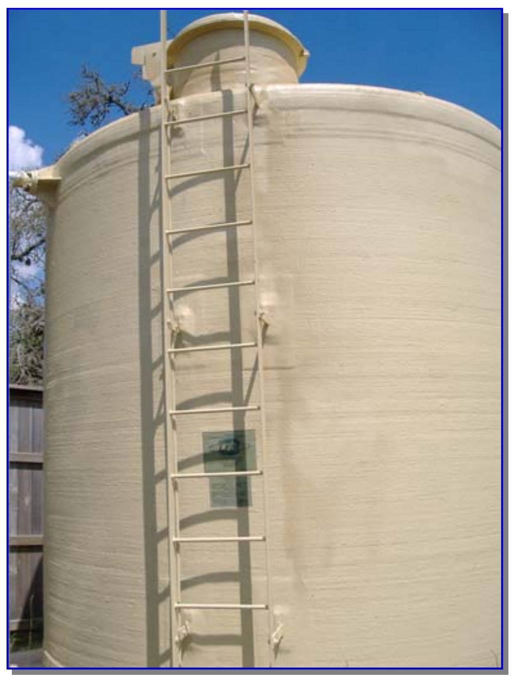
DRAFT FEASIBILITY REPORT
FEASIBILITY ANALYSIS OF WATER SUPPLY FOR SMALL PUBLIC WATER SYSTEMS

AQUA TEXAS, INC. – FALLING WATER SUBDIVISION
PWS ID# 1330145, CCN# 11157

Prepared for:

THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY



Prepared by:

THE UNIVERSITY OF TEXAS BUREAU OF ECONOMIC GEOLOGY

AND

PARSONS

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

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AUGUST 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 Falling Water Subdivision PWS located in Kerr County. Falling Water Subdivision is a residential subdivision in the initial stages of development and is currently growing at an approximate rate of one to two connections a month. Recent sample results from the Falling Water Subdivision water system exceeded the MCL for radium of 5 picoCuries per liter (pCi/L) (USEPA 2005; TCEQ 2004).

Basic system information for the Falling Water Subdivision PWS is shown in Table ES.1.

Table ES.1
Falling Water Subdivision PWS
Basic System Information

Population served	768
Connections	256
Average daily flow rate	0.029 million gallons per day (mgd)
Water system peak capacity	0.232 mgd
Typical radium range	5.2 to 6.7 pCi/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:

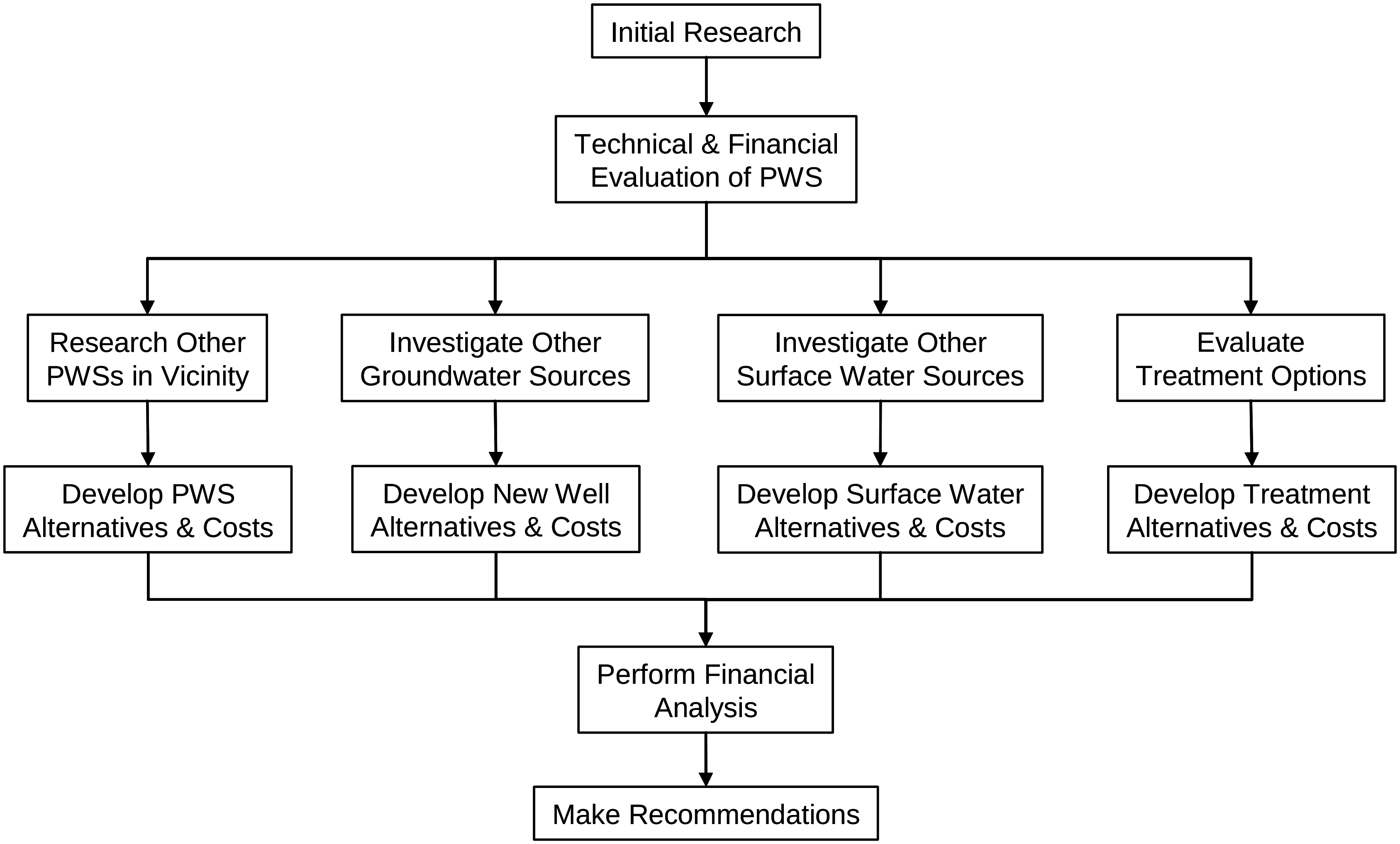
1. Gather data from the TCEQ and Texas Water Development Board databases, from TCEQ files, and from information maintained by the PWS;
2. Conduct financial, managerial, and technical (FMT) evaluations of the PWS;
3. Perform a geologic and hydrogeologic assessment of the study area;
4. Develop treatment 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 Falling Water Subdivision PWS obtains groundwater from a well in Kerr Country and a well in Kendall County, both of which are completed in the Edwards-Trinity aquifer. Radionuclides are commonly found in area wells at concentrations greater than the MCLs. Granite and volcanic ash derived from high-silica igneous systems is the source of uranium in sedimentary mineral deposits (Finch 1967). Radium concentrations can vary significantly over relatively short distances; as a result, there could be good quality groundwater nearby. However, the variability of radium concentrations makes it difficult to determine where wells can be located to produce

Figure ES-1
Summary of Project Methods



acceptable water. Additionally, systems with more than one well should 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 Falling Water Subdivision PWS is owned and operated by Aqua Texas, Inc., which is a subsidiary of Aqua America, Inc. Overall, the system had an above average 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 knowledgeable and dedicated staff, good communication, maintenance and use of up-to-date maps and system information, benefits from economies of scale, and good financial practices. Areas of concern for the system included lack of water system loss measurement or management, and lack of capital improvement planning.

There are several PWSs within 15 miles of Falling Water Subdivision PWS. 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 either the City of Kerrville or the City of Fredericksburg.

A number of centralized treatment alternatives for radium removal have been developed and were considered for this report, for example, the ion exchange (IX) system, WRT Z-88™ adsorption, and hydrous manganese oxide filtration ($KMnO_4$-filtration). Point-of-use (POU) and point-of-entry treatment alternatives were also considered. Temporary solutions such as providing bottled water or providing a centralized dispenser for treated or trucked-in water, were also considered as alternatives.

Developing a new well close to Falling Water Subdivision is likely to be the best solution if compliant groundwater can be found. Having a new well close to Falling Water Subdivision 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.

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

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

FINANCIAL ANALYSIS

Financial analysis of the Falling Water Subdivision PWS indicated that current water rates are high enough to maintain operations for the next 2 to 3 years. The current average annual water bill of $1,034 represents approximately 2.6 percent of the 2000 median household income (MHI) for Texas, which is $39,972. 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	$1,034	2.6
To meet current expenses	NA	$791	2.0
Nearby well within approximately 1 mile	100% Grant	$1,034	2.6
	Loan/Bond	$1,896	4.7
Central treatment	100% Grant	$2,927	7.3
	Loan/Bond	$4,153	10.4
Point-of-use	100% Grant	$6,810	17.0
	Loan/Bond	$7,274	18.1
Public dispenser	100% Grant	$1,289	3.2
	Loan/Bond	$1,321	3.3

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ACRONYMS AND ABBREVIATIONS

°F	Degrees Fahrenheit
Aqua Texas	Aqua Texas, Inc.
BAT	Best available technology
BEG	Bureau of Economic Geology
bgs	Below ground surface
CA	Chemical analysis
CCN	Certificate of Convenience and Necessity
CFR	Code of Federal Regulations
CO	Correspondence
DE	Diatomaceous earth
DWSRF	Drinking Water State Revolving Fund
ED	Electrodialysis
EDR	Electrodialysis reversal
FMT	Financial, managerial, and technical
GAM	Groundwater Availability Model
gpm	Gallons per minute
gpy	Gallons per year
ISD	Independent School District
IX	Ion exchange
$KMnO_4$	Hydrous manganese oxide
MCL	Maximum contaminant level
mg	Million gallons
mgd	Million gallons per day
MHI	Median household income
MnO_2	Manganese oxide
MOR	Monthly operating report
NMEFC	New Mexico Environmental Financial Center
O&M	Operation and Maintenance
Parsons	Parsons Infrastructure and Technology, Inc.
pCi/L	picoCuries per liter
POE	Point-of-entry
POU	Point-of-use
PRV	Pressure-reducing valve
PVC	Polyvinyl chloride
PWS	Public water system
RO	Reverse osmosis
SDWA	Safe Drinking Water Act
SSCT	Small System Compliance Technology

TCEQ	Texas Commission on Environmental Quality
TDS	Total dissolved solids
TSS	Total suspended solids
TWDB	Texas Water Development Board
UGRA	Upper Guadalupe River Authority
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound
WAM	Water Availability Model
WRT	Water Treatment Technologies, Inc.
WSC	Water Supply Corporation

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 (PWSs) 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 Subdivision	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 Falling Water Subdivision Water System, PWS ID# 1330145, Certificate of Convenience and Necessity (CCN) #11157, located in Kerr County. Recent sample results from the Falling Water Subdivision water system exceeded the MCL for radium of 5 picoCuries per liter (pCi/L) (USEPA 2005; TCEQ 2004). The location of the Falling Water Subdivision water system, 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 for PWSs that supply drinking water exceeding regulatory MCLs. This project only addresses those contaminants and does not address any other violations that may exist for a PWS. As mentioned above, the City of Eden water system had recent sample results exceeding the MCL for radium. In general, contaminant(s) in drinking water above the MCL(s) can have both short-term (acute) and long-term or lifetime (chronic) effects. According to the U.S. Environmental Protection Agency (USEPA), long-term ingestion of drinking water with radium-226 and/or radium-228 above the MCL may increase the risk of cancer (USEPA 2005).

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;

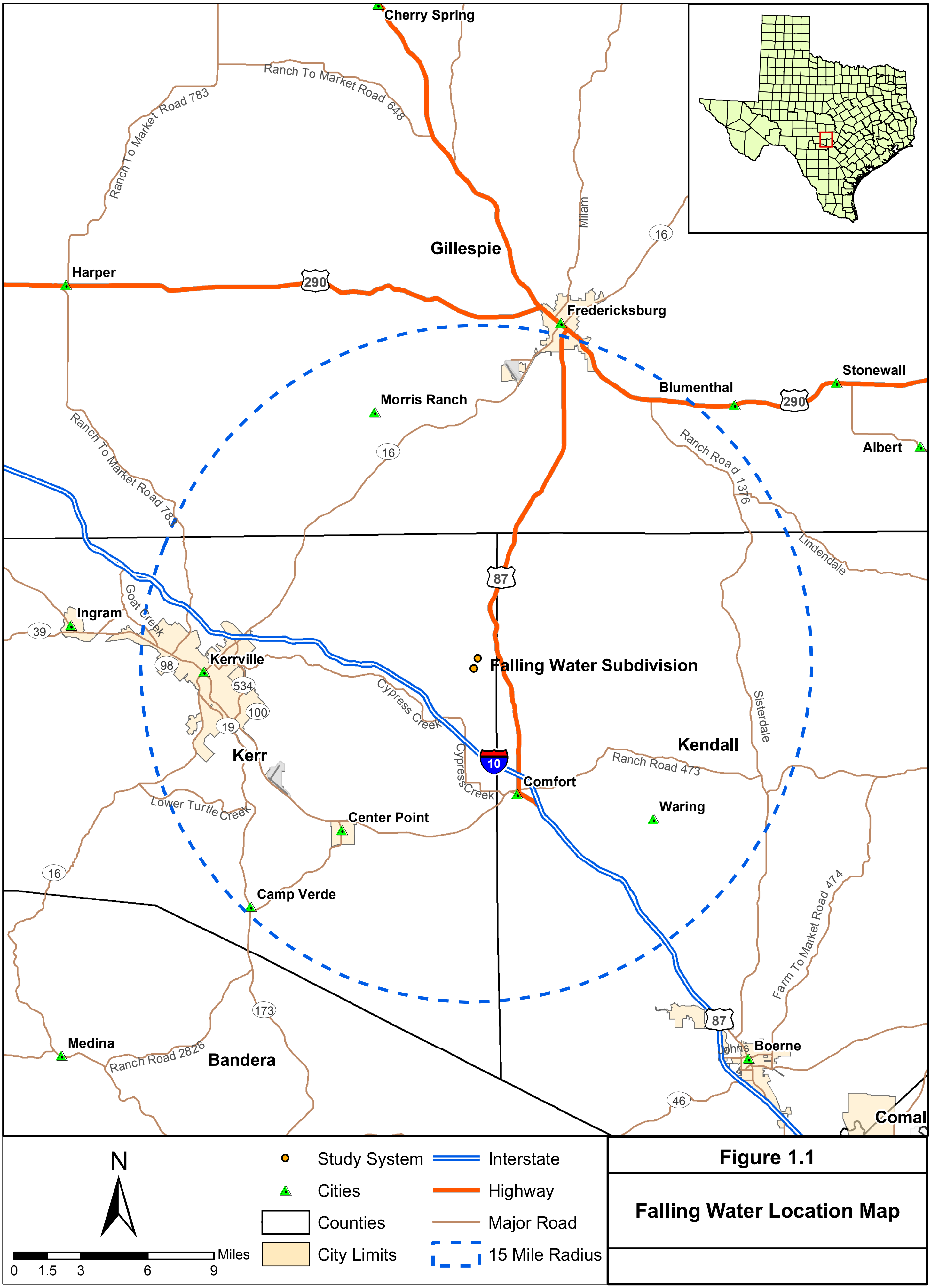

Figure 1.1

Falling Water Location Map

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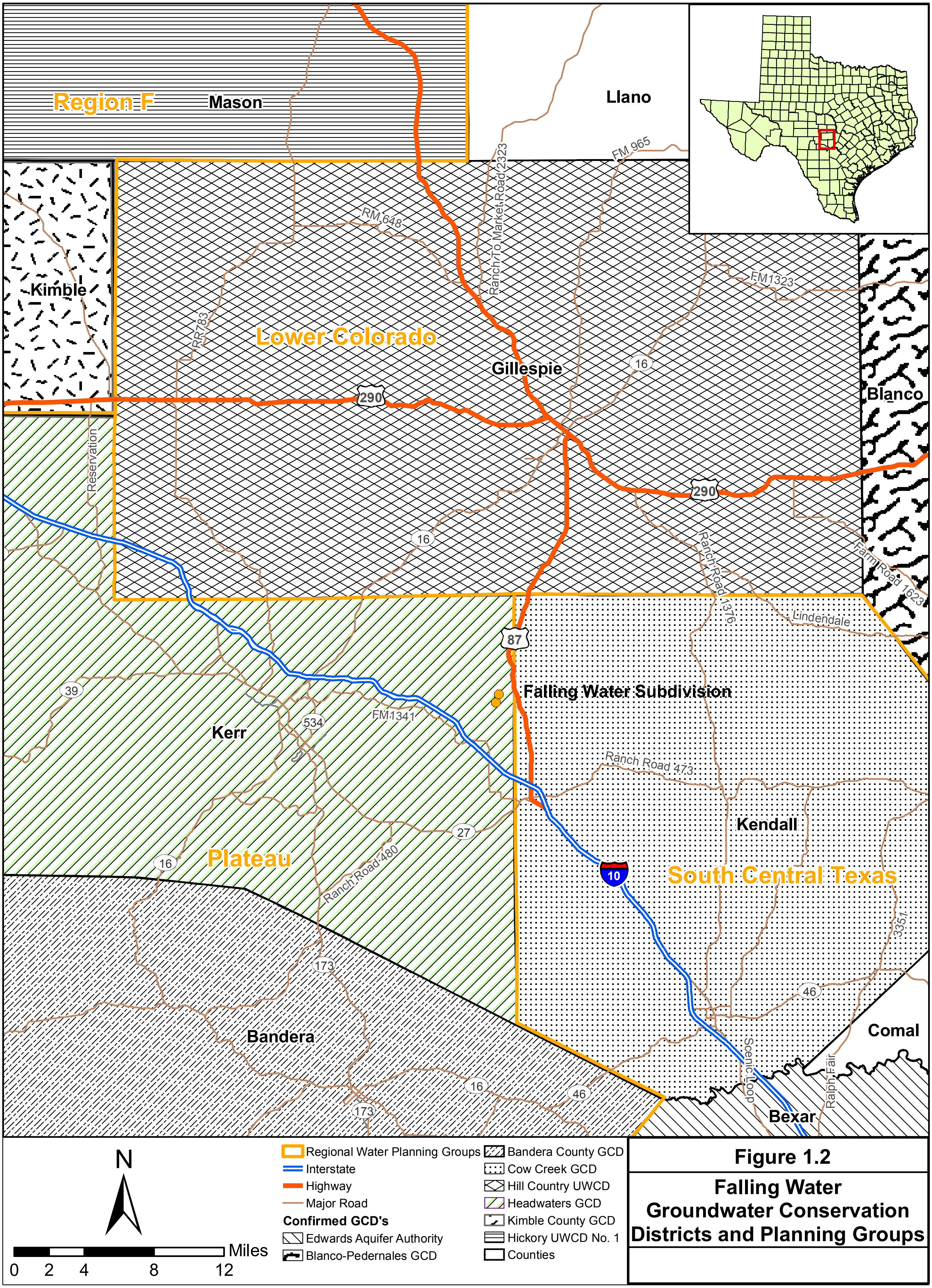

Figure 1.2

Falling Water Groundwater Conservation Districts and Planning Groups

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- 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 radium abatement options. Section 2 describes the methodology used to develop and assess compliance alternatives. The groundwater sources of radium are addressed in Section 3. Findings for the Falling Water Subdivision PWS, along with compliance alternatives development and evaluation, can be found in Section 4. Section 5 references the sources used in this report.

1.3 REGULATORY PERSPECTIVE

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

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

This project was conducted to assist in achieving these responsibilities.

1.4 ABATEMENT OPTIONS

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

1.4.1 Existing Public Water Supply Systems

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

1.4.1.1 Quantity

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

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

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

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

1.4.1.2 Quality

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

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

1.4.2 Potential for New Groundwater Sources

1.4.2.1 Existing Non-Public Supply Wells

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

- Use existing data sources (see below) to identify wells in the areas that have satisfactory quality. For the Falling Water Subdivision, the following standards could be used in a rough screening to identify compliant groundwater in surrounding systems:
  - Radium (total radium for radium-226 and radium-228) less than 4 pCi/L (below the MCL of 5 pCi/L); and
  - Total dissolved solids (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. Many owners have more than one well, and would probably be the best source of information regarding the latest test dates, who tested the water, 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.

1.4.2.2 Develop New Wells

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

1.4.3 Potential for Surface Water Sources

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

1.4.3.1 Existing Surface Water Sources

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

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

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

1.4.3.2 New Surface Water Sources

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

- Discussions with TCEQ to indicate the likelihood of obtaining those rights. The TCEQ may use the Water Availability Model (WAM) to assist in the determination.
- Discussions with land owners to indicate potential treatment plant locations.
- 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 radium 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 paragraphs.

The USEPA published a final rule in the Federal Register that established MCLs for radioactive contaminants ("radionuclides") on December 7, 2000 (USEPA 2000). The MCLs for radium (measured for radium-226 and radium-228) and uranium (combined uranium) are set at 5 pCi/L and 0.03 mg/L, respectively. The USEPA regulation applies to all community water systems and non-transient, non-community water systems, regardless of size.

The radionuclide MCLs became effective on December 8, 2003, and new monitoring requirements are being phased in between that date and December 31, 2007. All PWSs must complete initial monitoring for the new radionuclide MCLs by December 31, 2007.

The following BATs were identified in the final rule for achieving compliance with the MCLs for radium:

Combined radium-226 and radium-228:

- Reverse Osmosis (RO);
- Ion Exchange (IX); and
- Lime Softening.

In addition, the following small system compliance technologies (SSCT) are listed in the final rule (though the rule lists various limitations for the use of these technologies):

- RO;
- RO (point-of-use);
- IX;
- IX (point-of-use);
- Electrodialysis/Electrodialysis Reversal (EDR);
- Activated Alumina;
- Enhanced Coagulation/Filtration;
- Lime Softening;

- Greensand Filtration;
- Co-precipitation with Barium Sulfate; and
- Pre-formed Hydrous Manganese Oxide Filtration.

1.4.5 Description of Treatment Technologies

Radium-226 and radium-228 are cations (Ra^{2+}) dissolved in water and are not easily removed by particle filtration. A 2002 USEPA document (*Radionuclides in Drinking Water: A Small Entity Compliance Guide*, EPA 815-R-02-001) lists a number of small system compliance technologies that can remove radium (combined radium-226 and radium-228) from water. These technologies include IX, RO, EDR, lime softening, greensand filtration, co-precipitation with barium sulfate, and pre-formed hydrous manganese oxide filtration ($KMnO_4$-filtration). A relatively new process using the WRT Z-88™ medium (a medium that is specific for radium adsorption) has also been demonstrated to be an effective radium technology. Lime softening and co-precipitation with barium sulfate are relatively complex technologies that require chemistry skills and are not practical for small systems with limited resources; therefore these are not evaluated further.

1.4.5.1 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 the water. The process relies on the fact that certain ions are preferentially adsorbed on the ion exchange resin. Operations begin with a fully charged cation or anion bed having enough positively or negatively charged ions to carry out the cation or anion exchange. Usually a polymeric resin bed is composed of millions of spherical beads about the size of medium sand grains. As water passes the resin bed, the charged ions are released into the water, being substituted or replaced with the contaminants 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, sodium chloride, solution over the resin, displacing the contaminants ions with sodium ions for cation exchange and chloride ion 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 resins beds with a regeneration system, chlorine disinfection, and clear well storage. Treatment trains for surface water may also include raw water pumps, debris screens, and filters for pre-treatment. Additional treatment or management of the concentrate and the removed solids would be necessary prior to disposal, especially for radium removal resins which have elevated radioactivity.

For radium removal, a strong acid cation exchange resin in sodium form can remove 99 percent of the radium. This is the same type of resin used for hardness removal in IX softeners. The strong acid resin has less capacity for radium adsorption in water with high hardness and it has the following adsorption preference: $Ra^{2+} > Ba^{2+} > Ca^{2+} > Mg^{2+} > Na^{+}$. Hardness breakthrough occurs much earlier than radium in the fresh IX resin.

Because of this selectivity, radium and barium are much more difficult to remove from the resin during regeneration than calcium and magnesium. For economical reasons regeneration usually removes most of the hardness ions but leaves some of the radium and barium ions in the resin. Radium and barium can buildup on the resin after repeated cycles to the point where equilibrium is reached and then radium and barium would begin to break through shortly after hardness. In an operating IX system removing radium from water containing 200mg/L hardness, regeneration of the resin produced 2.4 bed volumes (BV) of 16,400mg/L TDS brine for every 100BV of water treated. In this case, the resin was regenerated using 6.5lb NaCl/ft^3 of resin. The radium concentration in the regeneration waste was approximately 40 times the influent radium concentration in the groundwater.

<u>Pretreatment</u> – There are pretreatment requirements for pH, organics, turbidity, and other raw water characteristics. Pretreatment may be required to reduce excessive amounts of total suspended solids (TSS), iron, and manganese, which could plug the resin bed, and typically includes media or carbon filtration.

<u>Maintenance</u> – The IX resin requires regular on-site regeneration, the frequency of which depends on the raw water characteristics (especially hardness), the contaminant concentration, and the size and number of the 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 with radioactivity); occasional solid wastes (in the form of broken resin beads) from the resin backwashes during regeneration; and if used, spent filters and backwash wastewater.

Advantages

- Well established process for radium removal.
- Fully automated and highly reliable process.
- Suitable for small and large installations.

Disadvantages

- Requires salt storage; regular regeneration.
- Concentrate disposal.
- Resins are sensitive to the presence of competing ions such as calcium and magnesium.

In considering application of IX for inorganics, it is important to understand what the effect of competing ions would be, and to what extent the brine can be recycled. Conventional IX cationic resin removes calcium and magnesium in addition to radium and, thus, the capacity for radium removal and frequency of regeneration depend on the hardness of the water to be treated. Spent regenerant is produced during IX bed regeneration, and it may have concentrations of the sorbed contaminants which would be expensive to treat and/or dispose because of hazardous waste regulations.

