks
GW-1	Purchase treated water from the City of Midland	- Storage tank - Pump station - 7.5-mile pipeline	$1,717,100	$100,600	$250,300	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.
GW-2	New well at Midland International Airport	- New well - Storage tank - Pump station - 22-mile pipeline	$5,044,700	$36,700	$476,500	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.
GW-3	Purchase treated water from the City of Odessa	- Storage tank - Pump station - 32-mile pipeline	$7,079,700	$118,600	$735,800	Good	N	Agreement must be successfully negotiated with the City of Odessa. Blending may be possible. Costs could be shared with other nearby small systems.
GW-4	Purchase treated water from the City of Stanton	- Storage tank - Pump station - 12-mile pipeline	$2,797,200	$26,900	$270,800	Fair	N	Agreement must be successfully negotiated with the City of Stanton. Blending may be possible. Costs could be shared with other nearby small systems.
GW-5	Continue operation of current well field with central RO treatment	- Central RO treatment plant	$692,100	$130,200	$238,100	Good	T	Costs could possibly be shared with other nearby small systems.
GW-6	Continue operation of current well field with central EDR treatment	- Central EDR treatment plant	$964,300	$115,800	$225,200	Good	T	Costs could possibly be shared with other nearby small systems.
GW-7	Install new compliant well within 10 miles	- New well - Storage tank - Pump station - 10-mile pipeline	$2,488,500	$25,900	$242,900	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost[2]	Reliability	System Impact	Remarks
GW-8	Install new compliant well within 5 miles	- New well - Storage tank - Pump station - 5-mile pipeline	$1,387,900	$21,700	$142,700	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.
GW-9	Install new compliant well within 1 mile	- New well - Storage tank - Pump station - 1-mile pipeline	$533,500	$18,300	$64,800	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.

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 D
2 – 20-year return period and 6 percent interest

4.5 COST OF SERVICE AND FUNDING ANALYSIS

A 30-year financial planning model was developed as part of the small water systems pilot project completed in 2004. Since that model was developed for PWSs that collect revenue from paying customers for water usage, it had to be adapted for Greenwood ISD whose water system costs are funded by property taxes and State funds.

Data for such models are typically derived from established budgets, audited financial reports, published water tariffs, and consumption data. Greenwood ISD did provide an unaudited financial report for fiscal year 2004, but it does not track revenues and expenses for the water system separately.

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.

4.5.1 Financial Plan Development

The O&M budget for 2004 for all school operations was $929,854. Several assumptions were made to derive estimates for input into the financial planning model. These assumptions were:

1) Water system expenses are 5% or $46,530 of the O&M budget.

2) 2004 revenues = 2004 expenses for operation of the water system.

3) The existing potable water system is paid for and has been fully depreciated.

Categories of expenses are shown in Table 4.4 based on estimated percentages.

Table 4.4 Estimated Water System Expenses

Category	%	2004 Water Expenses
Salaries	15	$ 6,980
Contract Labor	5	$ 2,326
Chemicals	20	$ 9,306
Utilities	30	$13,959
Repairs	30	$13,959
Total		$46,530

A consumption rate of 26.5 gpd per student was assumed which translates into 7,152 gpy per student based on a 9-month school year. Even though school is only in session 5 days per week, a 30-day month was assumed to account for sporting events and other activities held at the school. This amounts to a total of 11 million gallons of water usage per year, or about 19.5 gpd.

There are 1,538 students enrolled in Greenwood ISD. While students do not pay for the water they consume, a base rate of $20 per student was established which accounts for $30,760 of the water system revenues. Since it was assumed that water revenues equal water expenses, a hypothetical usage rate of $1.52 per 1,000 gallons was derived to account for the additional water system revenues. These values were used in the financial planning model.

While these assumptions are arbitrary, they help to frame costs of the water system operation and allow impacts of the incremental costs of the various alternatives to be evaluated.

4.5.2 Financial Plan Results

Each compliance alternative for Greenwood ISD was evaluated using the financial model to determine the increase in the average cost per student that would be necessary to pay for the improvements. Each alternative was examined under the various funding options described in Section 2.4.