1.4.5.2 WRT Z-88™ Media

Process – The WRT Z-88 radium treatment process is a proprietary process using a radium-specific adsorption resin or zeolite supplied by Water Remediation Technologies, Inc. (WRT). The Z-88 process is similar to IX except that no regeneration of the resin is conducted and the resin is disposed upon exhaustion. The Z-88 does not remove calcium and magnesium and, thus, can last for 2-4 years, according to WRT, before replacement is necessary. The process is operated in an upflow, fluidized mode with a surface loading rate of 10.5 gallons per minute per square foot (gpm/ft^2). Pilot testing of this technology has been conducted for radium removal successfully in many locations, including the State of Texas. Seven full-scale systems with capacities of 750 to 1,200 gpm/ft^2 have been constructed in the Village of Oswego, Illinois since July 2005. The treatment equipment is owned by WRT and they assume the responsibility for disposal of spent media at an approved disposal site. The customer pays WRT based on an agreed upon treated water unit cost (*e.g.*, $.0.50-1.00/1,000 gallons, depending on site location and volume).

Pretreatment – Pretreatment may be required to reduce excess amounts of TSS, iron, and manganese, which could plug the resin bed, and typically includes media or carbon filtration. No chemical addition is required for radium removal.

Maintenance – Maintenance is relatively low for this technology as no regeneration or chemical handling is required. Periodic water quality monitoring and inspection of mechanical equipment are required.

Waste Disposal – The Z-88 media would be disposed in an approved low level radioactive waste landfill by WRT once every 2-4 years. No liquid waste is generated for this process. However, if pretreatment filters are used then spent filters and backwash wastewater disposal would be required.

Advantages

- Simple and fully automated process.
- No liquid waste disposal.
- No chemical handling, storage, or feed systems.
- No change in water quality except radium reduction.
- Low capital cost as WRT owns the equipment.

Disadvantages

- Relatively new technology.

- Proprietary technology without direct competition.
- Long term contract with WRT required.

From a small utilities point of view, the Z-88 process is a desirable technology for radium removal as operation and maintenance (O&M) efforts are minimal and no regular liquid waste is generated. However, this technology is very new and there is no long-term full-scale operating experience. But since the equipment is owned by WRT and performance is guaranteed by WRT, the risk to the PWSs is minimized.

1.4.5.3 Reverse Osmosis

Process – RO is a pressure-driven membrane separation process capable of removing dissolved solutes from water by means of particle 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 and polyamide thin film composite. Common RO membrane configurations include spiral wound and hollow fine fiber, but most RO systems to date are of the spiral wound type. A typical RO installation includes a high pressure feed pump with chemical feed, parallel first and second stage membrane elements in pressure vessels, and valving and piping for feed, permeate, and concentrate streams. Factors influencing membrane selection are cost, recovery, rejection, raw water characteristics, and pretreatment. Factors influencing performance are raw water characteristics, pressure, temperature, and regular monitoring and maintenance. RO is capable of achieving over 95 percent removal of radium. The treatment process is relatively insensitive to pH. Water recovery is 60-80 percent, depending on the raw water characteristics. The concentrate volume for disposal can be significant.

Pretreatment – RO requires careful review of raw water characteristics and pretreatment is necessary to prevent membranes from fouling, scaling, or degrading other membranes. Removal or sequestering of suspended and colloidal solids is necessary to prevent 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, ion exchange softening, acid and antiscalant feed, activated carbon or bisulfite feed to dechlorinate, and cartridge filters to remove any remaining suspended solids to protect membranes from upsets.

Maintenance – Monitoring rejection percentage is required to ensure contaminant removal below MCL. Regular monitoring of membrane performance is necessary to determine fouling, scaling, or other membrane degradation. Acidic or caustic solutions are regularly flushed through the system at high volume/low pressure along with a cleaning agent to remove foulants and scalants. Frequency of membrane replacement is dependent on raw water characteristics, pretreatment, and maintenance.

Waste Disposal – Pretreatment waste streams, concentrate flows, 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

- Can remove radium effectively.
- Can remove other undesirable dissolved constituents.

Disadvantages

- Relatively expensive to install and operate.
- Needs sophisticated monitoring systems.
- Needs to handle multiple chemicals.
- Waste of water because of the significant concentrate flows.
- Concentrated disposal.

RO is an expensive alternative for removal of radium and is usually not economically competitive with other processes unless nitrate and/or TDS removal is also required. The biggest drawback for using RO to remove radium is the waste of water through concentrate disposal which is also difficult or expensive because of the volume involved.

1.4.5.4 Electrodialysis/Electrodialysis Reversal

Process – Electrodialysis (ED) is an electrochemical separation process in which ions migrate through ion-selective semi-permeable membranes as a result of their attraction to two electrically charged electrodes. The driving force for ion transfer is direct electric current. ED is different from RO in that it removes only dissolved inorganics but not particulates, organics, and silica. EDR is an improved form of ED in which the polarity of the direct current is changed approximately every 15 minutes. The change of polarity helps reduce the formation of scale and fouling films and, thus, achieves higher water recovery. EDR has been the dominant form of ED systems used for the past 25-30 years. A typical EDR system includes a membrane stack with a number of cell pairs, each consisting of a cation transfer membrane, a demineralized water 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 concentrate reject flow in parallel across the membranes and through the demineralized water 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 the dissolved salts, including radium, and multiple stages may be required to meet the MCL if radium concentration is high. The conventional EDR treatment train typically includes EDR membranes, chlorine disinfection, and clearwell storage.

<u>Pretreatment</u> – There are pretreatment requirements for pH, organics, turbidity, and other raw water characteristics. EDR typically requires acid and antiscalant feed to prevent scaling and a cartridge filter for prefiltration. Treatment of surface water may also require pretreatment steps such as raw water pumps, debris screens, rapid mix with addition of a coagulant, flocculation basin, sedimentation basin or clarifier, and gravity filters. Microfiltration could be used in place of flocculation, sedimentation, and filtration.

<u>Maintenance</u> – EDR membranes are durable, can tolerate pH from 1-10 and temperatures to 115^{o}F for cleaning. The membranes 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 could form. Depending on the raw water characteristics, the membranes would require regular maintenance or replacement. If used, pretreatment filter replacement and backwashing would be required. The EDR stack must be disassembled, mechanically cleaned, and reassembled at regular intervals.

<u>Waste Disposal</u> – Highly concentrated reject flows, electrode cleaning flows, and spent membranes require approved disposal methods. Pretreatment process residuals and spent materials also require approved disposal methods.

Advantages

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

Disadvantages

- Not suitable for high levels of iron, manganese, hydrogen sulfide, and hardness.
- Relatively expensive process and high energy consumption.
- Does not remove particulates, organics, or silica.

EDR can be quite expensive to run because of its energy usage. If radium removal is the only purpose, it is probably more expensive than other technologies; however, if nitrate and/or TDS removal is also required, then EDR is a competitive process.

1.4.5.5 Potassium Permanganate Greensand Filtration

<u>Process</u> – Manganese dioxide (MnO_2) is known to have capacity to adsorb radium from water. MnO_2 can be formed by oxidation of Mn^{2+} occurring in natural waters

and/or reduction of hydrous manganese oxide ($KMnO_4$) added to the water. The MnO_2 is in the form of colloidal MnO_2 which has a large surface area for adsorption. The MnO_2 does not adsorb calcium and magnesium so hardness is not a factor, but iron and manganese and other heavy metal cations can compete strongly with radium adsorption. If these cations are present it would be necessary to install a good iron and manganese removal process before the MnO_2 filtration process or to make sure some MnO_2 is still available for radium sorption. The $KMnO_4$-greensand filtration process can accomplish this purpose because it is coated with MnO_2 which is regenerated by the continuous feeding of $KMnO_4$. Many operating treatment systems that use continuous feed $KMnO_4$, 30-minute contact times, and manganese greensand, remove radium to concentrations below the MCL. The treatment system equipment includes a $KMnO_4$ feed system, a pressurized reaction tank, and a manganese greensand filter. Backwashing of the greensand filter is usually required, but periodic regeneration is not required.

Pretreatment – The $KMnO_4$-greensand filtration process usually does not require pretreatment except if turbidity is very high. The greensand filter usually has an anthracite layer to filter larger particles, while the greensand adsorbs dissolved cations such as radium.

Maintenance – The greensand requires periodic backwashing to remove suspended materials and metal oxides. $KMnO_4$ is usually supplied in powder form, and preparation of $KMnO_4$ solution is required. Occasional monitoring to ensure no overfeeding of $KMnO_4$ (pink water) is important to avoid problems in the distribution system and household fixtures.

Waste Disposal – Approval from local authorities is usually required for disposal/discharge of the backwash wastewater. If local sewer is not available, a backwash storage and settling tank would be required to recycle settled water to the process and periodically dispose of the settled solids.

Advantages

- Well established process for radium removal.
- No regeneration waste generated.
- Low pressure operation and no repumping required.
- No additional process for iron and manganese removal.

Disadvantages

- Need to handle powdered $KMnO_4$, which is an oxidant.
- Need to monitor and backwash regularly.

The $KMnO_4$-greensand filtration is a well-established removal process and is effective for radium removal, but iron and manganese can compete with radium adsorption. It is suitable for small and large systems and is cost competitive with other alternative technologies.

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

The SDWA [§1412(b)(4)(E)(ii)] regulates the design, management and operation of POU and POE treatment units used to achieve compliance with an MCL. These restrictions, relevant to arsenic 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 O&M and MCL compliance. The water system must retain unit ownership and oversight of unit installation, maintenance and sampling; the utility ultimately is the responsible party for regulatory compliance. The water system staff need not perform all installation, maintenance, or management functions, as these tasks may be contracted to a third party-but the final responsibility for the quality and quantity of the water supplied to the community resides with the water system, and the utility must monitor all contractors closely. Responsibility for O&M of POU or POE devices installed for SDWA compliance may not be delegated to homeowners.

- POU and POE units must have mechanical warning systems to automatically notify customers of operational problems. Each POU or POE treatment device must be equipped with a warning device (*e.g.*, alarm, light) that would alert users when their unit is no longer adequately treating their water. As an alternative, units may be equipped with an automatic shut-off mechanism to meet this requirement.

- If the American National Standards Institute (ANSI) has issued product standards for a specific type of POU or POE treatment unit, only those units that have been independently certified according to those standards may be used as part of a compliance strategy.

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

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

1.4.7 Water Delivery or Central Drinking Water Dispensers

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

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

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

Water delivery programs require consumer participation to a varying degree. Ideally, consumers would have to do no more than they currently do for a piped-water delivery system. Least desirable are those systems that require maximum effort on the part of the customer (*e.g.,* customer has to travel to get the water, transport the water, and physically handle the bottles). Such a system may appear to be lowest-cost to the utility; however, should a consumer experience ill effects from contaminated water and take legal action, the ultimate cost could increase significantly.

The ideal system would:

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

SECTION 2
EVALUATION 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.

These files were reviewed for the PWS and surrounding systems.

TREE 1 – EXISTING FACILITY ANALYSIS

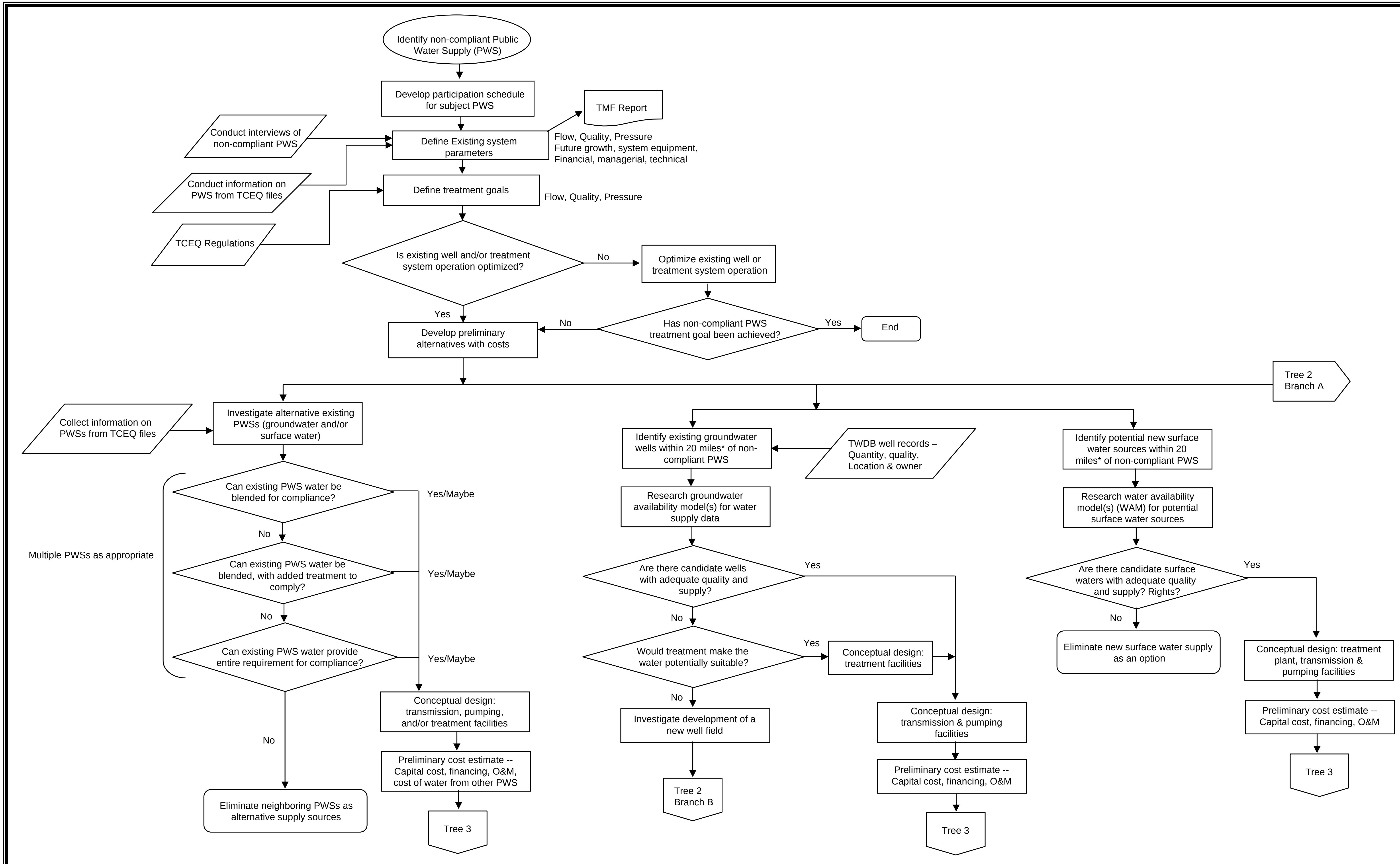


Figure 2.2
TREE 2 – DEVELOP TREATMENT ALTERNATAIVES

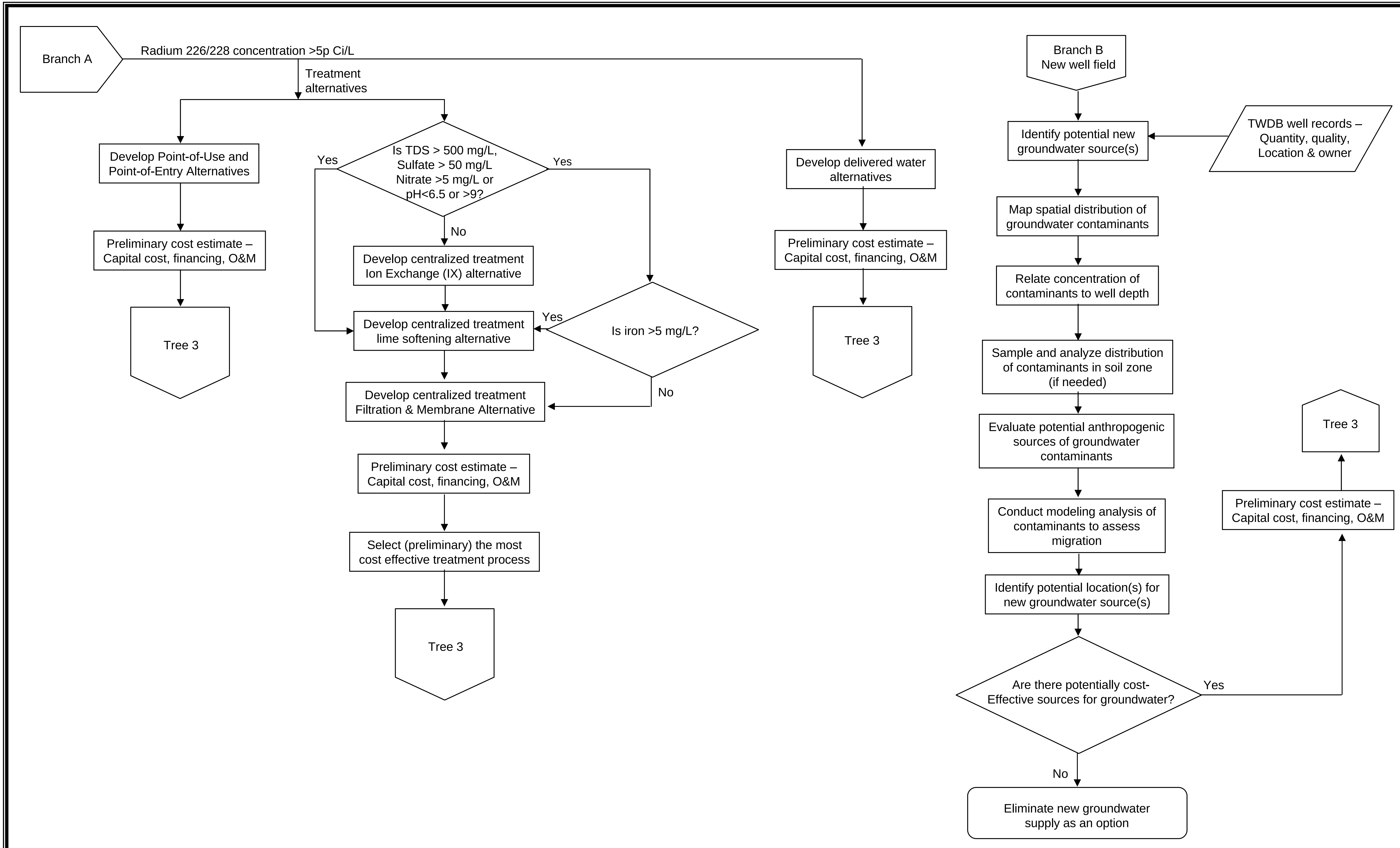


Figure 2.3
Tree 3 – PRELIMINARY ANALYSIS

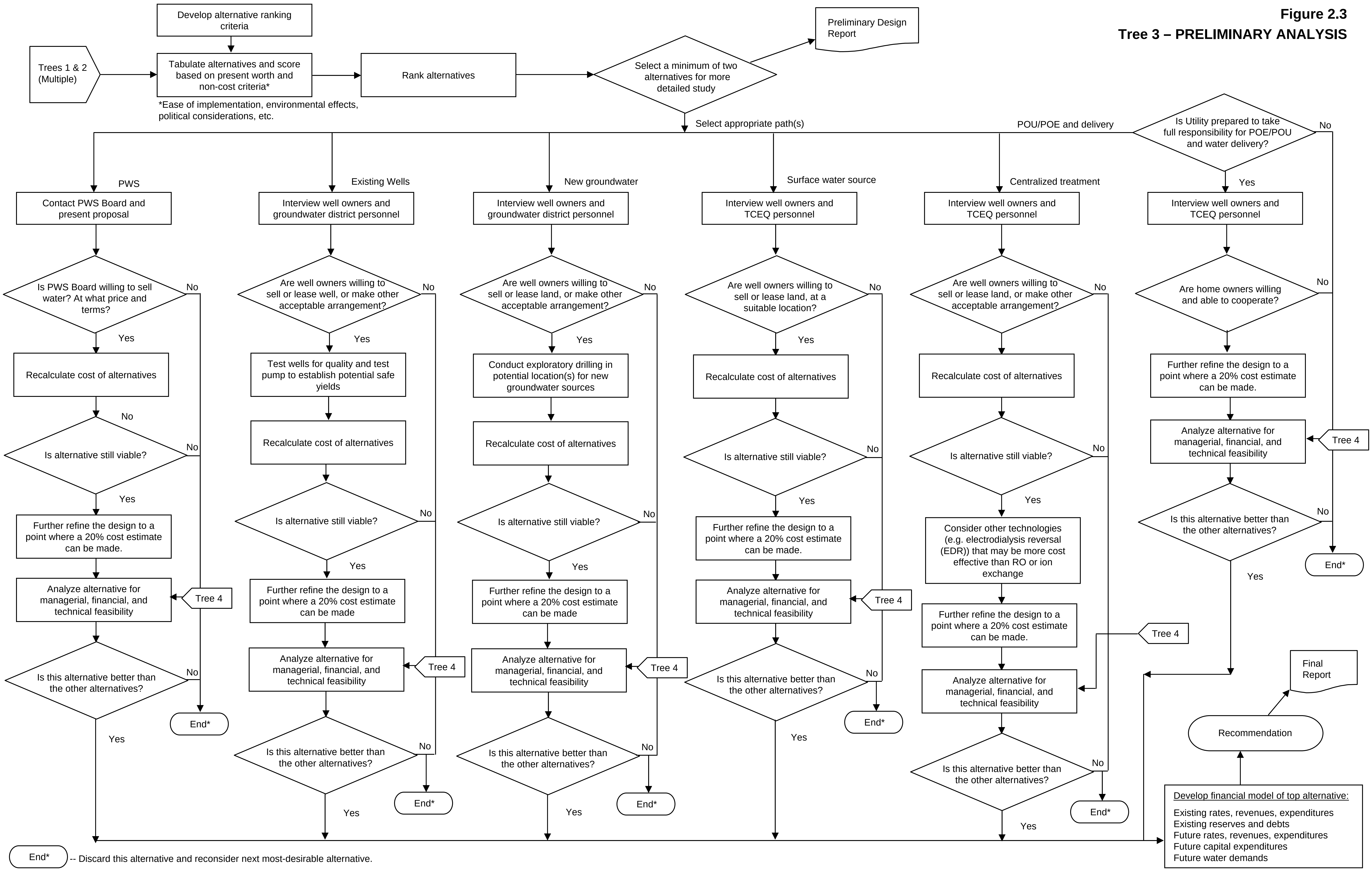
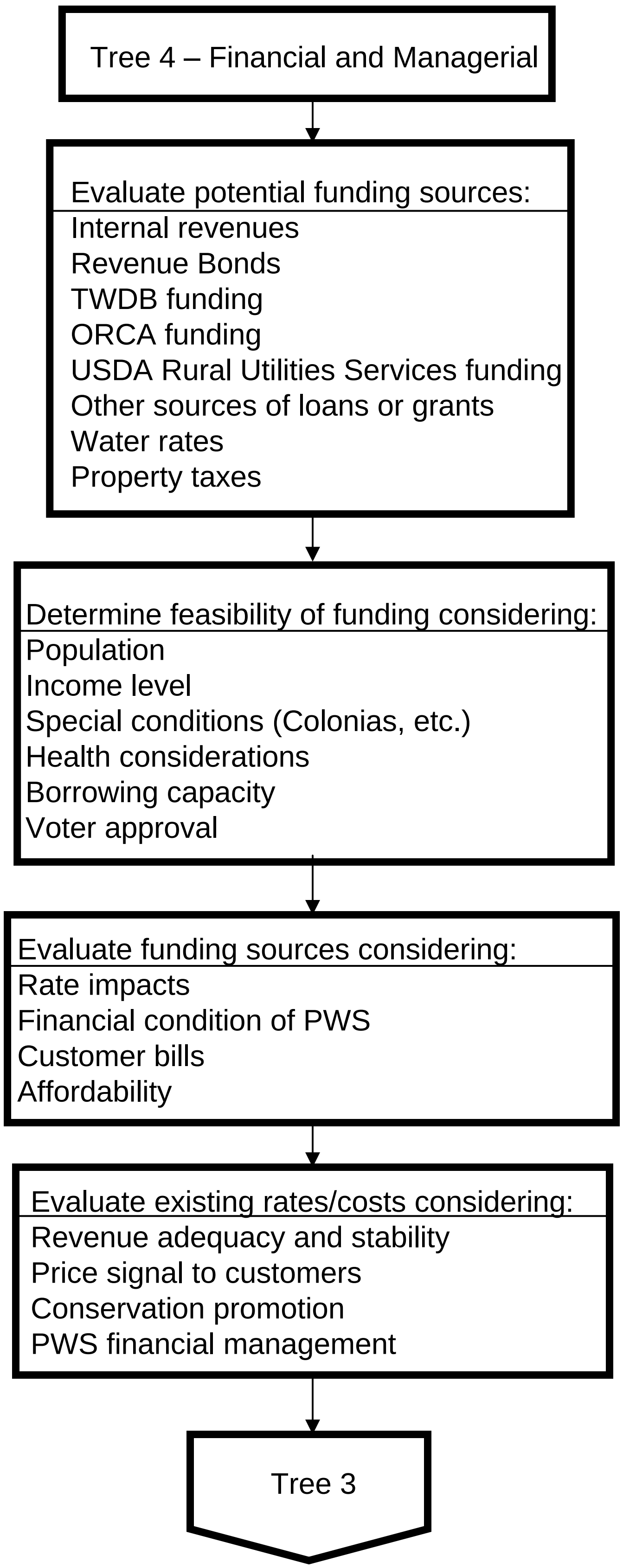


Figure 2.4
TREE 4 – FINANCIAL AND MANAGERIAL



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

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

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

2.2.1.2 Existing Wells

The TWDB maintains a groundwater database available at www.twdb.state.tx.us that has two tables with helpful information. The "Well Data Table" provides a physical description of the well, owner, location in terms of latitude and longitude, current use, and for some wells, items such as 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.

2.2.1.3 Surface Water Sources

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

2.2.1.4 Groundwater Availability Model

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

2.2.1.5 Water Availability Model

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

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

2.2.1.6 Financial Data

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

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

2.2.1.7 Demographic Data

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

2.2.2 PWS Interviews

2.2.2.1 PWS Capacity Assessment Process

A capacity assessment is the industry standard term for an evaluation of a water system's financial, managerial, and technical capacity to effectively deliver safe drinking water to its customers now and in the future at a reasonable cost, and to achieve, maintain and plan for compliance with applicable regulations. The assessment process involves interviews with staff and management who have a responsibility in the operations and 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 that 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 10 miles from the non-compliant PWS were not considered because the length of the pipeline required would make the alternative cost prohibitive. The quality of water provided was also investigated. For neighboring PWSs with compliant water, options for water purchase and/or expansion of existing well fields were considered. The neighboring PWSs with non-compliant water were considered as possible partners in sharing the cost for obtaining compliant water either through treatment or developing an alternate source.