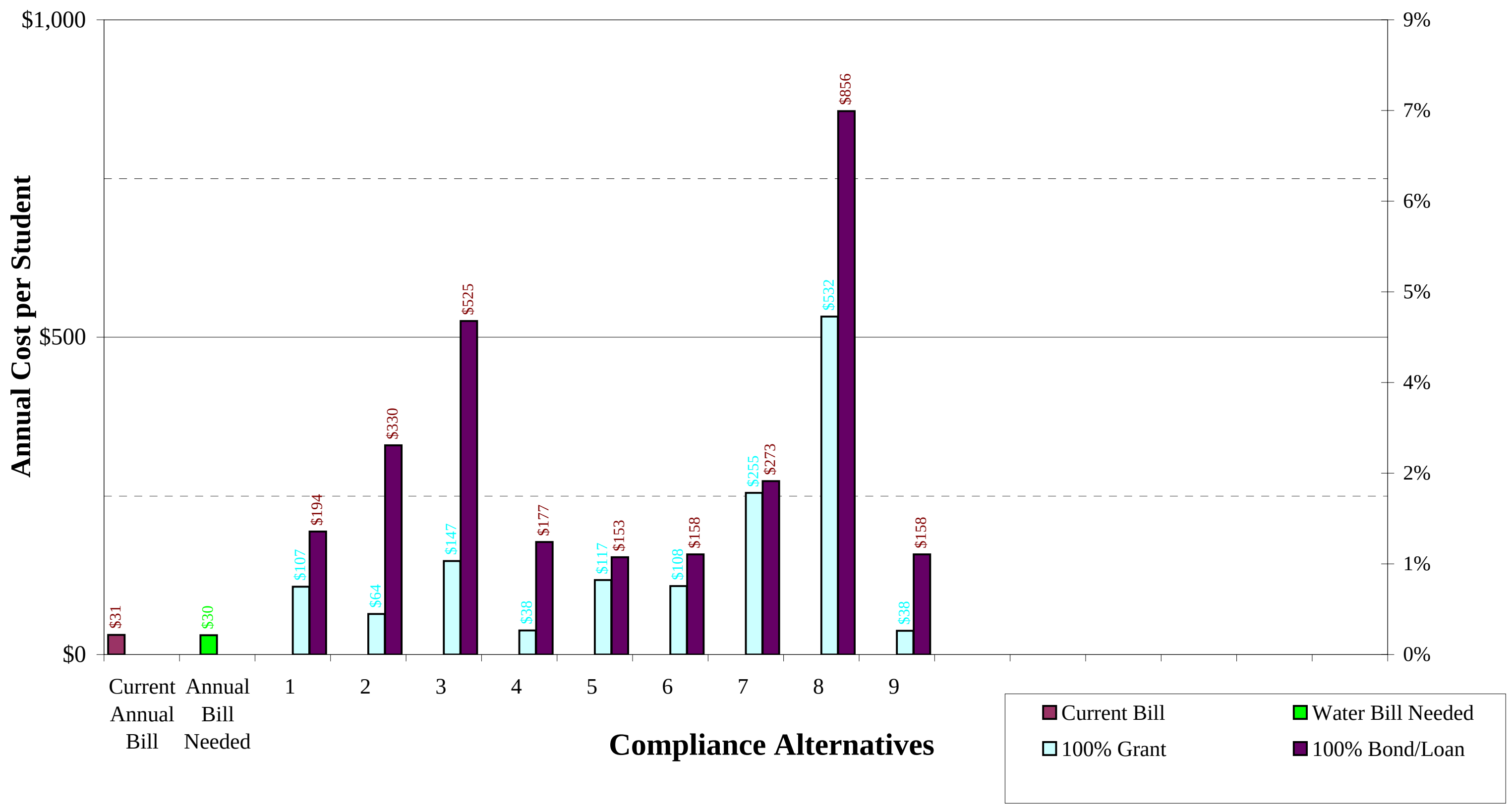
The financial model results are summarized in Table 4.5 and Figure 4.2 for all the alternatives. Figure 4.2 shows the current average annual costs per student of $31 based on the assumptions stated above. There are two bars shown for each alternative. The lowest bar is based on 100 percent grant funding of capital improvements for the compliance alternative. Thus, the higher average annual average cost per student reflects only higher O&M costs associated with the compliance alternative. The highest bar is based on funding capital requirements entirely with either loans or bonds, which represent the highest cost scenario. Therefore, the higher average annual cost per student in this case reflects both higher O&M costs and the principal and interests costs to service the debt associated with the compliance alternative.

Table 4.5 Financial Impact for Greenwood ISD Alternatives

		Funding Source #	0	1	2	3	4	5
#	**ALTERNATIVES**		**All Revenue**	**100% Grant**	**75% Grant**	**50% Grant**	**SRF**	**Loan/Bond**
GW-1	City of Midland	Average Annual Water Bill	$ 1,136	$ 165	$ 205	$ 245	$ 306	$ 325
		Maximum % of HH Income	3%	0%	1%	1%	1%	1%
		Percentage Rate Increase Compared to Current	3833%	492%	633%	773%	987%	1055%
		Year First Rate Increase Needed	2006	2007	2006	2006	2006	2006
GW-2	Midland Int'l Airport	Average Annual Water Bill	$ 3,233	$ 90	$ 212	$ 334	$ 519	$ 578
		Maximum % of HH Income	9%	0%	1%	1%	1%	2%
		Percentage Rate Increase Compared to Current	11090%	215%	645%	1075%	1727%	1935%
		Year First Rate Increase Needed	2006	2007	2006	2006	2006	2006
GW-3	City of Odessa	Average Annual Water Bill	$ 4,653	$ 237	$ 411	$ 585	$ 848	$ 932
		Maximum % of HH Income	13%	1%	1%	2%	2%	3%
		Percentage Rate Increase Compared to Current	16019%	755%	1367%	1979%	2908%	3203%
		Year First Rate Increase Needed	2006	2007	2006	2006	2006	2006
GW-4	City of Stanton	Average Annual Water Bill	$ 1,701	$ 44	$ 108	$ 172	$ 269	$ 300
		Maximum % of HH Income	5%	0%	0%	0%	1%	1%
		Percentage Rate Increase Compared to Current	5783%	47%	273%	498%	841%	950%
		Year First Rate Increase Needed	2006	2007	2006	2006	2006	2006
GW-5	Central RO	Average Annual Water Bill	$ 535	$ 184	$ 200	$ 217	$ 242	$ 250
		Maximum % of HH Income	1%	1%	1%	1%	1%	1%
		Percentage Rate Increase Compared to Current	1757%	560%	618%	676%	764%	792%
		Year First Rate Increase Needed	2006	2007	2006	2006	2006	2006
GW-6	Central EDR	Average Annual Water Bill	$ 696	$ 167	$ 190	$ 213	$ 248	$ 259
		Maximum % of HH Income	2%	0%	1%	1%	1%	1%
		Percentage Rate Increase Compared to Current	2310%	498%	579%	660%	783%	822%
		Year First Rate Increase Needed	2006	2007	2006	2006	2006	2006
GW-7	New well 10 miles	Average Annual Water Bill	$ 451.22	$ 427.93	$ 436.44	$ 444.94	$ 457.84	$ 461.94
		Maximum % of HH Income	1%	1%	1%	1%	1%	1%
		Percentage Rate Increase Compared to Current	1481%	1451%	1481%	1511%	1556%	1570%
		Year First Rate Increase Needed	2006	2007	2006	2006	2006	2006

		Funding Source #	0	1	2	3	4	5
#	**ALTERNATIVES**		**All Revenue**	**100% Grant**	**75% Grant**	**50% Grant**	**SRF**	**Loan/Bond**
GW-8	New well 5 miles	Average Annual Water Bill	$ 4,351.86	$ 920.56	$ 1,069.35	$ 1,218.15	$ 1,443.87	$ 1,515.75
		Maximum % of HH Income	12%	3%	3%	3%	4%	4%
		Percentage Rate Increase Compared to Current	15018%	3249%	3774%	4298%	5093%	5347%
		Year First Rate Increase Needed	2006	2007	2006	2006	2006	2006
GW-9	New well 1 mile	Average Annual Water Bill	$ 1,474	$ 42	$ 98	$ 153	$ 237	$ 264
		Maximum % of HH Income	4%	0%	0%	0%	1%	1%
		Percentage Rate Increase Compared to Current	4997%	43%	238%	433%	729%	823%
		Year First Rate Increase Needed	2006	2007	2006	2006	2006	2006

Figure 4-2 Alternative Cost Summary



Current Rates:

Base Cost Per Student	$20.00
Annual Consumption per Student	7,152 gallons

SECTION 5
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APPENDIX A
PWS INTERVIEW FORM

CAPACITY DEVELOPMENT ASSESSMENT FORM

*Prepared By*___________________________________ *Date*___________________________

Section 1. Public Water System Information

1. PWS ID # [ ] 2. Water System Name [ ]

3. County [ ]

4. Owner [ ] Address [ ]
   Tele. [ ] E-mail [ ]
   Fax [ ] Message [ ]

5. Admin [ ] Address [ ]
   Tele. [ ] E-mail [ ]
   Fax [ ] Message [ ]

6. Operator [ ] Address [ ]
   Tele. [ ] E-mail [ ]
   Fax [ ] Message [ ]

7. Population Served [ ] 8. No. of Service Connections [ ]

9. Ownership Type [ ] 10. Metered (Yes or No) [ ]

11. Source Type [ ]

12. Total PWS Annual Water Used [ ]

13. Number of Water Quality Violations (Prior 36 months)

    Total Coliform [ ] Chemical/Radiological [ ]

    Monitoring (CCR, Public Notification, etc.) [ ] Treatment Technique, D/DBP [ ]

A. Basic Information

1. Name of Water System:

2. Name of Person Interviewed:

3. Position:

4. Number of years at job:

5. Number of years experience with drinking water systems:

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

7. Certified Water Operator (Yes or No):

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

   7b. How long have you been certified?

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

B. Organization and Structure

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

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

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

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

    3b. May we see a copy?

C. Personnel

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

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

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

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

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

D. Communication

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

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

3. How are your work priorities set?

4. How are work tasks delegated to staff?

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

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

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

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

9. Describe communication between utility and customers.

E. Planning and Funding

1. Describe the rate structure for the utility.

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

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

3. How often are the rates reviewed?

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

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

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

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

8. How is the budget approved or adopted?

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

    9a. How are budget shortfalls handled?