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

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

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

2.3.2 New Groundwater Source

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

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

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

2.3.3 New Surface Water Source

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

2.3.4 Treatment

Treatment technologies for central treatment considered potentially applicable are IX, WRT Z-88 media adsorption, and potassium permanganate greensand filtration. EDR and RO are more expensive, generate more waste for disposal, and increase the amount of raw water used to produce the same amount of treated water. Hence, only the IX, WRT Z-88 media adsorption, and potassium permanganate greensand filtration are evaluated further.

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

2.4 COST OF SERVICE AND FUNDING ANALYSIS

The primary purpose of the cost of service and funding analysis was to determine the financial impact of implementing compliance alternatives, primarily by examining the required rate increases, and analyzing the fraction of household income that water bills consume. 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 the comparison of 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 were used for small rural water utilities due to small population sizes. Annual water bills are 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, corresponds to census tract data.

2.4.3 Annual Average Water Bill

The annual average household water bill was calculated for existing conditions and for future conditions incorporating the alternative solutions. Average residential consumption was estimated and applied to the existing rate structure to estimate the annual water bill. 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

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

2.4.5 Financial Plan Results

Results from the financial planning model were summarized in two ways: by percentage of household income and by total water rate increase 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:

- Percentage of the median annual household income that the average annual residential water bill represents.

- The first year in which a water rate increase would be required.
- The total increase in water rates required, compared to current rates.

Water rates resulting from the incremental capital costs of the alternative solutions 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).
- No change in estimate of uncollectible revenues over time.
- Average consumption per account unchanged over time.
- No change in unaccounted for water as percentage of total (more efficient water use would lower total water requirements and costs).

- No inflation included in the analyses (although the model 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).
- Minimum working capital fund established for each district based on specified months of O&M expenditures.
- O&M for alternatives begins 1 year after capital implementation.
- Balance of capital expenditures not funded from primary grant program is funded through debt (bond equivalent).
- Cash balance drives rate increases, unless provision chosen to override where current net cash flow is positive.

2.4.5.3 Interpretation of Financial Plan Results

Results from the financial plan model, as presented in Table 4.5, show the percentage of MHI represented by the annual water bill that resulted from any rate increases necessary to maintain financial viability over time. In some cases, this may require rate increases even without implementing a compliance alternative (the no action alternative). The table shows any increases such as these separately. The results table shows the total increase in rates necessary, including both the no-action alternative increase and any increase required for the alternative. For example, if the no action alternative required a 10 percent increase in rates and the results table shows a rate increase of 25 percent, then the impact from the alternative was an increase in water rates of 15 percent. Likewise, the percentage of household income in the table reflects the total impact from all rate increases.

2.4.5.4 Potential Funding Sources

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

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

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

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

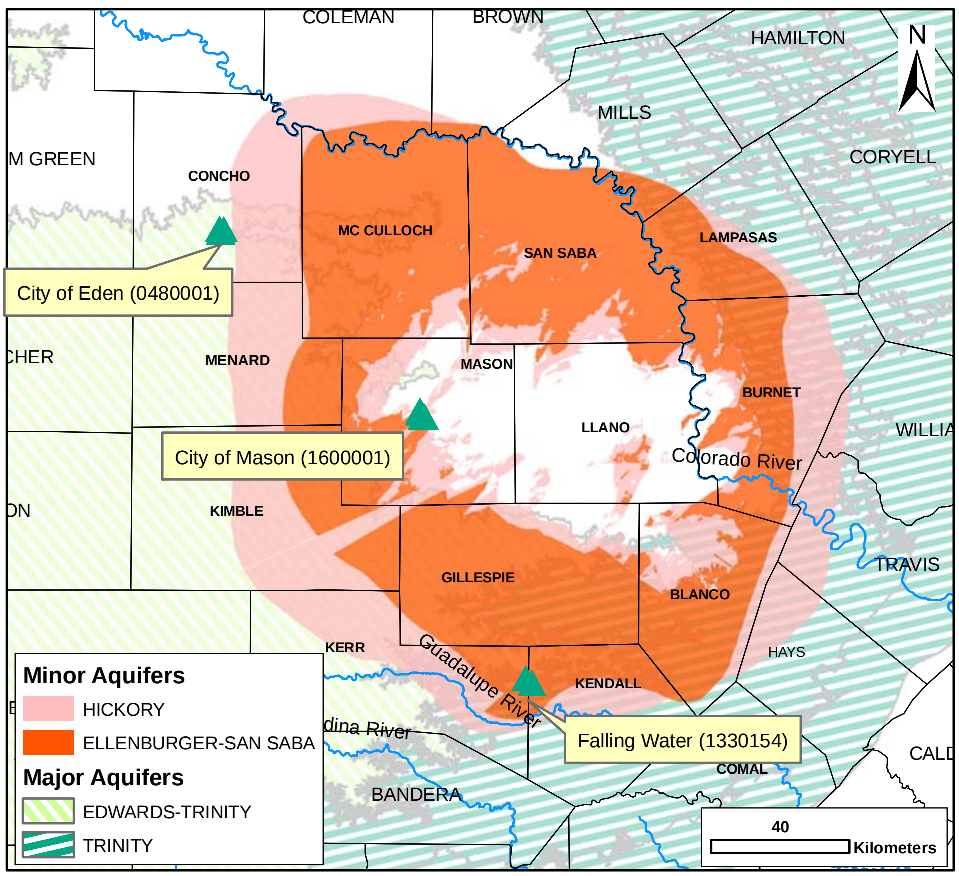
- United States Department of Agriculture, Rural Utilities Service, and
- United States Housing and Urban Development.

SECTION 3
UNDERSTANDING SOURCES OF CONTAMINANTS

3.1 RADIONUCLIDES IN CENTRAL TEXAS AQUIFERS

Three major aquifers (Edwards, Trinity, and Edwards-Trinity [Plateau]) and four minor aquifers (Ellenburger San Saba, Hickory, Lipan, and Marble Falls) provide groundwater to counties in Central Texas (Ashworth and Hopkins 1992). Aquifers of concern to this study are the Cambrian-age Hickory aquifer in Concho and Mason Counties, the Cretaceous-age Edwards-Trinity (Plateau) aquifer in Concho County, and the Trinity aquifer in Kerr and Kendall Counties. Figure 3.1 shows the three PWSs that are being evaluated (City of Eden, City of Mason, and Falling Water) and the major and minor aquifers in the study area. The Hickory aquifer is the major water-bearing unit used for groundwater supply in Concho, Kimble, Mason, McCulloch, Menard, and San Saba Counties (Black 1988; Pettigrew 1991). The most significant aquifer in central Texas in terms of importance and development is the Edwards-Trinity (Plateau) aquifer (Walker 1979).

Figure 3.1 PWS Wells and Aquifers in the Study Area



3.2 HYDROGEOLOGY

3.2.1 Hickory Aquifer

The Hickory aquifer is the major water-bearing unit used for groundwater supply in Concho, Kimble, Mason, McCulloch, Menard, and San Saba Counties (Black 1988; Pettigrew 1991). Outcrop portions of the Hickory aquifer are used for irrigation, whereas confined portions are used for municipal water supply (Black 1988). The only geologic unit contained within this aquifer is the Hickory Member of the Cambrian-age Riley Formation (Mason 1961). The Hickory Member has three distinct facies, the lowest of which has the greatest capacity to transmit water (outcrop permeability of 200–300 gal/day/ft^2) (Pettigrew 1991). The lowest facies contains coarse- to medium-grained, poorly sorted sand with minor siltstone and shale layers and can be identified throughout all of San Saba County (the study area of Pettigrew 1991). The middle and upper facies of the Hickory Member have much lower permeability and are very heterogeneous. The upper facies is cemented with hematite.

The thickness of the entire Hickory Member is as much as ~490 feet (McBride *et al*. 2002); thickness in Mason County is ~350 to 475 feet (Black 1988). However, widespread faulting makes the hydrogeology complex, because of the healed fractures and deformation bands impeding flow and resulting in compartmentalization of permeability (Black 1988; McBride, *et al.* 2002). Black (1988) stated that water level, geochemical, isotopic-age, and structural data indicate that the lower portions of the Hickory aquifer are nearly stagnant and have minimal interaction with outcrop portions of the aquifer.

The Hickory Member directly overlies, albeit unconformably, Precambrian basement rocks, consisting of granites and metamorphosed sedimentary and igneous rocks. According to Barnes and Schofield (1968), the Precambrian surface upon which the Hickory was deposited represents >400 million years of erosion and has topographic relief of as much as 300 feet. Approximately 7 million tons of elemental iron are estimated to be present in the top 30 feet of each square mile of Hickory sandstone (Barnes and Schofield 1968).

Granite and volcanic ash derived from high-silica igneous systems is the source of uranium in sedimentary mineral deposits (Finch 1967). It is now commonly recognized that billion-year-old, unmetamorphosed granitic plutons underlie much of the Llano Uplift region of central Texas. Studies of regional flow patterns and groundwater chemistry indicate that basal portions of the Hickory Member are recharged from underlying fractured granites (Mason 1961; Riemenschneider 1995). Also, extensive authigenic mineralization in the Hickory Member reflects many different stages of the movement of fluids throughout the ~400 million years since the Hickory was deposited (McBride, *et al.* 2002).

Depths of wells completed in the Hickory aquifer are between 234 to 800 feet and 4,160 to 4,200 feet in Mason and Concho Counties, respectively.

3.2.2 Edwards-Trinity (Plateau) Aquifer

The Edwards-Trinity (Plateau) aquifer extends from the Pecos River eastward to the west edge of the Llano Uplift and from the Balcones Fault System to the south northward into the southern margin of the southern High Plains (Figure 3.1). Geologic units that compose this aquifer include Twin Mountain, Antlers/Glen Rose, and Travis Peak members of the lower Cretaceous Trinity Group and overlying limestones and dolomites of the Comanche Peak, Edwards, and Georgetown Formations (Walker 1979; Ashworth and Hopkins 1992). In some areas, the aquifer is unconfined (Ashworth and Hopkins 1992), which is expected to be the case in Concho County, where the PWS wells of concern in this unit are only 35 to 36 feet deep. The TWDB database shows that the shallow Concho County PWS wells are completed in unit 218EDRDA (Edwards and associated limestones), not the Edwards-Trinity (Plateau) aquifer. Antler Sand is absent in Concho County owing to the presence of paleotopographic highs during Cretaceous deposition (Walker 1979).

3.2.3 Trinity Aquifer

The Trinity aquifer is found in the east half of the region (Figure 3.1). Geologic units that compose this aquifer include Paluxy, Glen Rose, and Twin Mountains-Travis Peak Formations of early Cretaceous age (Ashworth and Hopkins 1992). The aquifer is unconfined throughout Blanco, Gillespie, Kendall, Kerr, and Bandera Counties (Ashworth and Hopkins 1992).

3.2.4 Ellenburger-San Saba Aquifer

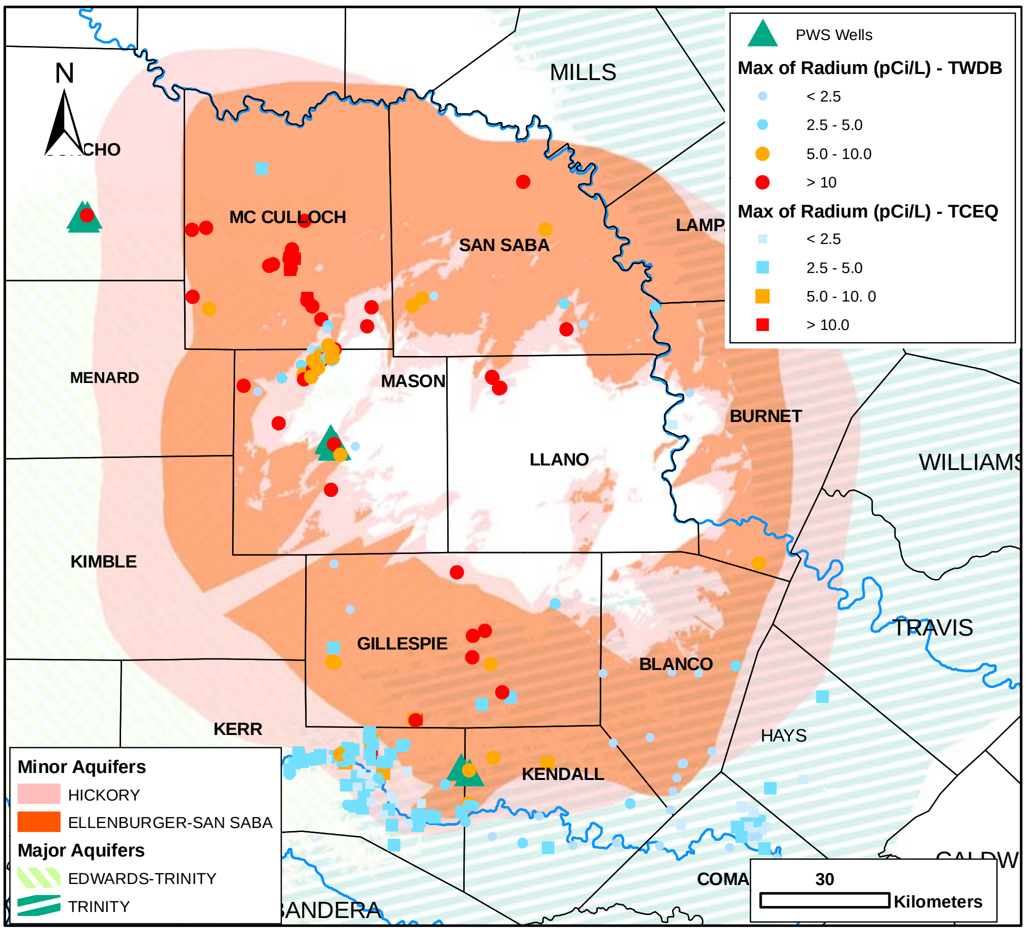
The Ellenburger-San Saba aquifer is a minor aquifer that occurs in parts of 15 counties in the Llano Uplift (Ashworth and Hopkins 1992). Outcrops of the geologic units surround older rocks in the core of the Llano uplift; the downdip portion extends to ~3,000 feet. The aquifer has been compartmentalized by regional block faulting. Most of the water pumped for municipal water supplies is at Fredericksburg, Johnson City, and Richland Springs. Water from San Saba springs supplies the City of San Saba. The geologic units that make up the aquifer include limestone and dolomite facies of the San Saba member of the Wilberns Formation (late Cambrian age) and the Honeycut, Gorman, and Tanyard Formations (Bluntzer 1992). Most water occurs in solution cavities along faults and fractures.

3.3 GENERAL RADIONUCLIDE TRENDS

The geochemistry of radionuclides is described in Appendix E. Radium and uranium trends within the study area were analyzed to examine spatial trends, as well as correlations with other water quality parameters. In the analysis, radium measurements from TWDB and TCEQ databases were used, and uranium measurements from the National Geochemical Database, also known as the National Uranium Resource Evaluation (NURE) database were used (http://pubs.usgs.gov/of/1997/ofr-97-0492/index.html). The term *radium* or *radium combined* is generally used to refer to radium 226 + radium 228. Otherwise, radium 226 or radium 228 is specified. Although

TCEQ allows public water systems to subtract the reported error from the radium concentrations to assess compliance, the following analysis of general trends uses the mean radium concentration and does not subtract the reported error. This approach is considered more conservative. Uranium measurements from TWDB and TCEQ databases were not used in the analysis. Data from these databases within the study area showed no uranium concentrations exceeding MCL for uranium (30 µg/L). Units of uranium in TCEQ and TWDB databases are in pCi/L, and a conservative conversion factor of 0.67 (USEPA 2004) was used to convert concentrations to µg/L. Figure 3.2 shows the spatial distribution of radium concentrations within the study area.

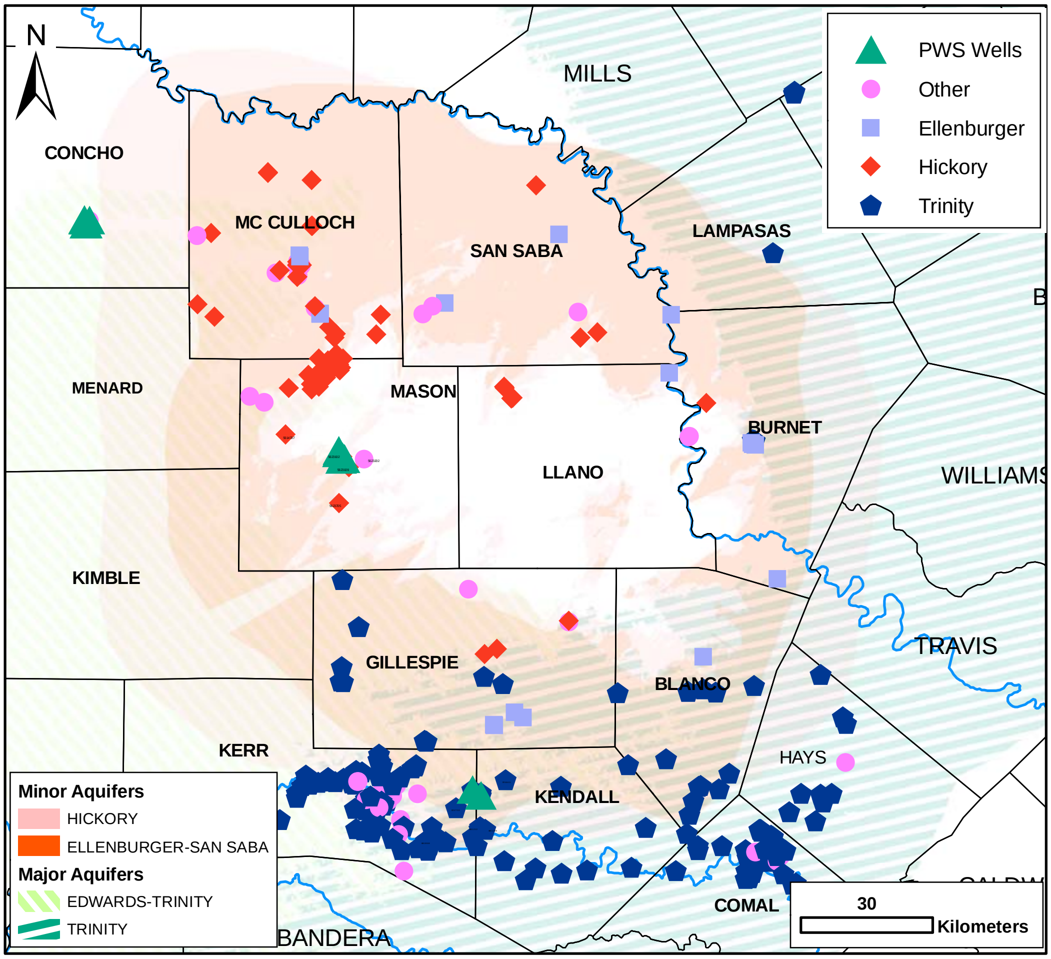
Figure 3.2 Radium Concentrations in the Study Area (TWDB and TCEQ Databases)



Samples are from the TWDB (Storet code 09503 and 81366) and TCEQ databases (Contaminant ID 4020 and 4030) for each sample. Radium 226 and radium 228 were combined, and the maximum combined value for each well is shown. Measurements that can be related to a specific well from a single entry point were used from the TCEQ database only. A total of 139 wells from the TCEQ database (sample dates between 1999 and 2005) and 129 wells from the TWDB database (sample dates between 1977 and 1994) were used in the analysis. Samples were limited to an area delimited by the following coordinates: bottom left corner -100.15E, 29.85N, and upper right corner -

98.04E, 31.59N. Coordinates are in decimal degrees, and the datum is North American Datum 1983 (NAD 1983). Figure 3.3 shows wells with radium samples categorized by aquifer.

Figure 3.3 Wells with Radium Samples Categorized by Aquifer



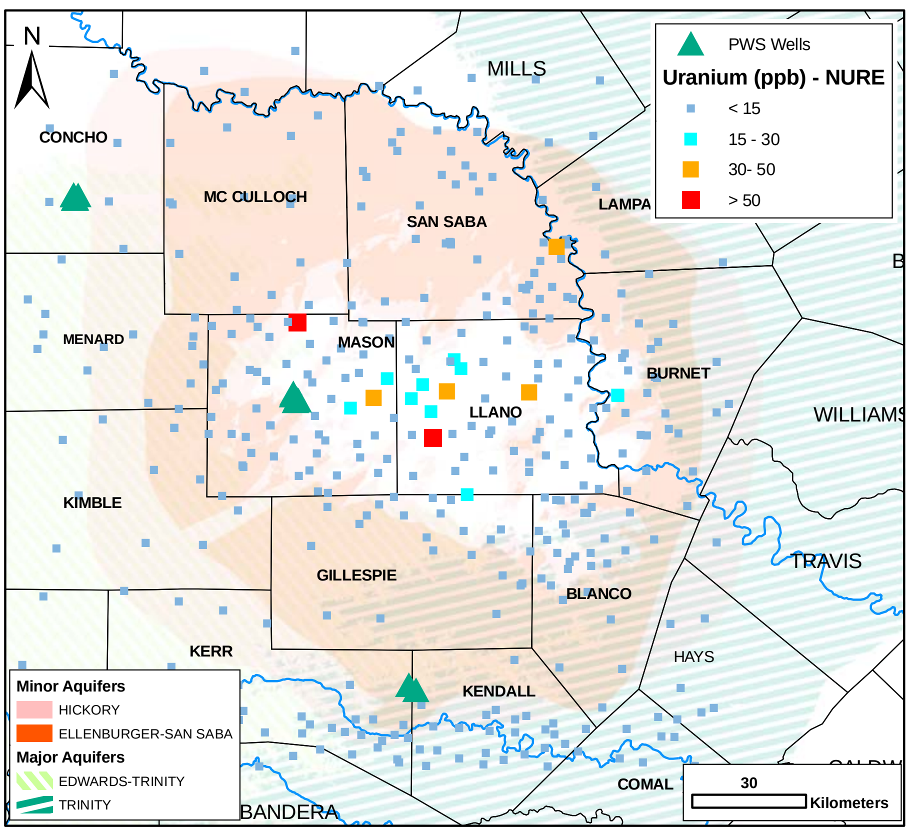
The above map (Figure 3.3) shows 129 wells from the TWDB database: 55 in the Hickory, 47 in the Trinity, nine in the Ellenburger, and 18 in other formations; 139 wells from the TCEQ PWS database: eight in the Hickory, eight in the Ellenburger, 101 in the Trinity and 22 in other formations. The two maps (Figures 3.2 and 3.3) show that the spatial distribution of high radium is correlated with the water source (aquifer). Most of the high radium concentrations (>5 pCi/L) are in wells within the Hickory and Ellenburger aquifers. Areas where wells are within the Trinity aquifer have few high concentrations. Table 3.1 shows the percentage of wells with maximum radium concentrations greater than the radium MCL (5 pCi/L) for the major aquifers in the study area.

Table 3.1 Wells with Radium Measurements

	TWDB Database			TCEQ Database			Combined TCEQ and TWDB		
Aquifer	Wells with radium samples	Wells with max. radium >5 pCi/L	% of wells with radium >5 pCi/L	Wells with radium samples	Wells with max. radium >5 pCi/L	% of wells with radium >5 pCi/L	Wells with radium samples	Wells with max. radium >5 pCi/L	% of wells with radium >5 pCi/ L
Ellenburger	9	5	56	8	2	25	17	7	41
Hickory	55	41	75	8	7	88	63	48	76
Trinity	47	10	21	101	6	6	148	16	11
Other	18	14	78	22	1	5	40	15	38

Maximum combined radium for each well was used in the analysis. Data show that wells in the Hickory aquifer are most susceptible to having radium exceeding the water quality standard (between 75 and 88% of wells had radium >5 pCi/L). Wells in the Ellenburger aquifer also had a high percentage of elevated radium concentrations (between 25 and 56% of wells had radium >5 pCi/L), and wells in the Trinity aquifer had the lowest occurrence rate of elevated radium (between 6 and 21% of wells had radium >5 pCi/L). Figure 3.4 shows uranium concentrations from the NURE database.

Figure 3.4 Uranium Concentrations (NURE Database)



Concentrations in the above map (Figure 3.4) are from the NURE database (418 samples in the study area), sampled between 1976 and 1980. Only six samples are above the water quality standard (30 µg/L), and 17 above 15 µg/L. High concentrations are spatially located within the Hickory and Ellenburger San Saba aquifer zones, although the NURE database does not designate the actual aquifer.

3.4 CORRELATION WITH DEPTH

Radium and uranium concentrations were compared with well depth to identify stratigraphic units that might be the source of radionuclides. In general, higher radium concentrations were in the deeper wells (Figure 3.5). Average and median concentrations in wells with depth <2,000 feet are 7.4 pCi/L and 4.7 pCi/L, respectively, and for wells with depth >2,000 feet, average and median concentrations are 23.0 pCi/L and 13.5 pCi/L, respectively. Figure 3.6 shows the probabilities of radium concentrations exceeding water quality MCL (5 pCi/L) for different depth ranges. It shows that wells with depths >2,000 feet have a higher probability (78%) of having radium concentrations exceeding the MCL. These results are expected because wells in the Hickory and Ellenburger San Saba aquifer are generally deeper. Uranium concentrations were not correlated with well depth.

Figure 3.5 Radium Concentrations vs. Well Depth (Wells in All Aquifers)

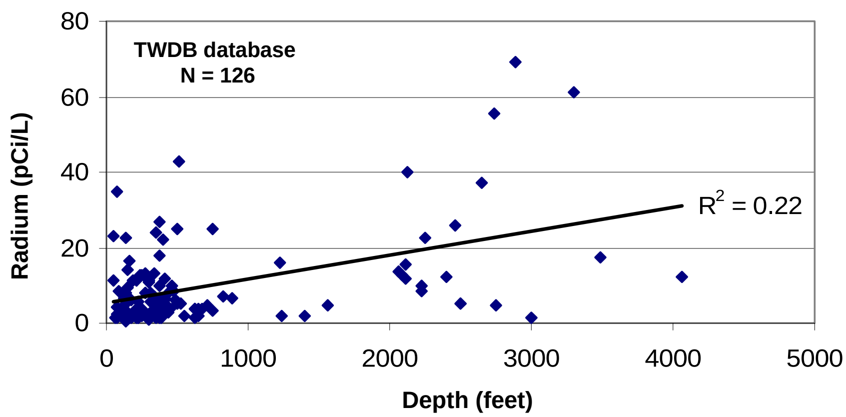
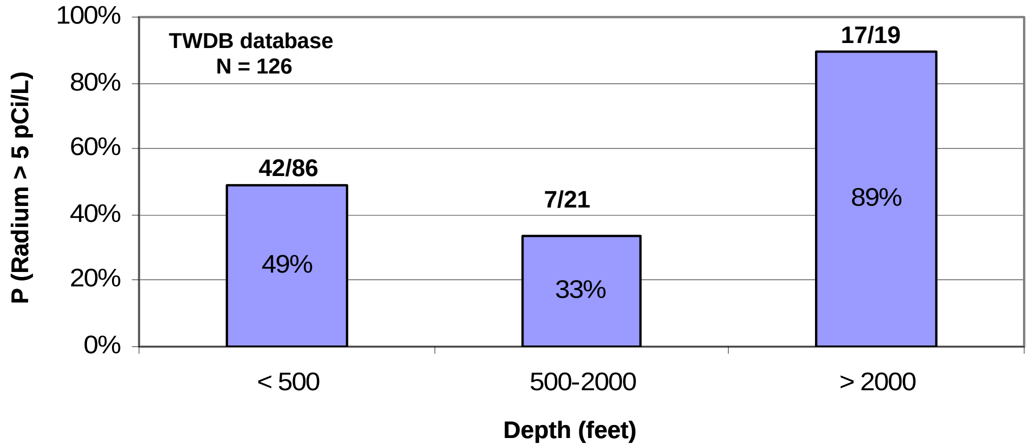
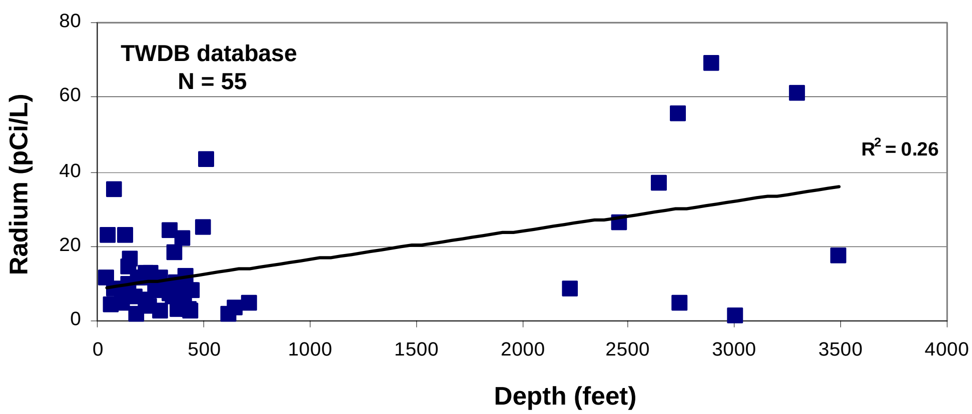


Figure 3.6 Probability of Radium Concentration Exceeding 5 pCi/L vs. Well Depth



Data are from the TWDB database, and N represents number of wells (126). The most recent radium sample is shown for each well. A similar analysis is shown below for the Hickory aquifer (Figure 3.7).

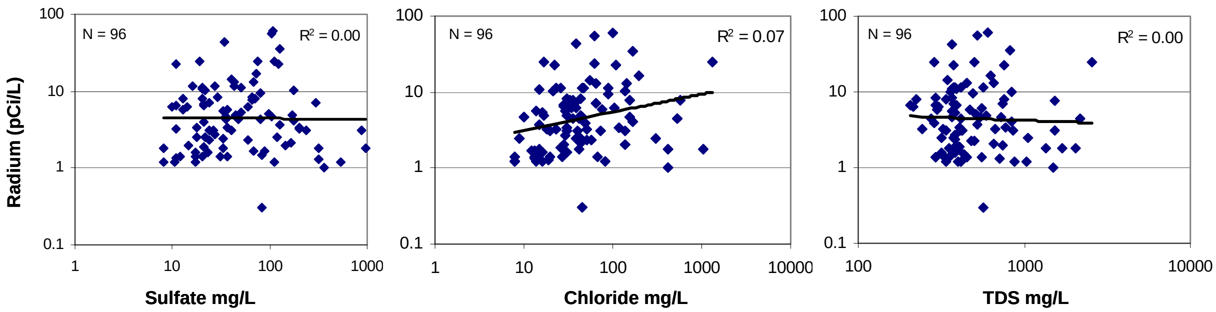
Figure 3.7 Radium Concentrations vs. Well Depth in the Hickory Aquifer



Data are from the TWDB database, and N represents number of wells (55) used in the analysis. The most recent sample is shown for each well. There are two ranges of well depths within the Hickory aquifer: 45 to 700 feet and 2,200 to 3,500 feet. Although highest radium concentrations (>50 pCi/L) are in deeper wells, the probability of radium exceeding 5 pCi/L MCL is similar for both depth intervals, 74 percent for shallower wells vs. 78 percent for deeper wells.

Radium is not strongly related to general water quality parameters (sulfate, chloride, and TDS) (Figure 3.8).

Figure 3.8 Correlation of Radium Concentrations with Sulfate, Chloride, and TDS

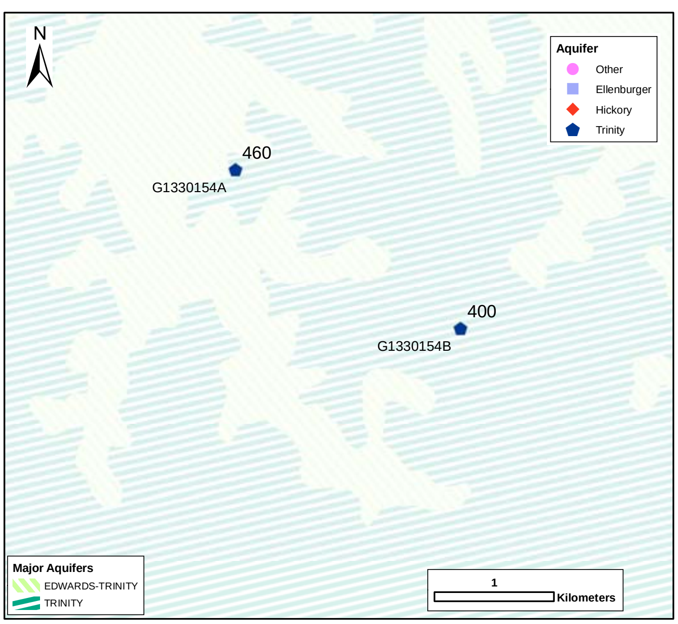


Data are from the TWDB database, and N represents number of wells in the analysis (96). The most recent radium sample for each well is shown. Sulfate, chloride, and TDS samples are from the same dates radium was sampled (if more than one sample existed for one day the average for the day was calculated).

3.5 DETAILED ASSESSMENT

Falling Water PWS has two wells: G1330154A (the active well) and G1330154B (the backup well). Each well is connected to a different entry point (Well A to entry point 1 and Well B to entry point 2). Both wells are screened in the Edwards-Trinity aquifer and have depths of 460 and 400 feet, respectively. Figure 3.9 shows well locations, aquifer, well depth, and screen depths. Geologic information is not available for PWS wells. Wells on the map are symbolized by aquifer and labeled by well depth (feet).

Figure 3.9 Falling Water PWS Well Information



Water source	Well depth (feet)	Screen depth (feet)	Aquifer
G1330154A	460	360 - 460	Trinity
G1330154B	400	NA	Trinity

Table 3.2 summarizes radium concentrations sampled at the Falling Water PWS from the TCEQ database.

Table 3.2 Radium Concentrations in the Falling Water PWS

Entry point / well number	Date	Radium 226 (pCi/L)	Radium 228 (pCi/L)	Radium combined (pCi/L)	Source
E.P. 1 (Well G1330154A)	1/22/2004	1.5	5.2	6.7	TCEQ
E.P. 2 (Well G1330154B)	1/22/2004	1.1	4.1	5.2	TCEQ

** E.P. = Entry point*

Two radium samples are in the TCEQ database, both in February 2004 (no samples from the TWDB database). Both samples have high radium concentrations (>5 pCi/L). There were no uranium samples for the PWS. Figure 3.10 shows radium and uranium concentrations from TWDB and NURE databases within 5-and 10-km buffers of PWS wells (no radium samples are in the TCEQ database within the 10-km buffer).

Groundwater radium concentrations can have a high degree of spatial variability. Because of this, it is important to understand differences in water quality produced by different wells. 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 depth and well logs to identify differences that could be responsible for the elevated concentration of radium in the other well. Then if blending 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 would also provide compliant water.

Figure 3.10 Radium Concentrations (TWDB) and Uranium Concentrations (NURE) in 5- and 10-km Buffers of Falling Water PWS Wells

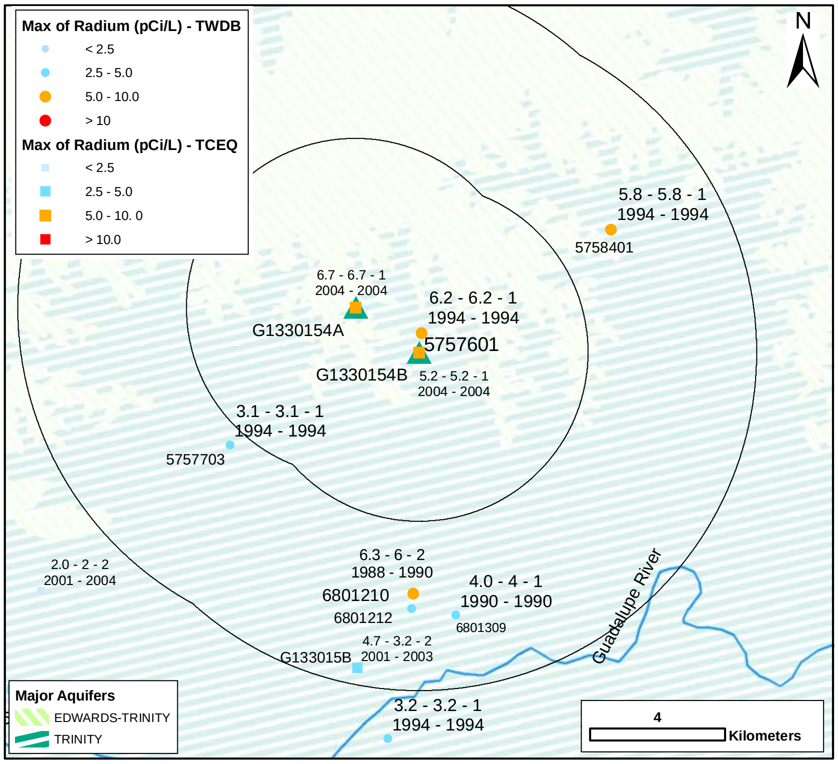


Figure 3.10 shows radium concentrations within the 10-km buffer from TWDB and TCEQ databases. Six wells are from the TWDB database, and one well is from the TCEQ database. Wells are symbolized by maximum concentration, and labels show maximum, minimum, and number of samples, as well as first and last sample year. Only two uranium samples are in the NURE database within the 10-km buffer, and both are <1.5 µg/L. Three wells from the TWDB have radium concentrations above the MCL (Wells 5758401, 6801210, and 5757601), and three have maximum concentrations <5 pCi/L. Other than the two assessed PWS wells, the TCEQ database contains only one well (G1330015B) with radium samples within the 10-km buffer.

Table 3.3 details radium concentrations, aquifer, well depth, and screen depth of wells within the 10-km buffer of the PWS wells.

Table 3.3 Water Source (Well) in the 10-km Buffer from Falling Water PWS Wells

Water source / Well Number	Max.-Min.-Num. of radium samples	Well depth	Screen depth	Aquifer	Source
G13300154A	6.7 – 6.7 - 1	460	NA	Trinity	TCEQ
G13300154B	5.2 – 5.2 – 1	400	NA	Trinity	TCEQ
5758401	5.8 - 5.8 - 1	310	256 – 310	Trinity	TWDB
5757601	6.2 - 6.2 - 1	375	NA	Trinity	TWDB
5757703	3.1 - 3.1 - 1	360	187-270	Trinity	TWDB
6801210 (W.S. G1300002E)	6.3 - 6 - 2	490	391-490	Trinity	TWDB
6801212 (W.S. G1300002C)	4.1 - 4.1 - 1	350 (TCEQ 400)	300-350	Trinity	TWDB
6801309	4.0 - 4.0 - 1	415	220-415	Trinity	TWDB
G1330015B (W.N. 6801208)	4.7 - 3.2 - 2	268	160-268	Trinity	TCEQ

W.S. = Water source number in the TCEQ PWS database, W.N. = Well number in the TWDB database
Source: TCEQ and TWDB databases

Radium concentrations do not seem to correlate with well depth or screen depth. Within the 10-km buffer, five wells have concentrations of radium above the MCL; these include PWS wells (G13300154A and G13300154B). Depth of wells with concentrations above the MCL range from 375 to 490 feet, and screen depth is between 256 and 490 feet. Four wells have concentrations below the MCL; the depth of these wells ranges from 160 to 415 feet, and screening depth ranges between 160 and 415 feet.

SECTION 4
ANALYSIS OF THE FALLING WATER SUBDIVISION PWS

4.1 DESCRIPTION OF EXISTING SYSTEM

4.1.1 Existing System

The Falling Water Subdivision is shown on Figure 4.1. The Falling Water Subdivision PWS is owned and operated by Aqua Texas, Inc., which is a subsidiary of Aqua America, Inc. Falling Water Subdivision is a residential subdivision in the initial stages of development and is currently growing at an approximate rate of one to two connections a month. At full build-out, the subdivision will have a maximum of 256 connections.

The water sources for this PWS are two wells, both of which are completed in the Edwards-Trinity aquifer (Code 218EDDT). Well #1 is located in Kerr County and is 460 feet in depth, while Well #2 is located in Kendall County and is 400 feet deep. The total production of the two wells is 0.232 mgd. Disinfection with hypochlorite is performed at each wellhead before water is pumped into the distribution system. There is an elevated ground storage tank in the system that has a capacity of 0.060 million gallons (MG).

Total radium has been detected between 5.2 pCi/L to 6.7 pCi/L since 2004, which exceeds the MCL of 5 pCi/L. Well #1 has shown higher levels of radium than Well #2. The Falling Water Subdivision PWS has not encountered any other water quality issues. Typical TDS concentrations are in the range of 558 to 614 mg/L.

The treatment employed is not appropriate or effective for removal of radium, so optimization is not expected to be effective for increasing removal of this contaminant. However, there is a potential opportunity for system optimization to reduce radium concentrations. The system has more than one well, and since radium concentrations can vary significantly between wells, radium concentrations should be understood for each well. If one or more wells happens to produce water with acceptable radium levels, as much production as possible should be shifted to that well. It may also be possible to identify radium-producing strata through comparison of well logs or through sampling of water produced by various strata intercepted by the well screen.

Basic system information is as follows:

- Population served: 189 (768 at full build-out)
- Connections: 63 (256 at full build-out)
- Average daily flow: 0.029 mgd (0.118 mgd, prorated based on full build-out)
- Total production capacity: 0.232 mgd
- Typical total radium range: 5.2 pCi/L to 6.7 pCi/L
- Typical TDS range: 558 to 614 mg/L

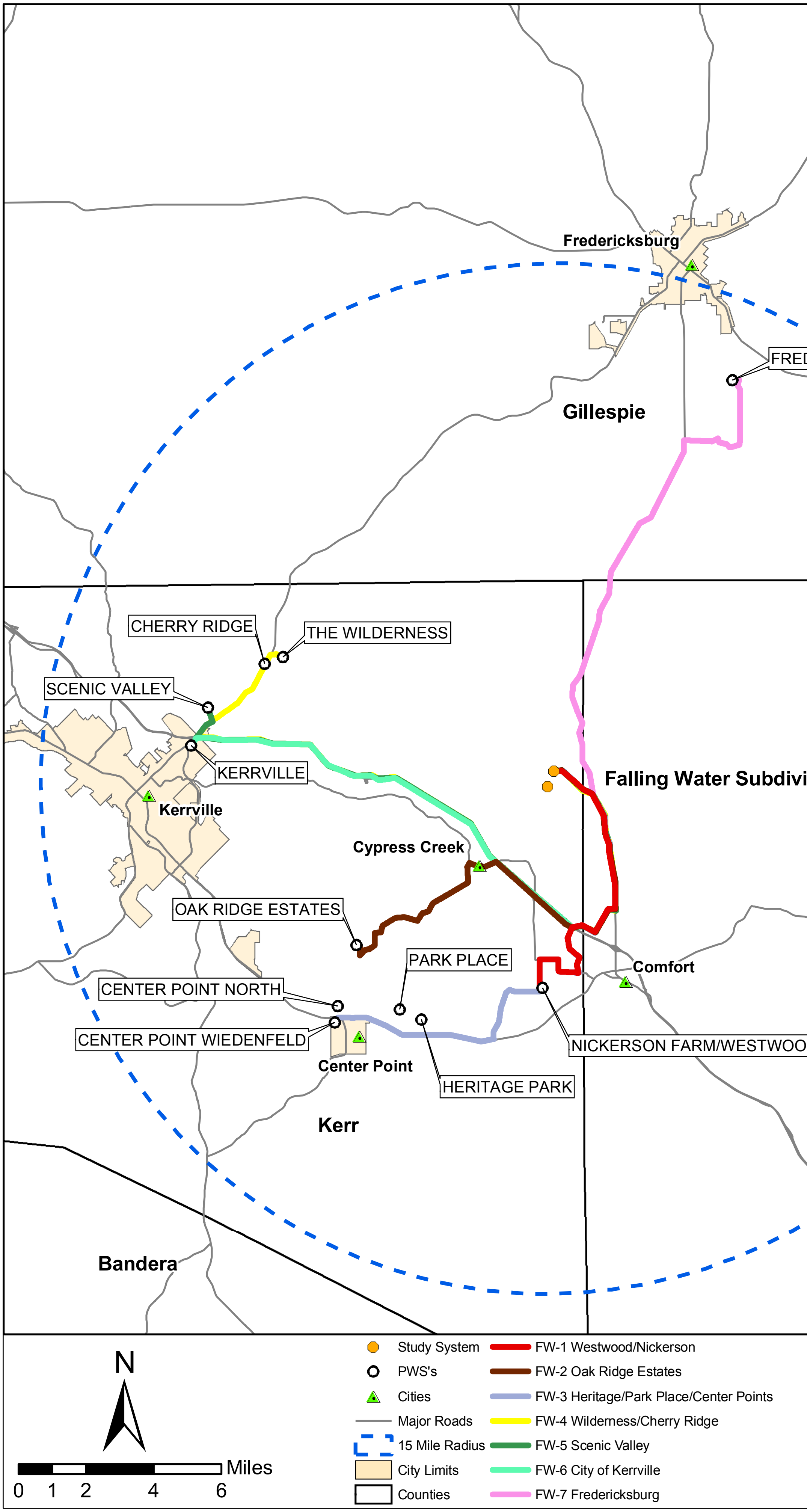


Figure 4.1

Falling Water Pipeline Alternatives

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Aqua Texas, Inc. has already investigated several possible solutions to its radium issue, including installing a filter system and drilling a new groundwater well. The capital cost of the filter system considered was estimated at approximately $75,000, with operating costs of between $1.00 and $1.50 per 1,000 gallons of water treated. However, the option investigated would produce a hazardous waste that would require disposal. Another alternative examined was the drilling of a new groundwater well that would be completed to a depth of 600 feet. Drilling a well to this depth was expected to avoid the radium problem. The estimated capital cost of completing the new well was over $200,000.

4.1.2 Capacity Assessment for the Falling Water Subdivision

The project team conducted a capacity assessment of the Falling Water system to evaluate the system's technical, managerial, and financial capabilities. The evaluation process involved interviews with staff and management who have a responsibility in either the 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 technical, managerial, and financial capability of the water system. The positive aspects of capacity describe those factors that the system is doing well. These factors should provide opportunities for the system to build upon 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 regulations or requirements, ensure proper revenue to pay the expenses of running the system, and to ensure the 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 they do have the opportunity to cause problems.

The following personnel involved with the Falling Water Subdivision PWS were interviewed:

- Tom Myers, Field Coordinator, Kerrville Office
- Chet Smith, Water Operator, Kerrville Office
- Jess Erlund, Maintenance and Construction Supervisor, Kerrville Office
- Brent Reeh, Area Manager, Pflugerville Office
- Kurt Scheibelhut, Regional Director of Accounting, Pflugerville Office
- Larry Mitchell, Environmental Compliance Coordinator, Pflugerville Office

All interviews were conducted in person.

4.1.2.1 General Structure

The Falling Water Subdivision PWS is owned by Aqua Texas, Inc. (Aqua Texas) and is operated out of the office in Kerrville as part of Aqua Texas' Southwest Region. Aqua Texas owns approximately 300 water systems and 60 wastewater systems statewide and their headquarters is located in Pflugerville, Texas. The Field Coordinator for the Falling Water Subdivision PWS provides managerial and some financial oversight of this system, as well as 28 other systems. The Field Coordinator is a certified operator. The Kerrville office has three full-time certified operators as well as a maintenance crew. Responsibility for the Falling Water Subdivision rotates among the three operators. There is one administrative staff member who is in the process of becoming a certified operator. Billings and collections are handled by the Aqua Texas office in Pflugerville, as are all compliance-related issues, such as reporting, public notices, and decisions concerning required system improvements.

The Falling Water Subdivision PWS currently has approximately 63 residential connections, serving a population of 189 people. The system is fully metered and is supplied by groundwater. The population and numbers of connections at future build-out are estimated to be 768 and 256, respectively.

4.1.2.2 General Assessment of Capacity

Overall, the system had an above average level of capacity, owing to the economies of scale provided by operating and maintaining 29 systems from one office, the dedication and commitment of their staff, and the financial resources provided by Aqua Texas and its parent company, Aqua America, Inc. The system appears to have the resources available through the local office as well as the main Aqua Texas office to deal with deficiencies and any potential compliance issues.

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, those positive aspects can assist the system in addressing capacity deficiencies or concerns. The factors particularly important for the Falling Water PWS are listed below.

- **Knowledgeable and dedicated staff** - There is almost no staff turnover due, in part, to the salary and benefits package provided by Aqua Texas. In addition, the company encourages employee professional growth by allowing ample training opportunities. Most of the staff has cross-trained in responsibilities, and most of the maintenance crew is composed of certified operators. The staff appears to be very dedicated to the system, and most have extensive experience with drinking water systems.

- **Communication –** There is excellent communication among the staff. There is a staff meeting every Monday morning, which includes a safety component, and a management meeting every other Friday. Work tasks are prioritized and staff roles are clearly defined. An answering service takes calls after hours and two people are always on call.
- **Maps and system information** – Maps of the system and general information is readily available to the operator responsible for the Falling Water Subdivision PWS. This information is available to the other operators as they alternate responsibility.
- **Benefits from economies of scale –** The Falling Water Subdivision PWS is one of 29 systems operated from the same office. This allows a very small water system to benefit from the pool of operators and a central maintenance crew. In addition, operating and capital costs are shared among all of the systems in the Aqua Texas Southwest Region and there is a single rate structure to cover all these systems. As new compliance rules and regulations that will require more complex and expensive treatment are introduced, the ability to take advantage of the economy of scale offered by a single rate is critical to keeps costs affordable for small systems.
- **Financial Practices –** The rates are reviewed on a monthly basis to ensure that they comply with the approved rate schedule. Also, operating budgets are developed for a 5-year period to make certain that adequate revenues will be available to meet anticipated operating expenses.

4.1.2.4 Capacity Deficiencies

The following capacity deficiencies were noted in conducting the assessment.

- **Water Losses –** The system does not have a program to measure or manage water system losses. The staff estimated a water loss as high as 50 percent during the previous year, mostly as a result of construction activities. A reduction in this loss would significantly reduce the amount of water that must be pumped and/or treated, depending on the compliance alternative implemented. Aqua Texas does not have a company program or policy to address water losses at a system level.
- **Long-term Planning –** Planning for capital expenditures is performed in the main office in Pflugerville, with input being provided from the Kerrville Office. While it appears that short-term needs for the system are identified and included in a capital budget, the system does not engage in any long-term (5 to 20 year) capital improvements planning. Thus, the system is not identifying future needs and including the cost of meeting those future system needs in the current rate schedule.

4.1.2.5 Potential Capacity Concerns

The following items are concerns regarding capacity, but there are no particular FMT 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.

- **Operating Budget and Rates –** Operating budgets and rates are developed for Falling Water by the Aqua Texas main office in Pflugerville. It appears there is little or no input from the Field Coordinator, except on an informal basis. It also appears the Field Coordinator does not receive any type of financial report. Aqua Texas is currently evaluating this practice and, in the future, may include their field offices in the development of the operating budgets to a greater extent. This issue is a concern rather than a deficiency because it has not yet resulted in an inability to meet operational needs.
- **Policy on pressure reducing valves –** Because of high pressure throughout the distribution system, many customers installed pressure reducing valves (PRV). At a customer's request, the operator will check and change the PRV. The Field Coordinator is currently developing a policy to define the responsibilities of the customer and the PWS concerning PRVs. Implementation of a clearly defined policy should prevent customer disputes.
- **Written Preventive Maintenance Schedule –** There are no written procedures for standard O&M practices available to operational staff. At this time, the staff knows what tasks are needed to be done and are able to operate the system without written procedures. However, if personnel leave or if additional staff are hired, the lack of written procedures may cause problems.
- **Emergency Plan –** The system does not have a written emergency plan, nor is there an emergency generator available at the Kerrville office.

4.2 ALTERNATIVE WATER SOURCE DEVELOPMENT

4.2.1 Identification of Alternative Existing Public Water Supply Sources

Using data drawn from the TCEQ drinking water and TWDB groundwater well databases, the PWSs surrounding the Falling Water Subdivision PWS were reviewed with regard to their reported drinking water quality and production capacity. PWSs that appeared to have water supplies with water quality issues were ruled out from evaluation as alternative sources, while those without identified water quality issues were investigated further. Owing to the large number of small (<1 mgd) water systems in the vicinity, small systems were only considered if they were established residential systems within 10 miles of the Falling Water Subdivision PWS. If it was determined that these PWSs had excess supply capacity and might be willing to sell the excess, or might be a suitable location for a new groundwater well, the system was taken forward for further consideration.