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

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

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

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

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

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

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

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

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

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

F. Policies, Procedures, and Programs

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

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

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

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

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

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

7. Approximately how many complaints are there per month?

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

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

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

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

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

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

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

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

G. Operations and Maintenance

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

    a. Process Control

    b. Purchases of supplies or small equipment

    c. Compliance sampling/reporting

    d. Staff scheduling

2. Describe your utility's preventative maintenance program.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

H. SDWA Compliance

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

2. How were the violations handled?

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

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

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

I. Emergency Planning

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

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

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

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

Attachment A

<u>A. Technical Capacity Assessment Questions</u>

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

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

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

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

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

   YES ☐ NO ☐

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

   _____NM Small System _____Class 2

   _____NM Small System Advanced _____Class 3

   _____Class 1 _____Class 4

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

   YES ☐ NO ☐ No Deficiencies ☐

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

   Source ☐ Storage ☐

   Treatment ☐ Distribution ☐

   Other _____

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

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

   Radionuclides YES ☐ NO ☐ Doesn't Apply ☐

   Arsenic YES ☐ NO ☐ Doesn't Apply ☐

   Stage 1 Disinfectants and Disinfection By-Product (DBP)

   YES ☐ NO ☐ Doesn't Apply ☐

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

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

   YES ☐ NO ☐

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

YES ☐ NO ☐

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

Drought _____ Limited Supply _____

System Failure _____ Other _____

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

YES ☐ NO ☐ Don't Know ☐

If YES, please complete the following table.

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

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

YES ☐ NO ☐

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

Source ☐ Storage ☐

Treatment ☐ Distribution ☐

Other ☐ _____

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

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

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

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

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

13. Are there any dead end lines in the system?

YES ☐ NO ☐

14. Does the system have a flushing program?

YES ☐ NO ☐

If YES, please describe.

15. Are there any pressure problems within the system?

YES ☐ NO ☐

If YES, please describe.

16. Does the system disinfect the finished water?

YES ☐ NO ☐

If yes, which disinfectant product is used? ______

Interviewer Comments on Technical Capacity:

B. Managerial Capacity Assessment Questions

17. Has the system completed a 5-year Infrastructure Capital Improvement Plan (ICIP) plan?

YES ☐ NO ☐

If YES, has the plan been submitted to Local Government Division?

YES ☐ NO ☐

18. Does the system have written operating procedures?

YES ☐ NO ☐

19. Does the system have written job descriptions for all staff?

YES ☐ NO ☐

20. Does the system have:

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

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

Water quality violations
YES ☐ NO ☐

Public notification
YES ☐ NO ☐

Sampling exemptions
YES ☐ NO ☐

22. Please describe how the above records are maintained:

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

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

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

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

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

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

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

If yes, from which agency and how much?

Describe the project?

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

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

YES ☐ NO ☐

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

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

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

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

Interviewer Comments on Managerial Capacity:

C. Financial Capacity Assessment

30. Does the system have a budget?

YES ☐ NO ☐

If YES, what type of budget?

Operating Budget ☐

Capital Budget ☐

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

YES ☐ NO ☐

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

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

YES ☐ NO ☐

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

34. Are rates reviewed annually?

YES ☐ NO ☐

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

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

Operation & Maintenance ☐

Infrastructure Repair & replacement ☐

Staffing ☐

Emergency/Reserve fund ☐

Debt payment ☐

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

YES ☐ NO ☐

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

YES ☐ NO ☐

If yes, is this policy implemented?

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

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

[Convert to % of active connections

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

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

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

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

YES ☐ NO ☐

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

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

YES ☐ NO ☐

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

YES ☐ NO ☐

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

YES ☐ NO ☐

If yes, please describe.

41. Has the system ever had a financial audit?

YES ☐ NO ☐

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

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

Interviewer Comments on Financial Assessment:

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

APPENDIX B
COST BASIS

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

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

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

Unit costs for pipeline components are based on recent bids on Texas Department of Highways projects. The amounts of boring and encasement and open cut and encasement were 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 and building, and tools. Construction cost of a storage tank is based on similar recent installations.

Electrical power cost is estimated to be $0.128 per 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 2005 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 2005 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 2005 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 a 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 each week, and that chlorine residual would be determined for each truck load.

Table B.1
Summary of General Data
Greenwood ISD
PWS #1650035
General PWS Information

Service Population 1,545
Total PWS Daily Water Usage 0.03 (mgd)

Number of Students 1545
Source 2005 Report

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	$ 30
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	$ 30

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	$ 40
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**
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
Electrical, RO	JOB	$ 50,000
Electrical, EDR	JOB	$ 50,000
Piping, RO	JOB	$ 20,000
Piping, EDR	JOB	$ 20,000
RO package	UNIT	$ 125,000
IX package	UNIT	$ 279,000
Transfer pumps (5 hp)	EA	$ 5,000
Permeate Tank	GAL	$ 3.00
Backwash tank	GAL	$ 2.00
Mixer on tank	EA	$ 15,000
Salt feeder	EA	$ 20,000
Tank, 20,000 GAL	GAL	$ 1.00
Tank, 10,000 GAL	GAL	$ 1.50
Excavation	CYD	$ 3.00
Compacted fill	CYD	$ 7.00
Lining	SF	$ 0.50
Vegetation	SY	$ 1.00
Access road	LF	$ 30
Reject water haul truck	EA	$ 100,000
Building Power	kwh/yr	$ 0.128
Equipment power	kwh/yr	$ 0.128
Labor	hr	$ 40
RO Materials	year	$ 5,000
EDR Materials	year	$ 5,000
Chemicals, RO	year	$ 1,800
Chemicals, EDR	year	$ 1,800
Analyses	test	$ 200
Haul reject water	miles	1.0
Truck rental	day	$ 700
Mileage	mile	$ 1.00
Disposal fee	kgal	$ 5.00