Table 4.1 is a list of the selected PWSs within approximately 15 miles of the Falling Water Subdivision. This distance was selected as the radius for the evaluation because of the relatively small number of PWSs in the proximity of the Falling Water Subdivision PWS and because 15 miles was considered to be the upper limit of economic feasibility for constructing a new water line.

Table 4.1 Selected Public Water Systems within 15 Miles of the Falling Water Subdivision

System Name	Distance from Falling Water	Comments/Other Issues
Kendall County WCID	5 miles	Large (>1 mgd) system with WQ issues: iron, TDS, radium, gross alpha.
Nickerson Farm Water System	6 miles	Small system without identified WQ issues. No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well. Owned by Aqua Texas, Inc. Evaluate further.
Westwood Park Subdivision	6 miles	Small system with iron exceedances. No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well. Evaluate further.
Oak Ridge Estates Water System	7 miles	Small system with iron exceedances. No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well. Evaluate further.
Hill Country Ranch Estates	7 miles	Small system with WQ issues: iron, TDS (marginal).
Heritage Park Water Service	8 miles	Small system with iron exceedances. No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well. Evaluate further.
Park Place Subdivision Center Point	8 miles	Small system with iron exceedances. No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well. Owned by Aqua Texas, Inc. Evaluate further.
Center Point North Water System	9 miles	Small system without identified WQ issues. No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well. Owned by Aqua Texas, Inc. Evaluate further.
Center Point Wiedenfeld Water Works	9 miles	Small system with iron exceedances. No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well. Evaluate further.
The Wilderness	9 miles	Small system with iron exceedances. No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well. Evaluate further.
Cherry Ridge Water Co.	9 miles	Small system with iron exceedances. No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well. Owned by Aqua Texas, Inc. Evaluate further.
Center Point Taylor System	9 miles	Small system with WQ issues: nitrate, gross alpha (marginal)
Center Point ISD	9 miles	Small system with WQ issues: nitrate
Liveoaks Mobile Home Park	10 miles	Small system with WQ issues: radium, gross alpha, iron (marginal)

Table 4.1 Selected Public Water Systems within 15 Miles of the Falling Water Subdivision

System Name	Distance from Falling Water	Comments/Other Issues
Scenic Valley Mobile Home Park	10 miles	Small system with marginal iron exceedances. No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well. Evaluate further.
City of Kerrville	12 miles	Large (>1 mgd) system. Have excess capacity and are willing to discuss selling water. Evaluate further.
Loma Vista Water System	13 miles	Large (>1 mgd) system with iron exceedances. Not willing to discuss selling water.
City of Fredericksburg	15 miles	Large (>1 mgd) system. Have excess capacity and are willing to discuss selling water. Currently blend water to address radium issues. Evaluate further.

Based upon the initial screening summarized in Table 4.1 above, twelve alternatives were selected for further evaluation. These are summarized in Table 4.2.

Table 4.2 Public Water Systems Within the Vicinity of the Falling Water Subdivision PWS Selected for Further Evaluation

System Name	Pop	Conn	Total Production (mgd)	Ave Daily Usage (mgd)	Approx. Dist. from Falling Wtr	Comments/Other Issues
Nickerson Farm Water System	156	52	0.230	nd	6 miles	No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well. Owned by Aqua Texas, Inc.
Westwood Park	267	89	0.099	nd	6 miles	No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well.
Oak Ridge Estates Water System	114	38	0.072	nd	7 miles	No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well.
Heritage Park Water Service	75	25	0.036	0.005	8 miles	No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well.
Park Place Subdivision Center Point	105	35	0.060	nd	8 miles	No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well. Owned by Aqua Texas, Inc.
Center Point North Water System	261	87	0.209	nd	9 miles	No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well. Owned by Aqua Texas, Inc.
Center Point Wiedenfeld Water Works	159	53	0.110	nd	9 miles	No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well.
The Wilderness	300	100	0.201	0.015	9 miles	No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well.

Table 4.2 Public Water Systems Within the Vicinity of the Falling Water Subdivision PWS Selected for Further Evaluation

System Name	Pop	Conn	Total Production (mgd)	Ave Daily Usage (mgd)	Approx. Dist. from Falling Wtr	Comments/Other Issues
Cherry Ridge Water Company	72	24	0.036	nd	9 miles	No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well. Owned by Aqua Texas, Inc.
Scenic Valley Mobile Home Park	270	90	0.176	0.075	10 miles	No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well.
City of Kerrville	21,653	11,534	10.380	3.755	12 miles	Have excess capacity and are willing to discuss selling water.
City of Fredericksburg	11,966	4,986	8.892	2.094	15 miles	Have excess capacity and are willing to discuss selling water. Already blend water to address radium issues.

4.2.1.1 Nickerson Farm Water System

Nickerson Farm Water System is located west of the City of Comfort, approximately 6 miles to the south of Falling Water Subdivision. The PWS is owned and operated by Aqua Texas, and is supplied by a single groundwater well completed in the Hosston Formation (Code 217HSTN). This well is 600 feet deep and has a total production of 0.230 mgd. Water is disinfected with hypochlorite and treated with an orthophosphate inhibitor before being sent to an 11,000 gallon storage tank. Nickerson Farm Water System serves a population of 156 and has 52 metered connections.

Nickerson Farm Water System does not have sufficient excess capacity to supplement Falling Water Subdivision's existing supply; however, based on the available water quality data, the location may be a suitable point for a new groundwater well. As Nickerson Farm Water System is owned and operated by Aqua Texas, owners of the Falling Water Subdivision PWS, getting approval for this alternative should be straightforward.

4.2.1.2 Westwood Park Subdivision

Westwood Park Subdivision is located west of the City of Comfort, approximately 6 miles to the south of Falling Water Subdivision. The PWS is supplied by a two groundwater wells, both of which are completed in the Glen Rose Limestone Formation (Code 218GLRS). The wells are 268 and 400 feet deep, respectively, and have a total production of 0.099 mgd. Water is disinfected with hypochlorite at each wellhead before being distributed. Westwood Park Subdivision serves a population of 267 and has 89 metered connections.

Westwood Park Subdivision does not have sufficient excess capacity to supplement Falling Water Subdivision's existing supply; however, based on the available water quality data, the location may be a suitable point for a new groundwater well.

4.2.1.3 Oak Ridge Estates Water System

Oak Ridge Estates Water System serves a mobile home park located approximately 7 miles southwest of Falling Water Subdivision. The PWS is supplied by a single groundwater well completed in the Hensell Sand and Cow Creek Limestone Formation (Code 218HSCC). This well is 540 feet deep and has a total production of 0.072 mgd. Water is disinfected with hypochlorite before being sent to an 8,000 gallon storage tank. Oak Ridge Estates Water System serves a population of 114 and has 38 metered connections.

Oak Ridge Estates Water System does not have sufficient excess capacity to supplement Falling Water Subdivision's existing supply; however, based on the available water quality data, the location may be a suitable point for a new groundwater well.

4.2.1.4 Heritage Park Water Service

Heritage Park Water Service is located in the vicinity of the City of Center Point, approximately 8 miles southwest of Falling Water Subdivision. The PWS is owned and operated by Wiedenfeld Water Works, Inc. and is supplied by a single groundwater well completed in the Hensell Sand Member of the Travis Peak Formation (Code 218HNSL). This well is 500 feet deep and has a total production of 0.036 mgd. Water is disinfected using hypochlorite before being distributed. Heritage Park Water Service serves a population of 75, has 25 metered connections, and has an approximate average daily usage of 0.005 mgd.

Heritage Park Water Service does not have sufficient excess capacity to supplement Falling Water Subdivision's existing supply; however, based on the available water quality data, the location may be a suitable point for a new groundwater well.

4.2.1.5 Park Place Subdivision Center Point

Park Place Subdivision Center Point is located in the vicinity of the City of Center Point, approximately 8 miles southwest of Falling Water Subdivision. The PWS is owned and operated by Aqua Texas and is supplied by a single groundwater well that is completed in the Glen Rose Limestone Formation (Code 218GLRS). This well is 442 feet deep and has a total production of 0.060 mgd. Water is disinfected using hypochlorite before being distributed. Park Place Subdivision serves a population of 105 and has 35 metered connections.

Park Place Subdivision Center Point does not have sufficient excess capacity to supplement Falling Water Subdivision's existing supply; however, based on the available water quality data, the location may be a suitable point for a new groundwater well. As Park Place Subdivision Center Point is owned and operated by Aqua Texas, owners of the Falling Water Subdivision PWS, getting approval for this alternative should be straightforward.

4.2.1.6 Center Point North Water System

Center Point North Water System is located in the vicinity of the City of Center Point, approximately 9 miles southwest of Falling Water Subdivision. The PWS is owned and operated by Aqua Texas and is supplied by a single groundwater well completed in the Lower Glen Rose Limestone Formation (Code 218GLRSL). This well is 380 feet deep and has a total production of 0.209 mgd. Water is disinfected using hypochlorite before being distributed. Center Point North Water System serves a population of 261 and has 87 metered connections.

Center Point North Water System does not have sufficient excess capacity to supplement Falling Water Subdivision's existing supply; however, based on the available water quality data, the location may be a suitable point for a new groundwater well. As Center Point North Water System is owned and operated by Aqua Texas, owners of the Falling Water Subdivision PWS, getting approval for this alternative should be straightforward.

4.2.1.7 Center Point Wiedenfeld Water Works

Center Point Wiedenfeld Water Works is located in the vicinity of the City of Center Point, approximately 9 miles southwest of Falling Water Subdivision. The PWS is owned and operated by Wiedenfeld Water Works, Inc. and is supplied by a single groundwater well completed in the Glen Rose Limestone Formation (Code 218GLRS). This well is 500 feet deep and has a total production of 0.110 mgd. Water is disinfected using hypochlorite before being distributed. Center Point Wiedenfeld Water Works serves a population of 159 and has 53 metered connections.

Center Point Wiedenfeld Water Works does not have sufficient excess capacity to supplement Falling Water Subdivision's existing supply; however, based on the available water quality data, the location may be a suitable point for a new groundwater well.

4.2.1.8 The Wilderness

The Wilderness PWS is located northeast of Kerrville, approximately 9 miles northwest of Falling Water Subdivision. The PWS is supplied by a single groundwater well completed in the Glen Rose Limestone Formation (Code 218GLRS). This well is 750 feet deep and has a total production of 0.201 mgd. Water is disinfected using hypochlorination before being distributed. The Wilderness serves a population of 300, has 100 metered connections, and has an approximate average daily usage of 0.015 mgd.

The Wilderness PWS does not have sufficient excess capacity to supplement Falling Water Subdivision's existing supply; however, based on the available water quality data, the location may be a suitable point for a new groundwater well.

4.2.1.9 Cherry Ridge Water Company

Cherry Ridge Water Company serves a mobile home park located northeast of Kerrville, approximately 9 miles to the northwest of Falling Water Subdivision. The PWS is owned and operated by Aqua Texas, and is supplied by a single groundwater well completed in the Hensell Sand Member of the Travis Peak Formation (Code 218HNSL). This well is 620 feet deep and has a total production of 0.036 mgd. Water is treated with a polyphosphate inhibitor and disinfected using hypochlorite before being distributed. Cherry Ridge Water Company serves a population of 72 and has 24 metered connections.

Cherry Ridge Water Company does not have sufficient excess capacity to supplement Falling Water Subdivision's existing supply; however, based on the available water quality data, the location may be a suitable point for a new groundwater well. As the Cherry Ridge Water Company is owned and operated by Aqua Texas, owners of the Falling Water Subdivision PWS, getting approval for this alternative should be straightforward.

4.2.1.10 Scenic Valley Mobile Home Park

Scenic Valley Mobile Home Park is located northeast of Kerrville, approximately 10 miles east of Falling Water Subdivision. The PWS is supplied by two groundwater wells that are both completed in the Hensell Sand Member of the Travis Peak Formation (Code 218HNSL). These wells are 370 and 400 feet deep, respectively, and have a total production of 0.176 mgd. Water is disinfected with hypochlorite before being distributed. Scenic Valley Mobile Home Park serves a population of 270, has 90 connections, and has an approximate average daily usage of 0.075 mgd.

Scenic Valley Mobile Home Park does not have sufficient excess capacity to supplement Falling Water Subdivision's existing supply; however, based on the available water quality data, the location may be a suitable point for a new groundwater well.

4.2.1.11 City of Kerrville

The City of Kerrville is located approximately 12 miles west of Falling Water Subdivision. The water supply for the City of Kerrville consists of a series of ground water wells and a surface water plant that treats water from the headwaters of the Guadalupe River. There are five groundwater extraction wells located throughout the City of Kerrville, all of which are completed in the Hosston Formation (Code 217HSTN). These wells range from 600 to 638 feet in depth and do not have any water quality issues. The current production rates are 6,625 acre-feet/year, or 5.91 mgd and 4.25 mgd for the well field and surface water plant, respectively. The City has a population of approximately 21,650 people and a total of 11,534 connections. The average annual usage for the city of Kerrville is between 3.4 and 3.8 mgd.

The water and waste water systems at the City of Kerrville consist of a staff of 42 personnel who run the day-to-day operations, maintain a small in-house testing lab, and handle small construction and maintenance activities. Until several years ago, the

Upper Guadalupe River Authority (UGRA) was involved with a portion of the operations of the Kerrville water system. UGRA is still in existence, but has no means of conveying the water via pipeline or tanker. It has access to 2,000 acre-feet/year or 1.79 mgd from the Upper Guadalupe River until its permit expires in 2010.

Water treatment facility personnel make the day-to-day technical decisions. However, the five-member City Council makes the decisions regarding major changes proposed by the public works staff, such as the current expansion to the surface water plant, which has an anticipated completion date of summer 2006. The sale of treated water to a system such as the Falling Water Subdivision PWS must be also approved by the five-member City Council. Future changes planned for the water system include modifying the surface water intake from a standard stream intake system to a river bank extraction system where the stream sediments between the extraction wells and the streambed serve as a filtration system.

To be prepared for any future drought conditions, the City of Kerrville evaluated the feasibility of aquifer storage and recovery in the Kerrville area. Based on the study, it was determined that the Lower Trinity below the Hammond Shale would serve as an excellent rock formation or aquifer for storing approximately 1.5 billion gallons of water (approximate volume of water usage per year). A portion of the water recovered from both the surface water supply and groundwater is chlorinated and then pumped through two injection wells into the Lower Trinity at a depth of about 600 feet. As of July 2005, approximately 485 million gallons of water have been pumped into the Lower Trinity. The first injection well was installed in 1998 followed by a second in 2003. A third injection well is currently being proposed.

The City of Kerrville has sufficient excess capacity to supplement Falling Water Subdivision's existing supply. If an agreement could be negotiated with the City Council, the City of Kerrville could be a viable alternative source of water.

4.2.1.12 City of Fredericksburg

The City of Fredericksburg is located approximately 15 miles north of Falling Water Subdivision. The water for Fredericksburg is collected from two wells in the Hickory Formation (Code 371HCKR), which are at a depths of 332 and 370 feet, and seven wells in the Ellenburger Formation (Code 367ELBG) at depths between 216 and 500 feet. The maximum production from the nine wells is rated at 8.9 mgd; however, the current production rate is 4.3 mgd and the average usage is 2.1 mgd. The City of Fredericksburg serves a population of approximately 12,000 and has almost 5,000 connections.

Groundwater from the two deeper wells is stored in a 1-million gallon tank, and groundwater from the seven shallow wells is stored in a second 1-million gallon tank. Analytical results for water samples from the two deeper wells indicate elevated levels of radium at 10 pCi/L, whereas radium has not been detected in the seven shallower wells. For this reason, the City of Fredericksburg has a verbal agreement with the TCEQ to blend the water from the two tanks to achieve compliance with the MCL for total radium (5 pCi/L).

According to the Utility Manager for the City of Fredericksburg, Mr. Gerry Banks, the City of Fredericksburg considered a water supply option in the early 1990s to transport water from Lake Buchanan to the City of Fredericksburg. The cost was estimated by the Lower Colorado River Authority to be approximately $20 million. Mr. Banks also indicated that LBG Guyton from Austin is currently in the process of developing a Groundwater Availability Evaluation for the Ellenburger Formation in the Fredericksburg area. Preliminary discussions between LBG and Mr. Banks indicate that the Ellenburger formation is very capable of serving as a suitable ground water source for Fredericksburg.

Future plans for the water system at the City of Fredericksburg include supplementing the current system with a third million gallon storage tank. A majority of the costs for the tank would be handled by the private funds being used to construct a golf course 3 miles from the City of Fredericksburg. Two more wells would be installed and would not be connected to the system, but would be available for future use. The golf course development would use well water for drinking water use, but plan to use surface water for maintaining the grounds.

All decisions relating to water treatment and distribution are made by the five-person City Council. The City does have excess capacity and could be a viable alternative source of water, assuming a suitable agreement could be negotiated.

4.2.2 Potential for New Groundwater Sources

4.2.2.1 Installing New Compliant Wells

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

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

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

4.2.2.2 Results of Groundwater Availability Modeling

The Falling Water Subdivision is located in the southeast edge of the Edwards-Trinity Plateau aquifer that extends along central and west Texas. The 2002 Texas Water

Plan indicates that the overall groundwater supply from the aquifer is likely to remain at nearly current levels for the next 50 years. The anticipated aquifer supply in the year 2050 is 220,374 acre-feet per year, representing a 3 percent decline relative to 2000 conditions.

In September 2004 the TWDB published results of the GAM for the Edwards-Trinity Plateau aquifer (Anaya and Jones 2004). The Edwards-Trinity Plateau aquifer GAM was not run for the Falling Water Subdivision system. The Falling Water Subdivision is located within the Southeastern Edwards Plateau segment of the aquifer. Over this segment, groundwater pumping represents approximately 25 percent of the aquifer discharge. GAM data indicate that the rate of total withdrawal from the Edwards-Trinity Plateau aquifer in Kerr County would increase substantially over the next decades, from an estimated 9,817 acre-feet per year in 2000, to 15,266 acre-feet per year by the year 2050. Potential groundwater usage by the system would represent a small addition to the regional withdrawal, making potential changes in aquifer levels by the Falling Water Subdivision system beyond the spatial resolution of the regional GAM model.

The Falling Water Subdivision overlays another two potential groundwater sources, the Trinity aquifer and the Hickory aquifer. The outcrop of the Trinity aquifer is present along east Kerr County, and in some areas water-bearing rock formations are located below the Edwards-Trinity aquifer. The Trinity aquifer runs along central and north Texas, and its water supply is expected to moderately decrease over the next 50 years. The 2002 Texas Water Plan anticipates a supply of 150,317 acre-feet by the year 2050, a 4 percent decline in supply relative to value estimated for the year 2000. A GAM model for the Hill Country area of the Trinity aquifer was completed by the TWDB in September 2000. Long-term numerical simulation of future water levels for drought-of-record conditions indicated that water levels in the aquifer may decline up to 100 feet by 2050. The largest water level decline is anticipated in the Cibolo Creek area in northern Bexar, western Comal, and southern Kendall counties. For northeast Kerr County, where Falling Water Subdivision is located, the anticipated decline by the year 2050 is moderate, within the 10 to 25 feet range (Mace, *et al.* 2000).

The southern edge of the Hickory aquifer downdip extends through north and east Kerr County. This aquifer is classified by the TWDB as minor on the basis of potential water production. The 2002 Texas Water Plan indicates the groundwater supply from the Hickory aquifer will steadily decline over several decades. The estimated decline in supply is 9 percent, from 50,699 acre-feet per year in 2000 to 46,133 acre-feet per year in 2050.

4.2.3 Potential for New Surface Water Sources

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

Falling Water Subdivision is located in the middle reach of the Colorado River Basin where current surface water availability is expected to steadily decrease as a result of increased water demand. The TWDB's 2002 Water Plan anticipates an 11 percent reduction in surface water availability in the Colorado River basin over the next 50 years, from 879,400 acre-feet per year in 2002 to 783,641 acre-feet per year in 2050.

The vicinity of the Falling Water Subdivision has a minimum availability of surface water for new uses as indicated by the TCEQ's availability maps for the Colorado River Basin. Unappropriated flows for new uses within 20 miles of the Falling Water Subdivision are available approximately 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 seven options for more-detailed consideration:

1. Nickerson Farm Water System. Two new groundwater wells would be completed in the vicinity of the well at Nickerson Farm Water System. A pipeline would be constructed and the water would be piped to Falling Water Subdivision (Alternative FW-1). *This alternative would have almost identical costs to a similar alternative involving the nearby Westwood Park Subdivision, so these alternatives will be considered to be identical for purposes of this report.*

2. Oak Ridge Estates Water System. Two new groundwater wells would be completed in the vicinity of the well at Oak Ridge Estates Water System. A pipeline would be constructed and the water would be piped to Falling Water Subdivision (Alternative FW-2).

3. Center Point Wiedenfeld Water Works. Two new groundwater wells would be completed in the vicinity of the well at Center Point Wiedenfeld Water Works. A pipeline would be constructed and the water would be piped to Falling Water Subdivision (Alternative FW-3). *This alternative would have almost identical costs to similar alternatives involving three other nearby PWSs (Heritage Park Water Service, Park Place Subdivision Center Point, and Center Point North Water System), so these alternatives will be considered to be identical for purposes of this report.*

4. The Wilderness. Two new groundwater wells would be completed in the vicinity of the well at the Wilderness PWS. A pipeline would be constructed and the water would be piped to Falling Water Subdivision (Alternative FW-4). *This alternative would have almost identical costs to a similar alternative involving the nearby Cherry Ridge Water Company, so these alternatives will be considered to be identical for purposes of this report.*

5. Scenic Valley Mobile Home Park. Two new groundwater wells would be completed in the vicinity of the well at the Scenic Valley Mobile Home Park.

A pipeline would be constructed and the water would be piped to Falling Water Subdivision (Alternative FW-5).

6. City of Kerrville. Treated water would be purchased from the City of Kerrville to be used by the Falling Water Subdivision. A pipeline would be constructed to convey water from the City of Kerrville's water treatment plant to Falling Water (Alternative FW-6).

7. City of Fredericksburg. Treated water would be purchased from the City of Fredericksburg to be used by the Falling Water Subdivision. A pipeline would be constructed to convey water from the City of Fredericksburg's water treatment plant to Falling Water (Alternative FW-7).

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 Falling Water Subdivision PWS. Under each of these alternatives, it is assumed that a source of compliant water can be located and then new wells would be completed and a pipeline would be constructed to transfer the compliant water to Falling Water Subdivision. These alternatives are FW-13, FW-14, and FW-15.

4.3 TREATMENT OPTIONS

4.3.1 Centralized Treatment Systems

Centralized treatment of the well field water is identified as a potential option. Ion exchange, WRT Z-88, and $KMnO_4$ treatment could all be potentially applicable. The central IX treatment alternative is FW-8, the central WRT Z-88 treatment alternative is FW-9, and the central $KMnO_4$ treatment alternative is FW-10.

4.3.2 Point-of-Use Systems

POU treatment using resin-based adsorption technology or RO is valid for total radium removal. The POU treatment alternative is FW-11.

4.3.3 Point-of-Entry Systems

POE treatment using resin based adsorption technology or RO is valid for total radium removal. The POE treatment alternative is FW-12.

4.4 BOTTLED WATER

Providing bottled water is considered an interim measure to be used until a compliance alternative is implemented. Even though the community is small and people know each other, it would be reasonable to require a quarterly communication advising customers of the need to take advantage of the bottled water program. An alternative to providing delivered bottled water is to provide a central, publicly accessible dispenser for treated drinking water. Alternatives addressing bottled water are FW-16, FW-17, and FW-18.

4.5 ALTERNATIVE DEVELOPMENT AND ANALYSIS

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

4.5.1 Alternative FW-1: New Wells in the Vicinity of Nickerson Farm Water System

This alternative involves completing two new wells in the vicinity of Nickerson Farm Water System, and constructing a pump station and pipeline to transfer the pumped groundwater to the Falling Water Subdivision PWS. Based on the water quality data in the TCEQ database, it is expected that groundwater from the wells would be compliant with drinking water MCLs. An agreement would need to be negotiated with Nickerson Farm Water System to expand its well field.

This alternative would require completing two new wells and a storage tank at the Nickerson Farm Water System, and constructing a pipeline from the wells to the existing intake point for the Falling Water Subdivision PWS. A pump station would also be required to overcome pipe friction and the elevation differences between Nickerson Farm Water System and Falling Water Subdivision. The required pipeline would be constructed of 6-inch polyvinyl chloride (PVC) pipe and would follow Highway 87 and several minor roads south to the Falling Water Subdivision. Using this route, the pipeline required would be approximately 10½ miles in length. The pipeline would terminate at the existing storage tanks owned by the Falling Water Subdivision.

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

This alternative has the potential to provide a regional solution, as there are several PWSs in the vicinity that have a need for compliant water. PWSs located close to the proposed pipeline route could share the cost of drilling the new wells and pipeline construction.

The estimated capital cost for this alternative includes completing the new wells, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the 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 $2.99 million, and the alternative's estimated annual O&M cost is $24,700. If the purchased water was used for blending rather than for the full water supply, the annual O&M cost for this alternative could be reduced because of reduced pumping costs and reduced water purchase costs. However, additional costs would be incurred for equipment to ensure proper blending, and additional monitoring to ensure the finished water is compliant.

The reliability of adequate amounts of compliant water under this alternative should be good. From the Falling Water Subdivision'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, and Aqua Texas personnel currently operate pipelines and a pump station. If the decision was made to perform blending then the operational complexity would increase.

Aqua Texas owns and operates both the Falling Water PWS and the Nickerson Farm Water System, so obtaining the necessary agreements to implement this option should not impact the feasibility of this alternative.

This alternative would have almost identical costs to a similar alternative involving the nearby Westwood Park Subdivision PWS and, consequently, these alternatives are considered to be identical for purposes of this report. The feasibility of the Westwood Park Subdivision alternative would be dependent on Aqua Texas, Inc. being able to reach an agreement with the Westwood Park Subdivision to install the new groundwater wells.

4.5.2 Alternative FW-2: New Wells in the Vicinity of Oak Ridge Estates

This alternative involves completing two new wells in the vicinity of Oak Ridge Estates, and constructing a pump station and pipeline to transfer the pumped groundwater to the Falling Water Subdivision PWS. Based on the water quality data in the TCEQ database, it is expected that groundwater from the wells would be compliant with drinking water MCLs, though there may be a minor issue with iron to take into consideration. An agreement would need to be negotiated with Oak Ridge Estates to expand its well field.