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.9. 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

Alternative GW - 1: Purchase Treated Water from City of Midland

Capital Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Pipeline				
4" Class 200 PVC water line	39,383	LF	$ 26	$ 1,023,958
8" Bore and encasement	600	LF	$ 55	$ 33,000
8" Open cut and encasement	650	LF	$ 30	$ 19,500
4" Gate valve and box	8	EA	$ 550	$ 4,332
Air valve	6	EA	$ 1,000	$ 6,000
Flush valve	8	EA	$ 750	$ 5,907
Metal detectable tape	39,383	LF	$ 0.15	$ 5,907
Subtotal				**$ 1,098,605**
Pump Station				
Pump	2	EA	$ 7,500	$ 15,000
Piping	1	EA	$ 3,000	$ 3,000
Valve, gate	4	EA	$ 400	$ 1,600
Valve, check	2	EA	$ 500	$ 1,000
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	$ 3,000	$ 3,000
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank, 20,000 gal	1	EA	$ 35,000	$ 35,000
Subtotal				**$ 85,600**
Subtotal				**$ 1,184,205**
Contingency				236,841
Design & CM				296,051
Total				**$ 1,717,097**

O&M Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Pipeline	7.5	mile	$ 200	$ 1,492
Water Purchase				
Midland	56393	1000 gal	$ 1.65	$ 93,048
Pump Station				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	41,000	kWH	$ 0.128	$ 5,248
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30.00	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 19,908**
Well O&M Credit				
Pump power	5000	kWH	$ 0.128	$ (640)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$ (10,800)
Subtotal				**$ (13,840)**
Total				**$ 100,609**

Table C.2

Alternative GW - 2: New Well at Midland International Airport

Capital Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Pipeline				
4" Class 200 PVC water line	116,547	LF	$ 26	$ 3,030,222
8" Bore and encasement	2,400	LF	$ 55	$ 132,000
8" Open cut and encasement	1,600	LF	$ 30	$ 48,000
4" Gate valve and box	23	EA	$ 550	$ 12,820
Air valve	22	EA	$ 1,000	$ 22,000
Flush valve	23	EA	$ 750	$ 17,482
Metal detectable tape	116,547	LF	$ 0.15	$ 17,482
Subtotal				**$ 3,280,006**
Pump Station				
Pump	2	EA	$ 7,500	$ 15,000
Piping	1	EA	$ 3,000	$ 3,000
Valve, gate	4	EA	$ 400	$ 1,600
Valve, check	2	EA	$ 500	$ 1,000
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	$ 3,000	$ 3,000
Tools	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 50,600**
Well Installation				
Well installation	300	LF	$ 333	$ 100,000
Water quality testing	2	EA	$ 1,500	$ 3,000
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
Storage tank, 20,000 gal	1	EA	$ 35,000	$ 35,000
Subtotal				**$ 148,500**
Subtotal				**$ 3,479,106**
Contingency				869,777
Design & CM				695,821
Total				**$ 5,044,704**

O&M Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Pipeline	22.1	mile	$ 200	$ 4,415
Pump Station				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	116,000	kWH	$ 0.128	$ 14,848
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30.00	$ 10,950
Subtotal				**$ 28,508**
Well and Tank				
Pump power	0	kWH	$ 0.128	$ -
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	52	Hrs	$ 30	$ 1,560
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 3,760**
Total				**$ 36,683**

Table C.3

Alternative GW - 3: Purchase Treated Water from City of Odessa

Capital Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Pipeline				
4" Class 200 PVC water line	169,971	LF	$ 26	$ 4,419,246
8" Bore and encasement	3,200	LF	$ 55	$ 176,000
8" Open cut and encasement	3,400	LF	$ 30	$ 102,000
4" Gate valve and box	34	EA	$ 550	$ 18,697
Air valve	30	EA	$ 1,000	$ 30,000
Flush valve	34	EA	$ 750	$ 25,496
Metal detectable tape	169,971	LF	$ 0.15	$ 25,496
Subtotal				**$ 4,796,934**
Pump Station				
Pump	2	EA	$ 7,500	$ 15,000
Piping	1	EA	$ 3,000	$ 3,000
Valve, gate	4	EA	$ 400	$ 1,600
Valve, check	2	EA	$ 500	$ 1,000
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	$ 3,000	$ 3,000
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank, 20,000 gal	1	EA	$ 35,000	$ 35,000
Subtotal				**$ 85,600**
Subtotal				**$ 4,882,534**
Contingency				976,507
Design & CM				1,220,634
Total				**$ 7,079,674**

O&M Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Pipeline	32.2	mile	$ 200	$ 6,438
Water Purchase				
Odessa	56393	1000 gal	$ 1.60	$ 90,229
Pump Station				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	164,750	kWH	$ 0.128	$ 21,088
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30.00	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 35,748**
Well O&M Credit				
Pump power	5000	kWH	$ 0.128	$ (640)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$ (10,800)
Subtotal				**$ (13,840)**
Total				**$ 118,575**

Table C.4

Alternative GW - 4: Purchase Treated Water from City of Stanton

Capital Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Pipeline				
4" Class 200 PVC water line	62,324	LF	$ 26	$ 1,620,424
8" Bore and encasement	800	LF	$ 55	$ 44,000
8" Open cut and encasement	1,000	LF	$ 30	$ 30,000
4" Gate valve and box	12	EA	$ 550	$ 6,856
Air valve	10	EA	$ 1,000	$ 10,000
Flush valve	12	EA	$ 750	$ 9,349
Metal detectable tape	62,324	LF	$ 0.15	$ 9,349
Subtotal				**$ 1,729,977**
Pump Station				
Pump	2	EA	$ 7,500	$ 15,000
Piping	1	EA	$ 3,000	$ 3,000
Valve, gate	4	EA	$ 400	$ 1,600
Valve, check	2	EA	$ 500	$ 1,000
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	$ 3,000	$ 3,000
Tools	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 50,600**
Well Installation				
Well installation	300	LF	$ 333	$ 100,000
Water quality testing	2	EA	$ 1,500	$ 3,000
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
Storage tank, 20,000 gal	1	EA	$ 35,000	$ 35,000
Subtotal				**$ 148,500**
Subtotal				**$ 1,929,077**
Contingency				385,815
Design & CM				482,269
Total				**$ 2,797,161**

O&M Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Pipeline	11.8	mile	$ 200	$ 2,361
Pump Station				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	55,750	kWH	$ 0.128	$ 7,136
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30.00	$ 10,950
Subtotal				**$ 20,796**
Well and Tank				
Pump power	0	kWH	$ 0.128	$ -
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	52	Hrs	$ 30	$ 1,560
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 3,760**
Total				**$ 26,917**

Table C.5

Alternative GW-5: Central RO Treatment Capital Cost

Capital Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Central-RO				
Site preparation	0.5	acre	$ 4,000	$ 2,000
Slab	15	CY	$ 1,000	$ 15,000
Building	500	SF	$ 60	$ 30,000
Building electrical	500	SF	$ 8.00	$ 4,000
Building plumbing	500	SF	$ 8.00	$ 4,000
Heating and ventilation	500	SF	$ 7.00	$ 3,500
Fence	700	LF	$ 15	$ 10,500
Paving	2,000	SF	$ 2.00	$ 4,000
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 20,000	$ 20,000
RO package including:				
High Pressure pumps-15 hp				
Cartridge filters & vessels				
RO membranes & vessels				
Control system				
Chemical feed systems				
Freight cost and startup services by vendor	1	UNIT	$ 150,000	$ 150,000
Transfer pumps (5 hp)	2	EA	$ 5,000	$ 10,000
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				**$ 408,375**
Contingency	20%			81,675
Design & CM	25%			102,094
Reject water haul truck	1	EA	$ 100,000	$ 100,000
Total				**$ 692,144**

O&M Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
O&M				
Building Power	7,500	kwh/yr	$ 0.128	$ 960
Equipment power	65000	kwh/yr	$ 0.128	$ 8,320
Labor	1,000	hrs/yr	$ 40	$ 40,000
Materials	1	year	$ 5,000	$ 5,000
Chemicals	1	year	$ 1,800	$ 1,800
Analyses	24	test	$ 200	$ 4,800
Subtotal				**$ 60,880**
Backwash Disposal				
Mileage	8000	miles	$ 1.00	$ 8,000
Disposal fee	12270	kgal/yr	$ 5.00	$ 61,350
Subtotal				**$ 69,350**
Total				**$ 130,230**

Table C.6

Alternative GW-6: Central EDR Treatment

Capital Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Central-EDR				
Site preparation	0.5	acre	$ 4,000	$ 2,000
Slab	20	CY	$ 1,000	$ 20,000
Building	600	SF	$ 60	$ 36,000
Building electrical	600	SF	$ 8.00	$ 4,800
Building plumbing	600	SF	$ 8.00	$ 4,800
Heating and ventilation	600	SF	$ 7.00	$ 4,200
Fence	800	LF	$ 15	$ 12,000
Paving	2,400	SF	$ 2.00	$ 4,800
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 20,000	$ 20,000
Product storage tank	20,000	GAL	$ 3.00	$ 60,000
EDR package including: Feed & concentrate pumps Cartridge filters & vessels EDR membrane stacks Electrical module Chemical feed systems Freight cost & startup services by vendor	1	UNIT	$ 323,000	$ 323,000
Reject pond				
Excavation	1,800	CYD	$ 3.00	$ 5,400
Compacted fill	1,500	CYD	$ 7.00	$ 10,500
Lining	26,100	SF	$ 0.50	$ 13,050
Vegetation	3,000	SY	$ 1.00	$ 3,000
Access road	750	LF	$ 30.00	$ 22,500
Subtotal				**$ 596,050**
Contingency	20%			119,210
Design & CM	25%			149,013
Reject water haul truck	1	EA	$ 100,000	$ 100,000
Total				**$ 964,273**