This alternative would require completing two new wells and a storage tank at the Oak Ridge Estates, and constructing a pipeline from the wells to the existing intake point for the Falling Water Subdivision PWS. A pump station would also be required to overcome pipe friction and the elevation differences between Oak Ridge Estates and Falling Water Subdivision. The required pipeline would be constructed of 6-inch PVC pipe and would follow several minor roads, Interstate 10, and Highway 87 to the Falling Water Subdivision. Using this route, the pipeline required would be approximately 16 miles in length. The pipeline would terminate at the existing storage tanks owned by the Falling Water Subdivision.

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

This alternative has the potential to provide a regional solution, as there are several PWSs in the vicinity that have a need for compliant water. PWSs located close to the proposed pipeline route could share the cost of drilling the new well and pipeline construction.

The estimated capital cost for this alternative includes completing the two new wells, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $4.38 million, and the alternative's estimated annual O&M cost is $30,000. If the purchased water was used for blending rather than for the full water supply, the annual O&M cost for this alternative could be reduced because of reduced pumping costs and reduced water purchase costs. However, additional costs would be incurred for equipment to ensure proper blending, and additional monitoring to ensure the finished water is compliant.

The reliability of adequate amounts of compliant water under this alternative should be good. From the Falling Water Subdivision'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, and Aqua Texas personnel currently operate pipelines and a pump station. If the decision was made to perform blending then the operational complexity would increase.

The feasibility of this alternative would be dependent on Aqua Texas being able to reach an agreement with Oak Ridge Estates to install the new groundwater wells.

4.5.3 Alternative FW-3: New Wells in the Vicinity of Center Point Wiedenfeld Water Works (Heritage Park)

This alternative involves completing two new wells in the vicinity of the Center Point Wiedenfeld Water Works, and constructing a pump station and pipeline to transfer the pumped groundwater to the Falling Water Subdivision PWS. Based on the water quality data in the TCEQ database, it is expected that groundwater from the wells would be compliant with drinking water MCLs, though there may be a minor issue with iron to take into consideration. An agreement would need to be negotiated with Wiedenfeld Water Works, Inc. to expand its well field.

This alternative would require completing two new wells and a storage tank at the Center Point Wiedenfeld Water Works, and constructing a pipeline from that well to the existing intake point for the Falling Water Subdivision PWS. A pump station would also be required to overcome pipe friction and the elevation differences between the Center Point Wiedenfeld Water Works and Falling Water Subdivision. The required pipeline would be constructed of 6-inch PVC pipe and would follow Ranch Road 473, several minor roads, and Highway 87 to the Falling Water Subdivision. Using this route, the pipeline required would be approximately 18 miles in length. The pipeline would terminate at the existing storage tanks owned by the Falling Water Subdivision.

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

This alternative has the potential to provide a regional solution, as there are several PWSs in the vicinity that have a need for compliant water. PWSs located close to the proposed pipeline route could share the cost of drilling the new well and pipeline construction.

The estimated capital cost for this alternative includes completing the two new wells, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $4.97 million, and the alternative's estimated annual O&M cost is $29,800. If the purchased water was used for blending rather than for the full water supply, the annual O&M cost for this alternative could be reduced because of reduced pumping costs and reduced water purchase costs. However, additional costs would be incurred for equipment to ensure proper blending, and additional monitoring to ensure the finished water is compliant.

The reliability of adequate amounts of compliant water under this alternative should be good. From the Falling Water Subdivision'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, and Aqua Texas personnel currently operate pipelines and a pump station. If the decision was made to perform blending then the operational complexity would increase.

The feasibility of the Center Point Wiedenfeld Water Works alternative would be dependent on Aqua Texas being able to reach an agreement with Wiedenfeld Water Works, Inc. to install the new groundwater wells.

This alternative would have almost identical costs to other similar alternatives involving the nearby PWSs: Heritage Park Water Service, Park Place Subdivision Center Point, and Center Point North Water System. Consequently, these alternatives are considered to be identical for purposes of this report. Aqua Texas owns and operates both the Park Place Subdivision Center Point PWS and the Center Point North Water System, so obtaining the necessary agreements to implement these options should not impact the feasibility of either alternative. The feasibility of the Heritage Park Water Service alternative would be dependent on Aqua Texas being able to reach an agreement with the Heritage Park Water Service to install the new groundwater wells.

4.5.4 Alternative FW-4: New Wells in the Vicinity of The Wilderness

This alternative involves completing two new wells in the vicinity of The Wilderness PWS, and the constructing of three pump stations and a pipeline to transfer the pumped groundwater to the Falling Water Subdivision PWS. Based on the water quality data in the TCEQ database, it is expected that the groundwater from the wells will be compliant with drinking water MCLs, though there may be a minor issue with iron to take into consideration. An agreement would need to be negotiated with The Wilderness to expand their well field.

This alternative would require completing the two new wells and storage tanks at The Wilderness, and constructing a pipeline from the wells to the existing intake point for the Falling Water Subdivision PWS. Three pump stations would also be required to overcome pipe friction and the elevation differences between The Wilderness and Falling Water Subdivision. The required pipeline would be constructed of 6-inch PVC pipe and would follow Route 16, Interstate 10, several minor roads, and Highway 87 to the Falling Water Subdivision. Using this route, the pipeline required would be approximately 24 miles in length. The pipeline would terminate at the existing storage tanks owned by the Falling Water Subdivision.

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

This alternative has the potential to provide a regional solution, as there are several PWSs in the vicinity that have a need for compliant water. PWSs located close to the proposed pipeline route could share the cost of drilling the new wells and pipeline construction.

The estimated capital cost for this alternative includes the cost to complete the new wells, and construct the pipeline and pump stations. The estimated O&M cost for this alternative includes the maintenance cost for the pipeline, and power and O&M labor and materials for the pump stations. The estimated capital cost for this alternative is $6.58 million, and the alternative's estimated annual O&M cost is $66,900. If the purchased water was used for blending rather than for the full water supply, the annual O&M cost for this alternative could be reduced because of reduced pumping costs and reduced water purchase costs. However, additional costs would be incurred for equipment to ensure proper blending, and additional monitoring to ensure the finished water is compliant.

The reliability of adequate amounts of compliant water under this alternative should be good. From the Falling Water Subdivision'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, and Aqua Texas personnel currently operate pipelines and a pump station. If the decision was made to perform blending then the operational complexity would increase.

The feasibility of The Wilderness alternative would be dependent on Aqua Texas, Inc. being able to reach an agreement with The Wilderness PWS to install the new groundwater wells.

This alternative would have almost identical costs to a similar alternative involving the nearby Cherry Ridge Water Company PWS and, consequently, these alternatives are considered to be identical for purposes of this report. Aqua Texas, Inc. owns and operates both the Falling Water PWS and the Cherry Ridge Water Company, so obtaining the necessary agreements to implement this option should not impact the feasibility of this alternative.

4.5.5 Alternative FW-5: New Wells in the Vicinity of Scenic Valley

This alternative involves completing two new wells in the vicinity of Scenic Valley Mobile Home Park, and constructing two pump stations and a pipeline to transfer the pumped groundwater to the Falling Water Subdivision PWS. Based on the water quality data in the TCEQ database, it is expected that groundwater from this area would be compliant with drinking water MCLs, though there may be a minor issue with iron to take into consideration. An agreement would need to be negotiated with Scenic Valley Mobile Home Park to expand its well field.

This alternative would require completing the two new wells and storage tanks at the Scenic Valley Mobile Home Park, and constructing a pipeline from the wells to the existing intake point for the Falling Water Subdivision PWS. Two pump stations would also be required to overcome pipe friction and the elevation differences between Scenic Valley Mobile Home Park and Falling Water Subdivision. The required pipeline would be constructed of 6-inch PVC pipe and would follow Route 16, Interstate 10, several minor roads, and Highway 87 to the Falling Water Subdivision. Using this route, the pipeline required would be approximately 21 miles in length. The pipeline would terminate at the existing storage tanks owned by the Falling Water Subdivision.

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

This alternative has the potential to provide a regional solution, as there are several PWSs in the vicinity that have a need for compliant water. PWSs located close to the proposed pipeline route could share the cost of drilling the new wells and pipeline construction.

The estimated capital cost for this alternative includes the cost to complete the new wells, and construct the pipeline and pump stations. The estimated O&M cost for this alternative includes the maintenance cost for the pipeline, and power and O&M labor and materials for the pump stations. The estimated capital cost for this alternative is $5.77 million, and the alternative's estimated annual O&M cost is $48,300. If the purchased water was used for blending rather than for the full water supply, the annual O&M cost for this alternative could be reduced because of reduced pumping costs and reduced water purchase costs. However, additional costs would be incurred for equipment to ensure proper blending, and additional monitoring to ensure the finished water is compliant.

The reliability of adequate amounts of compliant water under this alternative should be good. From the Falling Water Subdivision'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, and Aqua Texas personnel currently operate pipelines and a pump station. If the decision was made to perform blending then the operational complexity would increase.

The feasibility of this alternative would be dependent on Aqua Texas being able to reach an agreement with the Scenic Valley Mobile Home Park to install the new groundwater wells.

4.5.6 Alternative FW-6: Purchase Water from the City of Kerrville

This alternative involves purchasing compliant water from the City of Kerrville, which would be used to supply the Falling Water Subdivision. The City has indicated it does have excess production capacity and would be willing to consider selling water to PWSs within Kerr County, assuming a suitable agreement could be negotiated.

This alternative would require construction of two 5,000-gallon storage tanks at a point adjacent to the City of Kerrville's water system, and a pipeline from the tanks to the existing intake point for the Falling Water Subdivision. Two pump stations would also be required to overcome pipe friction and the elevation differences between Kerrville and the Falling Water Subdivision. The required pipeline would be constructed of 6-inch PVC pipe and would follow Interstate 10 and Highway 87 from Kerrville to the Falling Water Subdivision. Using this route, the length of pipe required would be approximately 20 miles. The pipeline would terminate at the existing storage tanks at the Falling Water Subdivision.

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

The estimated capital cost for this alternative includes constructing the pipeline and pump stations. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost that Aqua Texas currently pays to operate its well field, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump stations. The estimated capital cost for this alternative is $5.44 million, and the alternative's estimated annual O&M cost is $52,400. If the purchased water was used for blending rather than for the full water supply, the annual O&M cost for this alternative could be reduced because of reduced pumping costs and reduced water purchase costs. However, additional costs would be incurred for equipment to ensure proper blending, and additional monitoring to ensure the finished water is compliant.

The reliability of adequate amounts of compliant water under this alternative should be good. The City of Kerrville has adequate O&M resources. From Aqua Texas' 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, and Aqua Texas personnel currently operate pipelines and pump stations. If the decision was made to perform blending then the operational complexity would increase.

This alternative has the potential to provide a regional solution, as there are several PWSs in the vicinity that have a need for compliant water. PWSs located close to the proposed pipeline route could share the cost of pipeline construction.

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

4.5.7 Alternative FW-7: Purchase Water from the City of Fredericksburg

This alternative involves purchasing compliant water from the City of Fredericksburg, which would be used to supply the Falling Water Subdivision. The City currently has sufficient excess capacity to sell additional water outside their community, assuming that an agreement could be negotiated.

This alternative would require construction of two 5,000-gallon storage tanks at a point adjacent to the City of Fredericksburg's water system, and a pipeline from the tanks to the existing intake point for the Falling Water Subdivision. Two pump stations would also be required to overcome pipe friction and the elevation differences between Fredericksburg and the Falling Water Subdivision. The required pipeline would be constructed of 6-inch PVC pipe and would follow Highway 87 south from Fredericksburg to the Falling Water Subdivision. Using this route, the length of pipe required would be approximately 17 miles. The pipeline would terminate at the existing storage tanks at the Falling Water Subdivision.

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

The estimated capital cost for this alternative includes constructing the pipeline and pump stations. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost that Aqua Texas currently pays to operate its well field, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump stations. The estimated capital cost for this alternative is $4.59 million, and the alternative's estimated annual O&M cost is $48,400. Using the purchased water for blending would not be an option in this case, because the City of Fredericksburg already blends its drinking water to achieve compliance for radium.

The reliability of adequate amounts of compliant water under this alternative should be good. The City of Fredericksburg has adequate O&M resources. From Aqua Texas' 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, and Aqua Texas personnel currently operate pipelines and pump stations.

This alternative has the potential to provide a regional solution, as there are several PWSs in the vicinity that have a need for compliant water. PWSs located close to the proposed pipeline route could share the cost of pipeline construction.

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

4.5.8 Alternative FW-8: Central IX Treatment

The system would continue to pump water from the Falling Water Subdivision well field, and would treat the water through an IX system prior to distribution. For this option, a fraction of the raw water would be treated and then blended with the untreated water to obtain overall compliant water, as a means of extending the time between regenerations of the IX resin beds and to retain some hardness in the blended water prior to distribution. Water in excess of that currently produced would be required for backwashing and regeneration of the resin beds.

The IX treatment plant, located at the Falling Water Subdivision well field, features a 400-square foot building with a paved driveway, a skid holding the pre-constructed IX equipment, a 20-ton brine tank with regeneration equipment, two transfer pumps, a 20,000-gallon tank for storing the treated water, a 10,000-gallon tank for storing spent backwash water, and a 10,000-gallon tank for storing regenerant waste. Spent backwash water would be discharged to the sewer at a controlled rate; regenerant waste would be trucked off-site for disposal. The treated water would be chlorinated and stored in the new treated water tank prior to being pumped into the distribution system. The entire facility is fenced.

The estimated capital cost for this alternative is $446,500, and the estimated annual O&M cost is $59,200.

The reliability of adequate amounts of compliant water under this alternative is good, since IX treatment is a common and well-understood technology. IX treatment does not require high pressure, but can be affected by interfering constituents in the water. The O&M efforts required for the central IX treatment plant may be significant, and operating personnel would require training with ion exchange.

4.5.9 Alternative FW-9: Central WRT Z-88 Treatment

The system would continue to pump water from the Falling Water Subdivision well field, and would treat the water through the Z-88 adsorption system prior to distribution. The full flow of raw water would be treated by the Z-88 system as the media specifically adsorb radium and do not affect other constituents. There is no liquid waste generated in this process. The Z-88 media would be replaced and disposed by WRT in an approved low-level radioactive waste landfill after 2-3 years of operation.

This alternative consists of constructing the Z-88 treatment system at the existing Falling Water Subdivision well field. WRT owns the Z-88 equipment and the

Subdivision would pay for construction for the treatment unit and auxiliary facilities. The plant is composed of a tall (25-30-feet) 400 square foot building with a paved driveway; the pre-fabricated Z-88 adsorption system owned by WRT; and piping system. The entire facility would be fenced. The treated water would be chlorinated prior to distribution. It is assumed the well pumps would have adequate pressure to pump the water through the Z-88 system to the ground storage tanks without requiring new pumps.

The estimated capital cost for this alternative is $185,500, and the estimated annual O&M cost is $67,500.

Based on many pilot testing results and some full-scale plant data, this technology appears to be reliable. It is very simple to operate and the media replacement and disposal would be handled by WRT. Because WRT owns the equipment, the capital cost is relatively low. The main operating cost would be WRT's fee for the treated water. One concern with this technology is the potential health effect on O&M personnel because of the level of radioactivity accumulated in the Z-88 vessel after the media have been operating for a long time.

4.5.10 Alternative FW-10: Central $KMnO_4$ Treatment

The system would continue to pump water from the Falling Water well field, and would treat the water through a greensand filter system prior to distribution. For this option, all raw water would be treated and the flow would be decreased when one of the two 50 percent filters was being backwashed by raw water. It is assumed the existing well pumps would have adequate pressure to pump the water through the greensand filters to the ground storage tanks.

The greensand plant, located at the Falling Water well field, features a 400-square foot building with a paved driveway; a skid with the pre-constructed filters and a $KMnO_4$ solution tank; a 10,000-gallon spent backwash tank; and piping systems. The spent backwash water would be discharged to the sewer at a controlled rate. The entire facility is fenced.

The estimated capital cost for this alternative is $520,400, and the estimated annual O&M cost is $53,900.

The reliability of adequate amounts of compliant water under this alternative is good, since $KMnO_4$-greensand is an established treatment technology for radium removal. The O&M efforts required are moderate, but operating personnel need to ensure that $KMnO_4$ is not overfed. The spent backwash water contains MnO_2 particles with sorbed radium, but the level of radioactivity in the backwash is relatively low.

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

This alternative consists of the continued operation of the Falling Water well field, plus treatment of water to be used for drinking or food preparation at the point-of-use to remove radium. The purchase, installation, and maintenance of POU treatment systems to be installed "under the sink" would be necessary for this alternative. Blending is not an option in this case.

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

For the cost estimate, it is assumed the POU total radium treatment would involve RO. RO treatment processes typically produce a reject water stream that requires disposal. The reject stream results in an increase in the overall volume of water used. POU systems have the advantage of using only a minimum volume of treated water for human consumption. This minimizes the size of the treatment units, the increase in water required, and the waste for disposal. For this alternative, it is assumed the increase in water consumption is insignificant in terms of supply cost, and that the reject waste stream could be discharged to the house septic or sewer system.

This alternative does not present options for a shared solution.

The estimated capital cost for this alternative includes the cost to purchase and install the POU treatment systems. The estimated O&M cost for this alternative includes the purchase and replacement of filters and media or membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $169,000, and the estimated annual O&M cost for this alternative is $160,000. For the cost estimate, it is assumed that one POU treatment unit will be required for each of the 256 connections that will be in the Falling Water Subdivision system at full-build-out. It should be noted that the POU treatment units would need to be more complex than units typically found in commercial retail outlets in order to meet regulatory requirements, making purchase and installation more expensive.

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

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

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

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

This alternative would require the installation of the POE treatment units at houses and other buildings that provide drinking or cooking water. Aqua Texas would be responsible for purchasing and maintaining the treatment units, including media or membrane and filter replacement, periodic sampling, and necessary repairs. It may also be desirable to modify piping so water for non-consumptive uses can be withdrawn upstream of the treatment unit. The POE treatment units would be installed outside the residences, so entry would not be necessary for O&M. Some cooperation from customers would be necessary for installation and maintenance of the treatment systems.

For the cost estimate, it is assumed the POE total radium treatment would involve RO. RO treatment processes typically produce a reject water stream that requires disposal. The waste streams result in an increased overall volume of water used. POE systems treat a greater volume of water than POU systems. For this alternative, it is assumed the increase in water consumption is insignificant in terms of supply cost, and that the reject waste stream could be discharged to the house septic or sewer system.

This alternative does not present options for a shared solution.

The estimated capital cost for this alternative includes cost to purchase and install the POE treatment systems. The estimated O&M cost for this alternative includes the purchase and replacement of filters and media or membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $2.96 million, and the estimated annual O&M cost for this alternative is $358,400. For the cost estimate, it is assumed that one POU treatment unit will be required for each of the 256 connections that will be in the Falling Water Subdivision system at full-build-out.

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

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

4.5.13 Alternative FW-13: New Wells at 10 Miles

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

This alternative would require constructing two new 400-foot wells, 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 Falling Water Subdivision 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 6-inch PVC line that discharges to an existing storage tank at the Falling Water Subdivision. The pump station would include two pumps, including one standby, and would be housed in a building.

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

The estimated capital cost for this alternative includes installing the wells, 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 Falling Water wells. The estimated capital cost for this alternative is $2.81 million, and the estimated annual O&M cost for this alternative is $26,800.

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 Aqua Texas' perspective, this alternative would be similar to operate as the existing system. Aqua Texas personnel have experience with O&M of wells, pipelines, and pump stations.

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

4.5.14 Alternative FW-14: New Wells at 5 Miles

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

This alternative would require constructing two new 400-foot wells, a new pump station with storage tank near the new well, and a pipeline from the new wells/tank to the existing intake point for the Falling Water Subdivision 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 6-inch PVC line that discharges to an existing storage tank at the Falling Water Subdivision PWS. The pump station would include two pumps, including one standby, and would be housed in a building.

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

The estimated capital cost for this alternative includes installing the wells, 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 Falling Water wells. The estimated capital cost for this alternative is $1.59 million, and the estimated annual O&M cost for this alternative is $23,800.

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 Aqua Texas' perspective, this alternative would be similar to operate as the existing system. Aqua Texas personnel have experience with O&M of wells, pipelines, and pump stations.

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

4.5.15 Alternative FW-15: New Wells at 1 Mile

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

This alternative would require constructing two new 400-foot wells, and a pipeline from the new wells to the existing intake point for the Falling Water Subdivision system. For this alternative, the pipeline is assumed to be approximately 1 mile long, and would be a 6-inch PVC line that discharges to an existing storage tank at the Falling Water Subdivision PWS.

It is doubtful this alternative could present options for a regional solution, since there are no other PWSs in the immediate vicinity of the Falling Water Subdivision.

The estimated capital cost for this alternative includes installing the wells, and constructing the pipeline. The estimated O&M cost for this alternative includes O&M

for the pipeline, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing Falling Water wells. The estimated capital cost for this alternative is $359,300, and the estimated annual O&M cost for this alternative is $6,800.

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 Aqua Texas' perspective, this alternative would be similar to operate as the existing system. Aqua Texas personnel have experience with O&M of wells, pipelines, and pump stations.

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

4.5.16 Alternative FW-16: Public Dispenser for Treated Drinking Water

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

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

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing and installing the treatment system to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes purchasing and replacing filters and media or membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $11,600, and the estimated annual O&M cost for this alternative is $16,700.

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

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

4.5.17 Alternative FW-17: 100 Percent Bottled Water Delivery

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

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

This alternative does not present options for a regional solution.

The estimated initial capital cost is for setting up the program. The estimated O&M cost for this alternative includes program administration and purchase of the bottled water. The estimated capital cost for this alternative is $23,900, and the estimated annual O&M cost for this alternative is $472,200. For the cost estimate, it is assumed that each person requires 1 gallon of bottled water per day.

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

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

4.5.18 Alternative FW-18: Public Dispenser for Trucked Drinking Water

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

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

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

The estimated capital cost for this alternative includes purchasing a water truck and construction of the storage tank to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes O&M for the truck, maintenance for the tank, water quality testing, record keeping, and water purchase. The estimated capital cost for this alternative is $103,000, and the estimated annual O&M cost for this alternative is $16,200.

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

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

4.5.19 Summary of Alternatives

Table 4.3 provides a summary of the key features of each alternative for Falling Water Subdivision PWS.

1 **Table 4.3 Summary of Compliance Alternatives for Falling Water Subdivision PWS**

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
FW-1	New wells at Nickerson Farm Water System	- New wells - Pump station - 10½-mile pipeline	$2,993,000	$24,700	$285,700	Good	N	Nickerson Farm Water System is also an Aqua Texas PWS. Blending may be possible. Costs could possibly be shared with small systems along pipeline route.
FW-2	New wells at Oak Ridge Estates Water System	- New wells - Pump station - 16-mile pipeline	$4,376,700	$30,000	$411,500	Good	N	Agreement must be successfully negotiated with Oak Ridge Estates Water System, or land must be purchased. Blending may be possible. Costs could possibly be shared with small systems along pipeline route.
FW-3	New wells at Center Point Wiedenfeld Water Works	- New wells - Pump station - 18-mile pipeline	$4,974,200	$29,800	$463,400	Good	N	Agreement must be successfully negotiated with Wiedenfeld Water Works, or land must be purchased. Blending may be possible. Costs could possibly be shared with small systems along pipeline route.
FW-4	New wells at The Wilderness	- New wells - Pump stations - 24-mile pipeline	$6,582,300	$66,900	$640,800	Good	N	Agreement must be successfully negotiated with The Wilderness, or land must be purchased. Blending may be possible. Costs could possibly be shared with small systems along pipeline route.
FW-5	New wells at Scenic Valley Mobile Home Park	- New wells - Pump stations - 21-mile pipeline	$5,769,100	$48,300	$551,300	Good	N	Agreement must be successfully negotiated with Scenic Valley Mobile Home Park, or land must be purchased. Blending may be possible. Costs could possibly be shared with small systems along pipeline route.
FW-6	Purchase water from City of Kerrville	- Pump stations - 20-mile pipeline	$5,444,800	$52,400	$527,100	Good	N	Agreement must be successfully negotiated with the City of Kerrville. Blending may be possible. Costs could possibly be shared with small systems along pipeline route.
FW-7	Purchase water from City of Fredericksburg	- Pump stations - 17-mile pipeline	$4,591,700	$48,400	$448,700	Good	N	Agreement must be successfully negotiated with the City of Fredericksburg. Blending not possible. Costs could possibly be shared with small systems along pipeline route.
FW-8	Continue operation of Falling Water well field with central IX treatment	- Central IX treatment plant	$446,500	$59,200	$98,100	Good	T	Costs could possibly be shared with nearby small systems.
FW-9	Continue operation of Falling Water well field with central WRT Z-88 treatment	- Central WRT Z-88 treatment plant	$185,500	$67,500	$83,600	Good	T	Costs could possibly be shared with nearby small systems.

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
FW-10	Continue operation of Falling Water well field with central $KMnO_4$ treatment	- Central $KMnO_4$ treatment plant	$520,400	$53,900	$99,300	Good	T	Costs could possibly be shared with nearby small systems.
FW-11	Continue operation of Falling Water well field, and POU treatment	- POU treatment units	$169,000	$160,000	$174,700	Fair	T, M	Only one compliant tap in home. Cooperation of residents required for installation, maintenance, and testing.
FW-12	Continue operation of Falling Water well field, and POE treatment	- POE treatment units	$2,956,800	$358,400	$616,200	Fair (*better than POU*)	T, M	All home taps compliant and less resident cooperation required.
FW-13	Install new compliant wells within 10 miles	- New wells - Storage tank - Pump station - 10-mile pipeline	$2,810,800	$26,800	$271,900	Good	N	May be difficult to find wells with good water quality. Costs could possibly be shared with small systems along pipeline route.
FW-14	Install new compliant wells within 5 miles	- New wells - Storage tank - Pump station - 5-mile pipeline	$1,590,200	$23,800	$162,500	Good	N	May be difficult to find wells with good water quality. Costs could possibly be shared with small systems along pipeline route.
FW-15	Install new compliant wells within 1 mile	- New wells - 1-mile pipeline	$359,300	$6,800	$38,100	Good	N	May be difficult to find well with good water quality.
FW-16	Continue operation of Falling Water well field, but furnish public dispenser for treated drinking water	- Water treatment and dispenser unit	$11,600	$16,700	$17,700	Fair/interim measure	T	INTERIM SOLUTION: Does not provide compliant water to all taps, and requires a lot of effort by customers.
FW-17	Continue operation of Falling Water well field, but furnish bottled drinking water for all customers	- Set up bottled water system	$23,900	$472,200	$474,300	Fair/interim measure	M	INTERIM SOLUTION: Does not provide compliant water to all taps, and requires customers to order and use. Management of program may be significant.
FW-18	Continue operation of Falling Water well field, but furnish public dispenser for trucked drinking water	- Construct storage tank and dispenser - Purchase potable water truck	$103,000	$16,200	$25,100	Fair/interim measure	M	INTERIM SOLUTION: Does not provide compliant water to all taps, and requires a lot of effort by customers.

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

4.6 COST OF SERVICE AND FUNDING ANALYSIS

To evaluate the financial impact of implementing the compliance alternatives, a 30-year financial planning model was developed. This model can be found in Appendix D. The financial model is based on estimated cash flows, with and without implementation of the compliance alternatives. Data for such models are typically derived from established budgets, audited financial reports, published water tariffs, and consumption data. Aqua Texas manages over 280 PWSs in Texas that range in size 3 to 2,178 connections. Falling Water Subdivision is one of the smaller Aqua Texas facilities, having 47 connections. Information that was available to complete the financial analysis included 2004 revenues and expenses for all Aqua Texas facilities from the TCEQ website, 2005 water usage records for the Falling Water Subdivision received from Aqua Texas, and current water rates for Falling Water also from Aqua Texas.

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

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

4.6.1 Financial Plan Development

Since financial records for Falling Water Subdivision were not available, revenues and expenses had to be estimated for this PWS. Annual revenue was estimated using a base rate of $26.50 per month per connection, an actual usage at a rate of $2.31 per 1,000 gallons, and a projected water usage of 13,750,000 gallons, which was based on year-to-date water usage records. These values were entered into the financial model resulting in 2004 revenue of $44,145 (operating revenue plus required reserve) for the Falling Water Subdivision PWS compared to $21,021,336 total 2004 revenue for Aqua Texas, which represents 0.21% of total revenue. Expenses were estimated by prorating the Falling Water portion using the same 0.21% as shown in Table 4.4.

1 **Table 4.4 Summary of Falling Water 2004 Revenues and Expenses**

	AQUA TEXAS CCN 11157	AQUA TEXAS CCN12902	AQUA TEXAS Total	Falling Water
EXPENSES				
Salaries & Wages	$ 3,065,588	$ 97,022	$ 3,162,610	$ 6,641
Contract Labor	$ 161,132	$ 2,023	$ 163,155	$ 343
Purchased Water	$ 655,123	$ 54,174	$ 709,297	$ 1,490
Chemicals	$ 317,922	$ 14,513	$ 332,435	$ 698
Utilities	$ 1,154,312	$ 207,611	$ 1,361,923	$ 2,860
Repairs/Maintenance	$ 1,775,614	$ 125,388	$ 1,901,002	$ 3,992
Office Expenses	$ 811,219	$ 19,376	$ 830,595	$ 1,744
Accounting/Legal Fees	$ 314,973	$ 12,640	$ 327,613	$ 688
Insurance	$ 304,173	$ 11,939	$ 316,112	$ 664
Depreciation	$ 2,379,808	$ 227,259	$ 2,607,067	$ 5,475
Miscellaneous	$ 3,060,375	$ 100,843	$ 3,161,218	$ 6,639
Federal Income Tax	$ 1,601,740	$ 450,542	$ 2,052,282	$ 4,310
Property & Payroll Tax	$ 1,707,092	$ 107,452	$ 1,814,544	$ 3,811
Rate Case Expenses	$ 266,081	$ 37,549	$ 303,630	$ 638
Other	$ 1,976,361	$ 1,492	$ 1,977,853	$ 4,153
Total Expenses	**$ 19,551,513**	**$ 1,469,823**	**$ 21,021,336**	**$ 44,145**

4.6.2 Current Financial Condition

4.6.2.1 Cash Flow Needs

Using the base rate and water usage rates as noted above, the current average annual water bill for Falling Water customers is estimated at $1,034 or about 3.0 percent of the Kerr County median household income of $34,283, as given in the 2000 Census.

The long-term financial plan indicates that Aqua Texas rates are currently high enough to maintain operations for the next 2–3 years. However, Aqua Texas will need to raise rates in the future to service the debt associated with any capital improvements for the various alternatives that may be implemented to address compliance issues.

4.6.2.2 Ratio Analysis

There is insufficient financial information available for Aqua Texas and the Falling Water Subdivision to calculate the Current Ratio or the Debt to Net Worth Ratio. However, an Operating Ratio of 1.26 was calculated using available financial information. An Operating Ratio of 1.0 means that a utility is collecting just enough money to meet expenses; thus, an Operating Ratio of 1.26 is just another indication that Aqua Texas does not need to raise its future water rates for its Falling Water Customers, based on financial estimates and the no action alternative.

4.6.3 Financial Plan Results

Each of the compliance alternatives for the Falling Water Subdivision was evaluated using the financial model to determine the overall increase in water rates 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. Figure 4.2 shows that the current average annual bill for Falling Water Subdivision of $1,034 is sufficient to fully fund existing operations. There are two bars shown for each of the alternatives. The lowest bar is based on 100 percent grant funding of capital improvements for the compliance alternative. Thus, the higher average annual water bill 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 represents the highest cost scenario. Therefore, the higher average annual water bill in this case reflects both higher O&M costs and the principal and interests costs to service the debt associated with the compliance alternative. Figure 4.2 also shows the annual residential water bill as a percent of MHI for Kerr County.

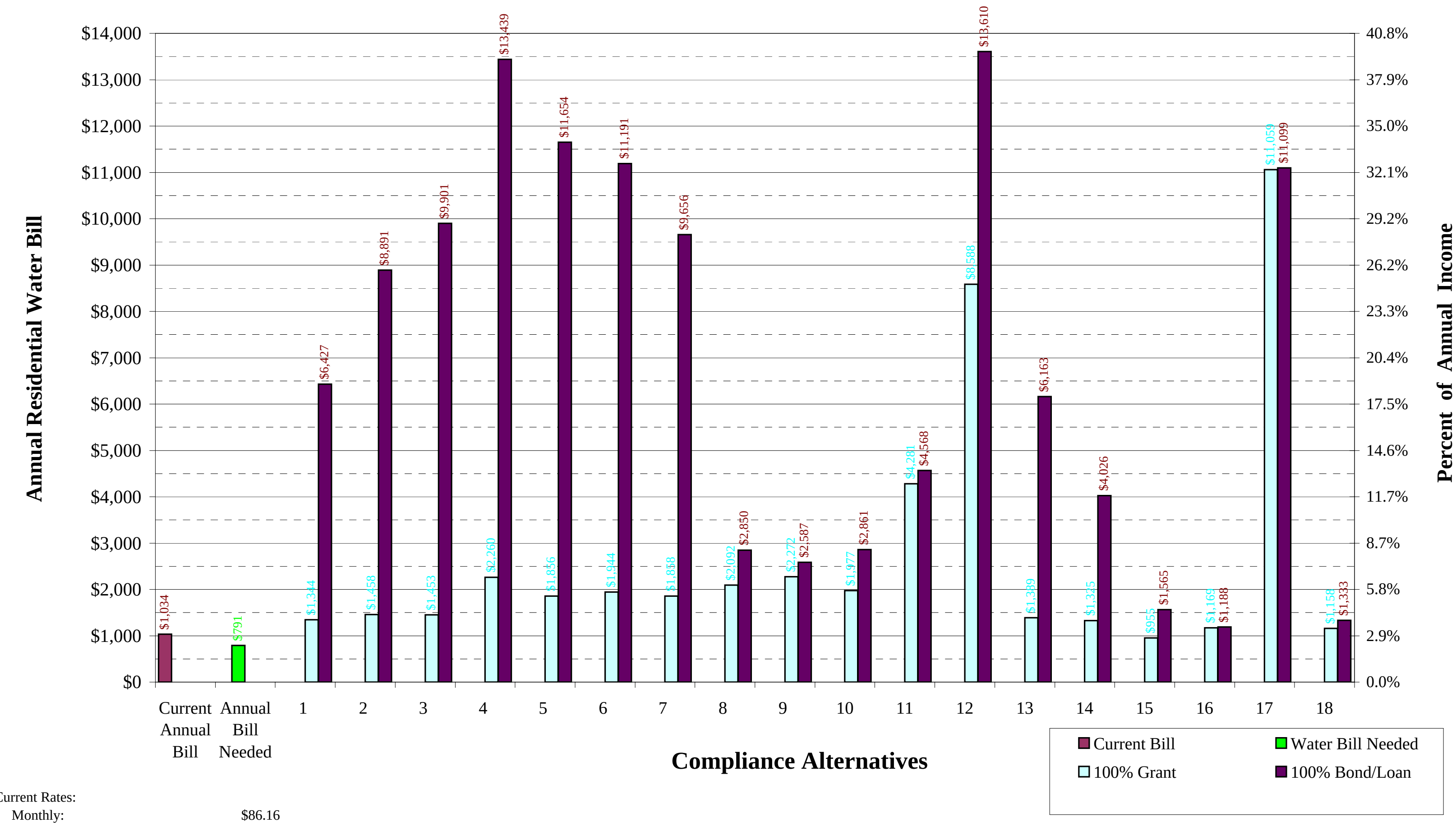
1 **Table 4.5 Financial Impact on Households for Falling Water Subdivision PWS**

#		Funding Source #	0	1	2	3	4	5
	ALTERNATIVES		All Revenue	100% Grant	75% Grant	50% Grant	SRF	Loan/Bond
FW-1	Westwood Park - Nickerson	Average Annual Water Bill	$ 61,744	$ 1,600	$ 3,936	$ 6,273	$9,817	$10,946
		Maximum % of HH Income	192%	5%	12%	20%	31%	35%
		Percentage Rate Increase Compared to Current	6276%	64%	310%	556%	929%	1047%
		Year First Rate Increase Needed	2006	2008	2006	2006	2006	2006
FW-2	Oak Ridge	Average Annual Water Bill	$ 89,948	$ 1,801	$ 5,218	$ 8,635	$ 13,818	$ 15,469
		Maximum % of HH Income	280%	6%	16%	27%	44%	49%
		Percentage Rate Increase Compared to Current	9191%	86%	494%	902%	1522%	1719%
		Year First Rate Increase Needed	2006	2008	2006	2006	2006	2006
FW-3	Heritage Park, etc	Average Annual Water Bill	$ 102,081	$ 1,794	$ 5,677	$ 9,560	$ 15,451	$ 17,327
		Maximum % of HH Income	318%	6%	18%	30%	49%	55%
		Percentage Rate Increase Compared to Current	10445%	86%	494%	902%	1522%	1719%
		Year First Rate Increase Needed	2006	2008	2006	2006	2006	2006
FW-4	The Wilderness - Cherry Ridge	Average Annual Water Bill	$ 135,471	$ 3,225	$ 8,364	$ 13,503	$ 21,298	$ 23,780
		Maximum % of HH Income	422%	10%	27%	43%	68%	76%
		Percentage Rate Increase Compared to Current	13899%	242%	682%	1323%	2142%	2403%
		Year First Rate Increase Needed	2006	2007	2006	2006	2006	2006
FW-5	Scenic Valley	Average Annual Water Bill	$ 18,588	$ 2,508	$ 7,012	$ 11516	$ 18,348	$ 20,523
		Maximum % of HH Income	370%	8%	22%	37%	58%	65%
		Percentage Rate Increase Compared to Current	12153%	163%	637%	1111%	1829%	2058%
		Year First Rate Increase Needed	2006	2008	2006	2006	2006	2006
FW-6	City of Kerrville	Average Annual Water Bill	$ 112,081	$ 2,664	$ 6,915	$ 11,166	$ 17,614	$ 19,667
		Maximum % of HH Income	349%	8%	22%	35%	56%	62%
		Percentage Rate Increase Compared to Current	11480%	181%	628%	1075%	1753%	1969%
		Year First Rate Increase Needed	2006	2007	2006	2006	2006	2006
FW-7	City of Fredericksburg	Average Annual Water Bill	$ 94,678	$ 2,512	$ 6,096	$ 9,681	$ 15,119	$ 16,851
		Maximum % of HH Income	295%	8%	19%	31%	48%	53%
		Percentage Rate Increase Compared to Current	9681%	164%	541%	918%	1490%	1672%
		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**
FW-8	Central IX	Average Annual Water Bill	$ 10,698	$ 2,927	$ 3,275	$ 3,624	$ 4,153	$ 4,321
		Maximum % of HH Income	33%	9%	10%	12%	13%	14%
		Percentage Rate Increase Compared to Current	1002%	209%	246%	282%	338%	356%
		Year First Rate Increase Needed	2006	2007	2007	2007	2006	2006
FW-9	Central WRT Z-88	Average Annual Water Bill	$ 5,560	$ 3,246	$ 3,391	$ 3,536	$ 3,755	$ 3,825
		Maximum % of HH Income	17%	10%	11%	11%	12%	12%
		Percentage Rate Increase Compared to Current	472%	244%	259%	274%	297%	305%
		Year First Rate Increase Needed	2006	2007	2007	2007	2007	2007
FW-10	Central KMnO4	Average Annual Water Bill	$ 12,096	$ 2,723	$ 3,129	$ 3,535	$ 4,152	$ 4,348
		Maximum % of HH Income	38%	9%	10%	11%	13%	14%
		Percentage Rate Increase Compared to Current	1147%	187%	230%	272%	337%	358%
		Year First Rate Increase Needed	2006	2007	2007	2007	2006	2006
FW-11	POU-Adsorption	Average Annual Water Bill	$ 7,047	$ 6,810	$ 6,942	$ 7,074	$ 7,274	$ 7,338
		Maximum % of HH Income	22%	22%	23%	23%	24%	24%
		Percentage Rate Increase Compared to Current	632%	632%	646%	660%	681%	688%
		Year First Rate Increase Needed	2006	2007	2007	2007	2007	2007
FW-12	POE-Adsorption	Average Annual Water Bill	$ 67,551	$ 14,453	$ 16,761	$ 19,069	$ 22,571	$ 23,686
		Maximum % of HH Income	211%	47%	55%	62%	73%	77%
		Percentage Rate Increase Compared to Current	6900%	1465%	1708%	1951%	2319%	2436%
		Year First Rate Increase Needed	2006	2007	2007	2006	2006	2006
FW-13	New well 10 mi	Average Annual Water Bill	$ 58,084	$ 1,680	$ 3,875	$ 6,069	$ 9,398	$ 10,458
		Maximum % of HH Income	181%	5%	12%	19%	30%	33%
		Percentage Rate Increase Compared to Current	5898%	73%	304%	535%	885%	996%
		Year First Rate Increase Needed	2006	2008	2006	2006	2006	2006
FW-14	New well 5 mi	Average Annual Water Bill	$ 33,235	$ 1,566	$ 2,807	$ 4,049	$ 5,932	$ 6,532
		Maximum % of HH Income	103%	5%	9%	13%	19%	21%
		Percentage Rate Increase Compared to Current	3329%	61%	191%	322%	520%	583%
		Year First Rate Increase Needed	2006	2008	2006	2006	2006	2006
FW-15	New well 1 mi	Average Annual Water Bill	$ 7,952	$ 1,034	$ 1,190	$ 1,470	$ 1,896	$ 2,031
		Maximum % of HH Income	25%	3%	4%	4%	6%	6%
		Percentage Rate Increase Compared to Current	715%	0%	19%	48%	93%	107%
		Year First Rate Increase Needed	2006	2009	2007	2006	2006	2006

#		Funding Source #	0	1	2	3	4	5
	ALTERNATIVES		**All Revenue**	**100% Grant**	**75% Grant**	**50% Grant**	**SRF**	**Loan/Bond**
FW-16	Dispenser	Average Annual Water Bill	$ 1,305	$ 1,289	$ 1,298	$ 1,307	$ 1,321	$ 1,325
		Maximum % of HH Income	4%	4%	4%	4%	4%	4%
		Percentage Rate Increase Compared to Current	31%	31%	32%	33%	34%	34%
		Year First Rate Increase Needed	2008	2009	2009	2009	2009	2009
FW-17	100% Bottled	Average Annual Water Bill	$ 18,869	$ 18,836	$ 18,854	$ 18,873	$ 18,901	$ 18,910
		Maximum % of HH Income	62%	62%	62%	62%	62%	62%
		Percentage Rate Increase Compared to Current	1943%	1943%	1945%	1947%	1950%	1951%
		Year First Rate Increase Needed	2007	2007	2007	2007	2007	2007
FW-18	Central Trucked	Average Annual Water Bill	$ 2,879	$ 1,270	$ 1,350	$ 1,430	$ 1,552	$ 1,591
		Maximum % of HH Income	9%	4%	4%	4%	5%	5%
		Percentage Rate Increase Compared to Current	191%	29%	37%	45%	58%	62%
		Year First Rate Increase Needed	2006	2009	2008	2008	2007	2007

Figure 4-2 Alternative Cost Summary



Current Rates:
Monthly: $86.16
Median Household Income $34,283
Average Monthly Residential Usage 24,379 gallons

SECTION 5
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APPENDIX A
PWS INTERVIEW FORM

CAPACITY DEVELOPMENT ASSESSMENT FORM

*Prepared By*_________________________________ *Date*__________________________

Section 1. Public Water System Information

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

3. County [ ]

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

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

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

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

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

11. Source Type [ ]

12. Total PWS Annual Water Used [ ]

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

    Total Coliform [ ] Chemical/Radiological [ ]

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

A. Basic Information

1. Name of Water System:

2. Name of Person Interviewed:

3. Position:

4. Number of years at job:

5. Number of years experience with drinking water systems:

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

7. Certified Water Operator (Yes or No):

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

   7b. How long have you been certified?

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

B. Organization and Structure

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

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

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

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

   3b. May we see a copy?

C. Personnel

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

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

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

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

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

D. Communication

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

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

3. How are your work priorities set?

4. How are work tasks delegated to staff?

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

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

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

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

9. Describe communication between utility and customers.

E. Planning and Funding

1. Describe the rate structure for the utility.

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

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

3. How often are the rates reviewed?

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

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

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

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

8. How is the budget approved or adopted?

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

   9a. How are budget shortfalls handled?

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

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

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

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

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

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

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

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

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

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

F. Policies, Procedures, and Programs

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

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

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

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

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

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

7. Approximately how many complaints are there per month?

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

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

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

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

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

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

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

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

G. Operations and Maintenance

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

    a. Process Control

    b. Purchases of supplies or small equipment

    c. Compliance sampling/reporting

    d. Staff scheduling

2. Describe your utility's preventative maintenance program.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

H. SDWA Compliance

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

2. How were the violations handled?

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

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

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

I. Emergency Planning

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

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

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

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

Attachment A

A. Technical Capacity Assessment Questions

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

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

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

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

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

   YES ☐ NO ☐

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

   _____NM Small System _____Class 2

   _____NM Small System Advanced _____Class 3

   _____Class 1 _____Class 4

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

   YES ☐ NO ☐ No Deficiencies ☐

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

   Source ☐ Storage ☐

   Treatment ☐ Distribution ☐

   Other _____

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

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

   Radionuclides YES ☐ NO ☐ Doesn't Apply ☐

   Arsenic YES ☐ NO ☐ Doesn't Apply ☐

   Stage 1 Disinfectants and Disinfection By-Product (DBP)

   YES ☐ NO ☐ Doesn't Apply ☐

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

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

   YES ☐ NO ☐

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

YES ☐ NO ☐

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

Drought _____ Limited Supply _____

System Failure _____ Other _____

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

YES ☐ NO ☐ Don't Know ☐

If YES, please complete the following table.

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

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

YES ☐ NO ☐

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

Source ☐ Storage ☐

Treatment ☐ Distribution ☐

Other ☐ _____

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

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

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

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

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

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

YES ☐ NO ☐

14. Does the system have a flushing program?

YES ☐ NO ☐

If YES, please describe.

15. Are there any pressure problems within the system?

YES ☐ NO ☐

If YES, please describe.

16. Does the system disinfect the finished water?

YES ☐ NO ☐

If yes, which disinfectant product is used? ______

Interviewer Comments on Technical Capacity:

B. Managerial Capacity Assessment Questions

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

YES ☐ NO ☐

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

YES ☐ NO ☐

18. Does the system have written operating procedures?

YES ☐ NO ☐

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

YES ☐ NO ☐

20. Does the system have:

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

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

Water quality violations
YES ☐ NO ☐

Public notification
YES ☐ NO ☐

Sampling exemptions
YES ☐ NO ☐

22. Please describe how the above records are maintained:

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

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

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

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

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

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

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

If yes, from which agency and how much?

Describe the project?

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

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

YES ☐ NO ☐

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

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

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

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

Interviewer Comments on Managerial Capacity:

C. Financial Capacity Assessment

30. Does the system have a budget?

YES ☐ NO ☐

If YES, what type of budget?

Operating Budget ☐

Capital Budget ☐

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

YES ☐ NO ☐

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

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

YES ☐ NO ☐

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

34. Are rates reviewed annually?

YES ☐ NO ☐

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

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

Operation & Maintenance ☐

Infrastructure Repair & replacement ☐

Staffing ☐

Emergency/Reserve fund ☐

Debt payment ☐

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

YES ☐ NO ☐

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

YES ☐ NO ☐

If yes, is this policy implemented?

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

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

[Convert to % of active connections

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

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

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

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

YES ☐ NO ☐

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

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

YES ☐ NO ☐

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

YES ☐ NO ☐

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

YES ☐ NO ☐

If yes, please describe.

41. Has the system ever had a financial audit?

YES ☐ NO ☐

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

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

Interviewer Comments on Financial Assessment:

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

APPENDIX B
COST BASIS

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

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

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

Unit costs for pipeline components are based on 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 $0.095 per kWH, as supplied by the City of Mason. 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
Falling Water Subdivision
PWS #1330154
General PWS Information

Service Population	768	**Number of Connections**	256
Total PWS Daily Water Usage	0.029 (mgd)	**Source**	2005 Report

Unit Cost Data
Central Texas

General Items	Unit	Unit Cost
Treated water purchase cost	*See alternative*	
Water purchase cost (trucked)	$/1,000 gals	$ 1.60
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, 06"	LF	$ 32
Bore and encasement, 10"	LF	$ 60
Open cut and encasement, 10"	LF	$ 35
Gate valve and box, 06"	EA	$ 490
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, 06"	EA	$ 4,000
Gate valve, 06"	EA	$ 590
Check valve, 06"	EA	$ 810
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	$ 0.095
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, IX	JOB	$ 50,000
Electrical, WRT Z-88	JOB	$ 50,000
Electrical, KMnO4	JOB	$ 50,000
Electrical GWUDI filtration	JOB	$ 20,000
Piping, IX	JOB	$ 20,000
Piping, WRT Z-88	JOB	$ 20,000
Piping, KMnO4	JOB	$ 20,000
Piping, GWUDI filtration	JOB	$ 10,000
IX package	UNIT	$ 100,000
WRT Z-88 package	UNIT	$ -
KMnO4 package	UNIT	$ 196,000
Transfer pumps (5 hp)	EA	$ 5,000
Sewer connection fee	EA	$ 15,000
Backwash tank	GAL	$ 2.00
Tank, 20,000 GAL	GAL	$ 1.00
Tank, 10,000 GAL	GAL	$ 1.50
Mixer on tank	EA	$ 15,000
Salt feeder	EA	$ 20,000
Excavation	CYD	$ 3.00
Compacted fill	CYD	$ 7.00
Lining	SF	$ 0.50
Vegetation	SY	$ 1.00
Access road	LF	$ 30
GWUDI Filter units	EA	$ 7,200
Turbidity meters	EA	$ 1,800
Blending controls	EA	$ 10,000
Building Power	kwh	$ 0.095
Equipment power	kwh	$ 0.095
Labor	hr	$ 40
IX Materials	year	$ 3,000
WRT Z-88 treated water	kgal	$ 1.00
KMnO4 Materials	year	$ 2,000
Backwash discharge to sewer	kgal	$ 5.00
Chemicals, IX	year	$ 3,000
Chemicals, KMnO4	year	$ 1,500
Analyses	test	$ 200
Spent media disposal	CY	$ 20
GWUDI cartridges, calibration	EA	$ 17,000
GWUDI calibration chem	EA	$ 400
Turbidity test	EA	$ 50
Truck rental	day	$ 700
Haul reject water	miles	$ 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.18. The cost estimates are conceptual in nature (+50%/-30%), and are intended for making comparisons between compliance options and to provide a preliminary indication of possible water rate impacts. Consequently, these costs are pre-planning level and should not be viewed as final estimated costs for alternative implementation.