O&M Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
O&M				
Building Power	9,000	kwh/yr	$ 0.128	$ 1,152
Equipment power	116000	kwh/yr	$ 0.128	$ 14,848
Labor	1,000	hrs/yr	$ 40	$ 40,000
Materials	1	year	$ 5,000	$ 5,000
Chemicals	1	year	$ 1,800	$ 1,800
Analyses	24	test	$ 200	$ 4,800
Subtotal				**$ 67,600**
Backwash Disposal				
Mileage	8000	miles	$ 1.00	$ 8,000
Disposal fee	8030	kgal/yr	$ 5.00	$ 40,150
Subtotal				**$ 48,150**
Total				**$ 115,750**

Table C.7

Alternative GW - 7: New Well at 10 Miles

Capital Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Pipeline				
4" Class 200 PVC water line	52,800	LF	$ 26	$ 1,372,800
8" Bore and encasement	1,000	LF	$ 70	$ 70,000
8" Open cut and encasement	950	LF	$ 40	$ 38,000
4" Gate valve and box	11	EA	$ 900	$ 9,504
Air valve	11	EA	$ 1,000	$ 11,000
Flush valve	11	EA	$ 750	$ 7,920
Metal detectable tape	52,800	LF	$ 0.15	$ 7,920
Subtotal				**$ 1,517,144**
Well Installation				
Well installation	300	LF	$ 333	$ 100,000
Water quality testing	2	EA	$ 1,500	$ 3,000
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
Storage tank, 20,000 gal	1	EA	$ 35,000	$ 35,000
Subtotal				**$ 148,500**
Pump Station				
Pump	2	EA	$ 7,500	$ 15,000
Piping, 4"	1	EA	$ 3,000	$ 3,000
Valve, gate	4	EA	$ 400	$ 1,600
Valve, check	2	EA	$ 500	$ 1,000
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	$ 3,000	$ 3,000
Tools	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 50,600**
Subtotal				**$ 1,716,244**
Contingency				343,249
Design & CM				429,061
Total				**$ 2,488,554**

O&M Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Pipeline	10.0	mile	$ 200	$ 2,000
Well and Tank				
Pump power	0	kWH	$ 0.128	$ -
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	52	Hrs	$ 30	$ 1,560
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 3,760**
Pump Station				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	50,850	kWH	$ 0.128	$ 6,509
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30.00	$ 10,950
Subtotal				**$ 20,169**
Total				**$ 25,929**

Table C.8

Alternative GW-8: New Well at 5 Miles

Capital Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Pipeline				
4" Class 200 PVC water line	26,400	LF	$ 26	$ 686,400
8" Bore and encasement	400	LF	$ 70	$ 28,000
8" Open cut and encasement	500	LF	$ 40	$ 20,000
4" Gate valve and box	5	EA	$ 900	$ 4,752
Air valve	11	EA	$ 1,000	$ 11,000
Flush valve	5	EA	$ 750	$ 3,960
Metal detectable tape	26,400	LF	$ 0.15	$ 3,960
Subtotal				**$ 758,072**
Well Installation				
Well installation	300	LF	$ 333	$ 100,000
Water quality testing	2	EA	$ 1,500	$ 3,000
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
Storage tank, 20,000 gal	1	EA	$ 35,000	$ 35,000
Subtotal				**$ 148,500**
Pump Station				
Pump	2	EA	$ 7,500	$ 15,000
Piping, 4"	1	EA	$ 3,000	$ 3,000
Valve, gate	4	EA	$ 400	$ 1,600
Valve, check	2	EA	$ 500	$ 1,000
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	$ 3,000	$ 3,000
Tools	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 50,600**
Subtotal				**$ 957,172**
Contingency				191,434
Design & CM				239,293
Total				**$ 1,387,899**

O&M Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Pipeline	5.0	mile	$ 200	$ 1,000
Well and Tank				
Pump power	0	kWH	$ 0.128	$ -
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	52	Hrs	$ 30	$ 1,560
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 3,760**
Pump Station				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	25,450	kWH	$ 0.128	$ 3,258
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30.00	$ 10,950
Subtotal				**$ 16,918**
Total				**$ 21,678**

Table C.9

Alternative GW-9: New Well at 1 Mile

Capital Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Pipeline				
4" Class 200 PVC water line	5,280	LF	$ 26	$ 137,280
8" Bore and encasement	200	LF	$ 70	$ 14,000
8" Open cut and encasement	100	LF	$ 40	$ 4,000
4" Gate valve and box	1	EA	$ 900	$ 950
Air valve	11	EA	$ 1,000	$ 11,000
Flush valve	1	EA	$ 750	$ 792
Metal detectable tape	5,280	LF	$ 0.15	$ 792
Subtotal				**$ 168,814**
Well Installation				
Well installation	300	LF	$ 333	$ 100,000
Water quality testing	2	EA	$ 1,500	$ 3,000
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
Storage tank, 20,000 gal	1	EA	$ 35,000	$ 35,000
Subtotal				**$ 148,500**
Pump Station				
Pump	2	EA	$ 7,500	$ 15,000
Piping, 4"	1	EA	$ 3,000	$ 3,000
Valve, gate	4	EA	$ 400	$ 1,600
Valve, check	2	EA	$ 500	$ 1,000
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	$ 3,000	$ 3,000
Tools	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 50,600**
Subtotal				**$ 367,914**
Contingency				73,583
Design & CM				91,979
Total				**$ 533,476**

O&M Cost

Cost Item	Qty	Unit	Unit Cost	Total amount
Pipeline	1.0	mile	$ 200	$ 200
Well and Tank				
Pump power	0	kWH	$ 0.128	$ -
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	52	Hrs	$ 30	$ 1,560
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 3,760**
Pump Station				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	5,100	kWH	$ 0.128	$ 653
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30.00	$ 10,950
Subtotal				**$ 14,313**
Total				**$ 18,273**

APPENDIX D
EXAMPLE FINANCIAL MODEL

Step 1

Water System: Greenwood ISD

Step 2

Click Here to Update Verification and Raw

Water System	Greenwood ISD		
Alternative Description	Central Treatment - RO		
Sum of Amount		Year	Funding Alternative
		2007	
Group	Type	100% Grant	Bond
Capital Expenditures	Capital Expenditures-Funded from Bonds	$ -	$ 692,100
	Capital Expenditures-Funded from Grants	$ 692,100	$ -
	Capital Expenditures-Funded from Revenue/Reserves	$ -	$ -
	Capital Expenditures-Funded from SRF Loans	$ -	$ -
Capital Expenditures Sum		$ 692,100	$ 692,100
Debt Service	Revenue Bonds	$ -	$ 54,141
	State Revolving Funds	$ -	$ -
Debt Service Sum		$ -	$ 54,141
Operating Expenditures	Chemicals, Treatment	$ 9,306	$ 9,306
	Contract Labor	$ 2,326	$ 2,326
	Repairs	$ 4,653	$ 4,653
	Salaries & Benefits	$ 6,980	$ 6,980
	Supplies	$ 4,653	$ 4,653
	Utilities	$ 13,959	$ 13,959
	Maintenance	$ 4,653	$ 4,653
Operating Expenditures Sum		$ 46,530	$ 46,530
Residential Operating Revenues	Residential Tier2 Annual Rate	$ -	$ -
	Residential Tier3 Annual Rate	$ -	$ -
	Residential Tier4 Annual Rate	$ -	$ -
	Residential Unmetered Annual Rate	$ -	$ -
	Residential Base Annual Rate	$ 39	$ 39
	Residential Tier 1 Annual Rate	$ 16,386	$ 16,386
Residential Operating Revenues Sum		$ 16,425	$ 16,425

Location_Name	Greenwood ISD	
Alt_Desc	Central Treatment - RO	
		Current_Year
Funding_Alt	Data	2007
100% Grant	Sum of Beginning_Cash_Bal	$ (25,105)
	Sum of Total_Expenditures	$ 738,630
	Sum of Total_Receipts	$ 708,525
	Sum of Net_Cash_Flow	$ (30,105)
	Sum of Ending_Cash_Bal	$ (55,210)
	Sum of Working_Cap	$ -
	Sum of Repl_Resv	$ -
	Sum of Total_Reqd_Resv	$ -
	Sum of Net_Avail_Bal	$ (55,210)
	Sum of Add_Resv_Needed	$ (55,210)
	Sum of Rate_Inc_Needed	336%
	Sum of Percent_Rate_Increase	0%
Bond	Sum of Beginning_Cash_Bal	$ (25,105)
	Sum of Total_Expenditures	$ 792,771
	Sum of Total_Receipts	$ 708,525
	Sum of Net_Cash_Flow	$ (84,246)
	Sum of Ending_Cash_Bal	$ (109,351)
	Sum of Working_Cap	$ -
	Sum of Repl_Resv	$ -
	Sum of Total_Reqd_Resv	$ -
	Sum of Net_Avail_Bal	$ (109,351)
	Sum of Add_Resv_Needed	$ (109,351)
	Sum of Rate_Inc_Needed	666%
	Sum of Percent_Rate_Increase	0%

APPENDIX E
GENERAL GEOCHEMISTRY FOR ARSENIC AND NITRATE

General Arsenic Geochemistry

On January 22, 2001 the 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 is 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 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.

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

Appendix References

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