Table C.1

PWS Name *Falling Water Subdivision*
Alternative Name *New Well at Westwood Park-Nickerson*
Alternative Number *FW-1*

Distance from PWS to new well location	10.55	miles
Estimated well depth	600	feet
Number of wells required	2	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	7	n/a	n/a	n/a
Number of Crossings, open cut	17	n/a	n/a	n/a
PVC water line, Class 200, 06"	55,699	LF	$ 32	$ 1,782,368
Bore and encasement, 10"	1,400	LF	$ 60	$ 84,000
Open cut and encasement, 10"	850	LF	$ 35	$ 29,750
Gate valve and box, 06"	11	EA	$ 490	$ 5,459
Air valve	11	EA	$ 1,000	$ 11,000
Flush valve	11	EA	$ 750	$ 8,355
Metal detectable tape	55,699	LF	$ 0.15	$ 8,355
Subtotal				**$ 1,929,286**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 06"	1	EA	$ 4,000	$ 4,000
Gate valve, 06"	4	EA	$ 590	$ 2,360
Check valve, 06"	2	EA	$ 810	$ 1,620
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 62,875**
Well Installation				
Well installation	1,200	LF	$ 25	$ 30,000
Water quality testing	4	EA	$ 1,500	$ 6,000
Well pump	2	EA	$ 7,500	$ 15,000
Well electrical/instrumentation	2	EA	$ 5,000	$ 10,000
Well cover and base	2	EA	$ 3,000	$ 6,000
Piping	2	EA	$ 2,500	$ 5,000
Subtotal				**$ 72,000**
Subtotal of Component Costs				**$ 2,064,161**
Contingency	20%			$ 412,832
Design & Constr Management	25%			$ 516,040
TOTAL CAPITAL COSTS				**$ 2,993,034**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	10.5	mile	$ 200	$ 2,110
Subtotal				**$ 2,110**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.095	$ 1,121
Pump Power	17,550	kWH	$ 0.095	$ 1,667
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 15,938**
Well O&M				
Pump power	2,229	kWH	$ 0.095	$ 212
Well O&M matl	2	EA	$ 1,200	$ 2,400
Well O&M labor	360	Hrs	$ 30	$ 10,800
Subtotal				**$ 13,412**
O&M Credit for Existing Well Closure				
Pump power	1,486	kWH	$ 0.095	$ (141)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,741)**
TOTAL ANNUAL O&M COSTS				**$ 24,719**

Table C.2

PWS Name *Falling Water Subdivision*
Alternative Name *New Well at Oak Ridge*
Alternative Number *FW-2*

Distance from PWS to new well location	15.78	miles
Estimated well depth	540	feet
Number of wells required	2	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	11	n/a	n/a	n/a
Number of Crossings, open cut	22	n/a	n/a	n/a
PVC water line, Class 200, 06"	83,339	LF	$ 32	$ 2,666,848
Bore and encasement, 10"	2,200	LF	$ 60	$ 132,000
Open cut and encasement, 10"	1,100	LF	$ 35	$ 38,500
Gate valve and box, 06"	17	EA	$ 490	$ 8,167
Air valve	16	EA	$ 1,000	$ 16,000
Flush valve	17	EA	$ 750	$ 12,501
Metal detectable tape	83,339	LF	$ 0.15	$ 12,501
Subtotal				**$ 2,886,517**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 06"	1	EA	$ 4,000	$ 4,000
Gate valve, 06"	4	EA	$ 590	$ 2,360
Check valve, 06"	2	EA	$ 810	$ 1,620
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 62,875**
Well Installation				
Well installation	1,080	LF	$ 25	$ 27,000
Water quality testing	4	EA	$ 1,500	$ 6,000
Well pump	2	EA	$ 7,500	$ 15,000
Well electrical/instrumentation	2	EA	$ 5,000	$ 10,000
Well cover and base	2	EA	$ 3,000	$ 6,000
Piping	2	EA	$ 2,500	$ 5,000
Subtotal				**$ 69,000**
Subtotal of Component Costs				**$ 3,018,392**
Contingency	20%			$ 603,678
Design & Constr Management	25%			$ 754,598
TOTAL CAPITAL COSTS				**$ 4,376,668**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	15.8	mile	$ 200	$ 3,157
Subtotal				**$ 3,157**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.095	$ 1,121
Pump Power	61,900	kWH	$ 0.095	$ 5,881
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 20,152**
Well O&M				
Pump power	2,006	kWH	$ 0.095	$ 191
Well O&M matl	2	EA	$ 1,200	$ 2,400
Well O&M labor	360	Hrs	$ 30	$ 10,800
Subtotal				**$ 13,391**
O&M Credit for Existing Well Closure				
Pump power	1,486	kWH	$ 0.095	$ (141)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,741)**
TOTAL ANNUAL O&M COSTS				**$ 29,958**

Table C.3

PWS Name ***Falling Water Subdivision***
Alternative Name ***New Well at Heritage Park***
Alternative Number ***FW-3***

Distance from PWS to new well location	17.97	miles
Estimated well depth	500	feet
Number of wells required	2	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	13	n/a	n/a	n/a
Number of Crossings, open cut	30	n/a	n/a	n/a
PVC water line, Class 200, 06"	94,886	LF	$ 32	$ 3,036,352
Bore and encasement, 10"	2,600	LF	$ 60	$ 156,000
Open cut and encasement, 10"	1,500	LF	$ 35	$ 52,500
Gate valve and box, 06"	19	EA	$ 490	$ 9,299
Air valve	18	EA	$ 1,000	$ 18,000
Flush valve	19	EA	$ 750	$ 14,233
Metal detectable tape	94,886	LF	$ 0.15	$ 14,233
Subtotal				**$ 3,300,617**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 06"	1	EA	$ 4,000	$ 4,000
Gate valve, 06"	4	EA	$ 590	$ 2,360
Check valve, 06"	2	EA	$ 810	$ 1,620
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 62,875**
Well Installation				
Well installation	1,000	LF	$ 25	$ 25,000
Water quality testing	4	EA	$ 1,500	$ 6,000
Well pump	2	EA	$ 7,500	$ 15,000
Well electrical/instrumentation	2	EA	$ 5,000	$ 10,000
Well cover and base	2	EA	$ 3,000	$ 6,000
Piping	2	EA	$ 2,500	$ 5,000
Subtotal				**$ 67,000**
Subtotal of Component Costs				**$ 3,430,492**
Contingency	20%			$ 686,098
Design & Constr Management	25%			$ 857,623
TOTAL CAPITAL COSTS				**$ 4,974,213**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	18.0	mile	$ 200	$ 3,594
Subtotal				**$ 3,594**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.095	$ 1,121
Pump Power	55,300	kWH	$ 0.095	$ 5,254
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 19,525**
Well O&M				
Pump power	1,857	kWH	$ 0.095	$ 176
Well O&M matl	2	EA	$ 1,200	$ 2,400
Well O&M labor	360	Hrs	$ 30	$ 10,800
Subtotal				**$ 13,376**
O&M Credit for Existing Well Closure				
Pump power	1,486	kWH	$ 0.095	$ (141)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,741)**
TOTAL ANNUAL O&M COSTS				**$ 29,754**

Table C.4

PWS Name *Falling Water Subdivision*
Alternative Name *New Well at Wilderness-Cherry Ridge*
Alternative Number *FW-4*

Distance from PWS to new well location	23.72	miles
Estimated well depth	700	feet
Number of wells required	2	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	3	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	13	n/a	n/a	n/a
Number of Crossings, open cut	21	n/a	n/a	n/a
PVC water line, Class 200, 06"	125,229	LF	$ 32	$ 4,007,328
Bore and encasement, 10"	2,600	LF	$ 60	$ 156,000
Open cut and encasement, 10"	1,050	LF	$ 35	$ 36,750
Gate valve and box, 06"	25	EA	$ 490	$ 12,272
Air valve	24	EA	$ 1,000	$ 24,000
Flush valve	25	EA	$ 750	$ 18,784
Metal detectable tape	125,229	LF	$ 0.15	$ 18,784
Subtotal				**$ 4,273,919**
Pump Station(s) Installation				
Pump	6	EA	$ 7,500	$ 45,000
Pump Station Piping, 06"	3	EA	$ 4,000	$ 12,000
Gate valve, 06"	12	EA	$ 590	$ 7,080
Check valve, 06"	6	EA	$ 810	$ 4,860
Electrical/Instrumentation	3	EA	$ 10,000	$ 30,000
Site work	3	EA	$ 2,000	$ 6,000
Building pad	3	EA	$ 4,000	$ 12,000
Pump Building	3	EA	$ 10,000	$ 30,000
Fence	3	EA	$ 5,870	$ 17,610
Tools	3	EA	$ 1,000	$ 3,000
Storage Tank - 5,000 gals	3	EA	$ 7,025	$ 21,075
Subtotal				**$ 188,625**
Well Installation				
Well installation	1,400	LF	$ 25	$ 35,000
Water quality testing	4	EA	$ 1,500	$ 6,000
Well pump	2	EA	$ 7,500	$ 15,000
Well electrical/instrumentation	2	EA	$ 5,000	$ 10,000
Well cover and base	2	EA	$ 3,000	$ 6,000
Piping	2	EA	$ 2,500	$ 5,000
Subtotal				**$ 77,000**
Subtotal of Component Costs				**$ 4,539,544**
Contingency	20%			$ 907,909
Design & Constr Management	25%			$ 1,134,886
TOTAL CAPITAL COSTS				**$ 6,582,339**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	23.7	mile	$ 200	$ 4,744
Subtotal				**$ 4,744**
Pump Station(s) O&M				
Building Power	35,400	kWH	$ 0.095	$ 3,363
Pump Power	133,250	kWH	$ 0.095	$ 12,659
Materials	3	EA	$ 1,200	$ 3,600
Labor	1,095	Hrs	$ 30	$ 32,850
Tank O&M	3	EA	$ 1,000	$ 3,000
Subtotal				**$ 55,472**
Well O&M				
Pump power	2,600	kWH	$ 0.095	$ 247
Well O&M matl	2	EA	$ 1,200	$ 2,400
Well O&M labor	360	Hrs	$ 30	$ 10,800
Subtotal				**$ 13,447**
O&M Credit for Existing Well Closure				
Pump power	1,486	kWH	$ 0.095	$ (141)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,741)**
TOTAL ANNUAL O&M COSTS				**$ 66,921**

Table C.5

PWS Name *Falling Water Subdivision*
Alternative Name *New Well at Scenic Valley*
Alternative Number *FW-5*

Distance from PWS to new well location	21.04	miles
Estimated well depth	400	feet
Number of wells required	2	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	2	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	12	n/a	n/a	n/a
Number of Crossings, open cut	15	n/a	n/a	n/a
PVC water line, Class 200, 06"	111,108	LF	$ 32	$ 3,555,456
Bore and encasement, 10"	2,400	LF	$ 60	$ 144,000
Open cut and encasement, 10"	750	LF	$ 35	$ 26,250
Gate valve and box, 06"	22	EA	$ 490	$ 10,889
Air valve	21	EA	$ 1,000	$ 21,000
Flush valve	22	EA	$ 750	$ 16,666
Metal detectable tape	111,108	LF	$ 0.15	$ 16,666
Subtotal				**$ 3,790,927**
Pump Station(s) Installation				
Pump	4	EA	$ 7,500	$ 30,000
Pump Station Piping, 06"	2	EA	$ 4,000	$ 8,000
Gate valve, 06"	8	EA	$ 590	$ 4,720
Check valve, 06"	4	EA	$ 810	$ 3,240
Electrical/Instrumentation	2	EA	$ 10,000	$ 20,000
Site work	2	EA	$ 2,000	$ 4,000
Building pad	2	EA	$ 4,000	$ 8,000
Pump Building	2	EA	$ 10,000	$ 20,000
Fence	2	EA	$ 5,870	$ 11,740
Tools	2	EA	$ 1,000	$ 2,000
Storage Tank - 5,000 gals	2	EA	$ 7,025	$ 14,050
Subtotal				**$ 125,750**
Well Installation				
Well installation	800	LF	$ 25	$ 20,000
Water quality testing	4	EA	$ 1,500	$ 6,000
Well pump	2	EA	$ 7,500	$ 15,000
Well electrical/instrumentation	2	EA	$ 5,000	$ 10,000
Well cover and base	2	EA	$ 3,000	$ 6,000
Piping	2	EA	$ 2,500	$ 5,000
Subtotal				**$ 62,000**
Subtotal of Component Costs				**$ 3,978,677**
Contingency	20%			$ 795,735
Design & Constr Management	25%			$ 994,669
TOTAL CAPITAL COSTS				**$ 5,769,082**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	21.0	mile	$ 200	$ 4,209
Subtotal				**$ 4,209**
Pump Station(s) O&M				
Building Power	23,600	kWH	$ 0.095	$ 2,242
Pump Power	94,150	kWH	$ 0.095	$ 8,944
Materials	2	EA	$ 1,200	$ 2,400
Labor	730	Hrs	$ 30	$ 21,900
Tank O&M	2	EA	$ 1,000	$ 2,000
Subtotal				**$ 37,486**
Well O&M				
Pump power	1,486	kWH	$ 0.095	$ 141
Well O&M matl	2	EA	$ 1,200	$ 2,400
Well O&M labor	360	Hrs	$ 30	$ 10,800
Subtotal				**$ 13,341**
O&M Credit for Existing Well Closure				
Pump power	1,486	kWH	$ 0.095	$ (141)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,741)**
TOTAL ANNUAL O&M COSTS				**$ 48,295**

Table C.6

PWS Name *Falling Water Subdivision*
Alternative Name *Purchase Water from City of Kerrville*
Alternative Number *FW-6*

Distance from Alternative to PWS (along pipe)	20.2	miles
Total PWS annual water usage	10.585	MG
Treated water purchase cost	$ 1.60	per 1,000 gals
Number of Pump Stations Needed	2	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	12	n/a	n/a	n/a
Number of Crossings, open cut	19	n/a	n/a	n/a
PVC water line, Class 200, 06"	106,396	LF	$ 32.00	$ 3,404,672
Bore and encasement, 10"	2,400	LF	$ 60.00	$ 144,000
Open cut and encasement, 10"	950	LF	$ 35.00	$ 33,250
Gate valve and box, 06"	21	EA	$ 490.00	$ 10,427
Air valve	20	EA	$ 1,000.00	$ 20,000
Flush valve	21	EA	$ 750.00	$ 15,959
Metal detectable tape	106,396	LF	$ 0.15	$ 15,959
Subtotal				**$ 3,644,268**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 06"	2	EA	$ 4,000	$ 8,000
Gate valve, 06"	8	EA	$ 590	$ 4,720
Check valve, 06"	4	EA	$ 810	$ 3,240
Electrical/Instrumentation	2	EA	$ 10,000	$ 20,000
Site work	2	EA	$ 2,000	$ 4,000
Building pad	2	EA	$ 4,000	$ 8,000
Pump Building	2	EA	$ 10,000	$ 20,000
Fence	2	EA	$ 5,870	$ 11,740
Tools	2	EA	$ 1,000	$ 2,000
Storage Tank - 5,000 gals	2	EA	$ 7,025	$ 14,050
Subtotal				**$ 110,750**
Subtotal of Component Costs				**$ 3,755,018**
Contingency	20%			$ 751,004
Design & Constr Management	25%			$ 938,754
TOTAL CAPITAL COSTS				**$ 5,444,776**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	20.2	mile	$ 200	$ 4,030
Subtotal				**$ 4,030**
Water Purchase Cost				
From Source	10,585	1,000 gal	$ 1.60	$ 16,936
Subtotal				**$ 16,936**
Pump Station(s) O&M				
Building Power	23,600	kWH	$ 0.095	$ 2,242
Pump Power	100,950	kWH	$ 0.095	$ 9,590
Materials	2	EA	$ 1,200	$ 2,400
Labor	730	Hrs	$ 30	$ 21,900
Tank O&M	2	EA	$ 1,000	$ 2,000
Subtotal				**$ 38,132**
O&M Credit for Existing Well Closure				
Pump power	1,486	kWH	$ 0.095	$ (141)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,741)**
TOTAL ANNUAL O&M COSTS				**$ 52,357**

Table C.7

PWS Name ***Falling Water Subdivision***
Alternative Name ***Purchase Water from City of Fredericksburg***
Alternative Number ***FW-7***

Distance from Alternative to PWS (along pipe)	16.9	miles
Total PWS annual water usage	10.585	MG
Treated water purchase cost	$ 1.65	per 1,000 gals
Number of Pump Stations Needed	2	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	9	n/a	n/a	n/a
Number of Crossings, open cut	27	n/a	n/a	n/a
PVC water line, Class 200, 06"	89,009	LF	$ 32.00	$ 2,848,288
Bore and encasement, 10"	1,800	LF	$ 60.00	$ 108,000
Open cut and encasement, 10"	1,350	LF	$ 35.00	$ 47,250
Gate valve and box, 06"	18	EA	$ 490.00	$ 8,723
Air valve	17	EA	$ 1,000.00	$ 17,000
Flush valve	18	EA	$ 750.00	$ 13,351
Metal detectable tape	89,009	LF	$ 0.15	$ 13,351
Subtotal				**$ 3,055,964**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 06"	2	EA	$ 4,000	$ 8,000
Gate valve, 06"	8	EA	$ 590	$ 4,720
Check valve, 06"	4	EA	$ 810	$ 3,240
Electrical/Instrumentation	2	EA	$ 10,000	$ 20,000
Site work	2	EA	$ 2,000	$ 4,000
Building pad	2	EA	$ 4,000	$ 8,000
Pump Building	2	EA	$ 10,000	$ 20,000
Fence	2	EA	$ 5,870	$ 11,740
Tools	2	EA	$ 1,000	$ 2,000
Storage Tank - 5,000 gals	2	EA	$ 7,025	$ 14,050
Subtotal				**$ 110,750**
Subtotal of Component Costs				**$ 3,166,714**
Contingency	20%			$ 633,343
Design & Constr Management	25%			$ 791,678
TOTAL CAPITAL COSTS				**$ 4,591,735**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	16.9	mile	$ 200	$ 3,372
Subtotal				**$ 3,372**
Water Purchase Cost				
From Source	10,585	1,000 ga	$ 1.65	$ 17,465
Subtotal				**$ 17,465**
Pump Station(s) O&M				
Building Power	23,600	kWH	$ 0.095	$ 2,242
Pump Power	60,600	kWH	$ 0.095	$ 5,757
Materials	2	EA	$ 1,200	$ 2,400
Labor	730	Hrs	$ 30	$ 21,900
Tank O&M	2	EA	$ 1,000	$ 2,000
Subtotal				**$ 34,299**
O&M Credit for Existing Well Closure				
Pump power	1,486	kWH	$ 0.095	$ (141)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,741)**
TOTAL ANNUAL O&M COSTS				**$ 48,395**

Table C.8

PWS Name *Falling Water Subdivision*
Alternative Name *Central Treatment - IX*
Alternative Number *FW-8*

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Central-IX				
Site preparation	0.5	acre	$ 4,000	$ 2,000
Slab	15	CY	$ 1,000	$ 15,000
Building	400	SF	$ 60	$ 24,000
Building electrical	400	SF	$ 8.00	$ 3,200
Building plumbing	400	SF	$ 8.00	$ 3,200
Heating and ventilation	400	SF	$ 7.00	$ 2,800
Fence	300	LF	$ 15	$ 4,500
Paving	1,600	SF	$ 2.00	$ 3,200
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 20,000	$ 20,000
IX package including:				
Regeneration system				
Brine tank				
IX resins & vessels	1	UNIT	$ 100,000	$ 100,000
Transfer pumps (5 hp)	2	EA	$ 5,000	$ 10,000
Clean water tank	20,000	GAL	$ 1.00	$ 20,000
Regenerant tank	10,000	GAL	$ 1.50	$ 15,000
Backwash tank	10,000	GAL	$ 2.00	$ 20,000
Sewer Connection Fee	1	EA	$ 15,000	$ 15,000
Subtotal				**$ 307,900**
Contingency	20%			61,580
Design & CM	25%			76,975
Total				**$ 446,455**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
Building Power	6,000	kwh/yr	$ 0.095	$ 570
Equipment power	15000	kwh/yr	$ 0.095	$ 1,425
Labor	1,000	hrs/yr	$ 40	$ 40,000
Materials	1	year	$ 3,000	$ 3,000
Chemicals	1	year	$ 3,000	$ 3,000
Analyses	24	test	$ 200	$ 4,800
Haul backwash and brine				
Truck rental	8.4	days	$ 700	$ 5,880
Mileage charge	504	miles	$ 1.00	$ 504
Subtotal				**$ 59,179**
Total				**$ 59,179**

Table C.9

PWS Name ***Falling Water Subdivision***
Alternative Name ***Central Treatment - WRT Z-88***
Alternative Number ***FW-9***

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Central-WRT Z-88				
Site preparation	0.50	acre	$ 4,000	$ 2,000
Slab	15	CY	$ 1,000	$ 15,000
Building	400	SF	$ 60	$ 24,000
Building electrical	400	SF	$ 8.00	$ 3,200
Building plumbing	400	SF	$ 8.00	$ 3,200
Heating and ventilation	400	SF	$ 7.00	$ 2,800
Fence	300	LF	$ 15	$ 4,500
Paving	1,600	SF	$ 2.00	$ 3,200
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 20,000	$ 20,000
WRT Z-88 package including:				
Z-88 vessels				
Adsorption media	1	UNIT	$ -	$ -
Subtotal				**$ 127,900**
Contingency	20%			$ 25,580
Design & CM	25%			$ 31,975
Total				**$ 185,455**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
Building Power	6,000	kwh/yr	$ 0.095	$ 570
Equipment power	1,000	kwh/yr	$ 0.095	$ 95
Labor	500	hrs/yr	$ 40	$ 20,000
Analyses	24	test	$ 200	$ 4,800
WRT treated water	42,000	kgal/yr	$ 1.00	$ 42,000
Subtotal				**$ 67,465**
Total				**$ 67,465**

Table C.10

PWS Name *Falling Water Subdivision*
Alternative Name *Central Treatment - KMnO4*
Alternative Number *FW-10*

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Central-$KMnO_4$-Greensand				
Site preparation	0.50	acre	$ 4,000	$ 2,000
Slab	15	CY	$ 1,000	$ 15,000
Building	400	SF	$ 60	$ 24,000
Building electrical	400	SF	$ 8.00	$ 3,200
Building plumbing	400	SF	$ 8.00	$ 3,200
Heating and ventilation	400	SF	$ 7.00	$ 2,800
Fence	300	LF	$ 15	$ 4,500
Paving	1,600	SF	$ 2.00	$ 3,200
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 20,000	$ 20,000
$KMnO_4$-Greensand package including:				
Greensand filters				
Solution tank	1	UNIT	$ 196,000	$ 196,000
Backwash Tank	10,000	GAL	$ 2.00	$ 20,000
Sewer Connection Fee	1	EA	$ 15,000	$ 15,000
Subtotal				**$ 358,900**
Contingency	20%			$ 71,780
Design & CM	25%			$ 89,725
Total				**$ 520,405**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
Building Power	6,000	kwh/yr	$ 0.095	$ 570
Equipment power	1,000	kwh/yr	$ 0.095	$ 95
Labor	1,000	hrs/yr	$ 40	$ 40,000
Materials	1	year	$ 2,000	$ 2,000
Chemicals	1	year	$ 1,500	$ 1,500
Analyses	24	test	$ 200	$ 4,800
Subtotal				**$ 48,965**
Sludge Disposal				
Truck rental	6.3	days	$ 700	$ 4,382
Mileage	376	miles	$ 1.00	$ 376
Disposal fee	31.3	kgal/yr	$ 5.00	$ 157
Subtotal				**$ 4,914**
Total				**$ 53,879**

Table C.11

PWS Name ***Falling Water Subdivision***
Alternative Name ***Point-of-Use Treatment***
Alternative Number ***FW-11***

Number of Connections for POU Unit Installation 256

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POU-Treatment - Purchase/Installation				
POU treatment unit purchase	256	EA	$ 250	$ 64,000
POU treatment unit installation	256	EA	$ 150	$ 38,400
Subtotal				**$ 102,400**
Subtotal of Component Costs				**$ 102,400**
Contingency	20%			$ 20,480
Design & Constr Management	25%			$ 25,600
Procurement & Administration	20%			$ 20,480
TOTAL CAPITAL COSTS				**$ 168,960**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POU materials, per unit	256	EA	$ 225	$ 57,600
Contaminant analysis, 1/yr p	256	EA	$ 100	$ 25,600
Program labor, 10 hrs/unit	2,560	hrs	$ 30	$ 76,800
Subtotal				**$ 160,000**
TOTAL ANNUAL O&M COSTS				**$ 160,000**

Table C.12

PWS Name ***Falling Water Subdivision***
Alternative Name ***Point-of-Entry Treatment***
Alternative Number ***FW-12***

Number of Connections for POE Unit Installation 256

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POE-Treatment - Purchase/Installation				
POE treatment unit purchase	256	EA	$ 3,000	$ 768,000
Pad and shed, per unit	256	EA	$ 2,000	$ 512,000
Piping connection, per unit	256	EA	$ 1,000	$ 256,000
Electrical hook-up, per unit	256	EA	$ 1,000	$ 256,000
Subtotal				**$1,792,000**
Subtotal of Component Costs				**$1,792,000**
Contingency	20%			$ 358,400
Design & Constr Management	25%			$ 448,000
Procurement & Administration	20%			$ 358,400
TOTAL CAPITAL COSTS				**$2,956,800**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POE materials, per unit	256	EA	$ 1,000	$ 256,000
Contaminant analysis, 1/yr per unit	256	EA	$ 100	$ 25,600
Program labor, 10 hrs/unit	2,560	hrs	$ 30	$ 76,800
Subtotal				**$ 358,400**
TOTAL ANNUAL O&M COSTS				**$ 358,400**

Table C.13

PWS Name	***Falling Water Subdivision***
Alternative Name	***New Well at 10 Miles***
Alternative Number	***FW-13***

Distance from PWS to new well location	10.0	miles
Estimated well depth	400	feet
Number of wells required	2	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	6	n/a	n/a	n/a
Number of Crossings, open cut	12	n/a	n/a	n/a
PVC water line, Class 200, 06"	52,800	LF	$ 32	$ 1,689,600
Bore and encasement, 10"	1,200	LF	$ 60	$ 72,000
Open cut and encasement, 10"	600	LF	$ 35	$ 21,000
Gate valve and box, 06"	11	EA	$ 490	$ 5,174
Air valve	10	EA	$ 1,000	$ 10,000
Flush valve	11	EA	$ 750	$ 7,920
Metal detectable tape	52,800	LF	$ 0.15	$ 7,920
Subtotal				**$ 1,813,614**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 06"	1	EA	$ 4,000	$ 4,000
Gate valve, 06"	4	EA	$ 590	$ 2,360
Check valve, 06"	2	EA	$ 810	$ 1,620
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 62,875**
Well Installation				
Well installation	800	LF	$ 25	$ 20,000
Water quality testing	4	EA	$ 1,500	$ 6,000
Well pump	2	EA	$ 7,500	$ 15,000
Well electrical/instrumentation	2	EA	$ 5,000	$ 10,000
Well cover and base	2	EA	$ 3,000	$ 6,000
Piping	2	EA	$ 2,500	$ 5,000
Subtotal				**$ 62,000**
Subtotal of Component Costs				**$ 1,938,489**
Contingency	20%			$ 387,698
Design & Constr Management	25%			$ 484,622
TOTAL CAPITAL COSTS				**$ 2,810,810**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	10.0	mile	$ 200	$ 2,000
Subtotal				**$ 2,000**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.095	$ 1,121
Pump Power	41,539	kWH	$ 0.095	$ 3,946
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 18,217**
Well O&M				
Pump power	1,486	kWH	$ 0.095	$ 141
Well O&M matl	2	EA	$ 1,200	$ 2,400
Well O&M labor	360	Hrs	$ 30	$ 10,800
Subtotal				**$ 13,341**
O&M Credit for Existing Well Closure				
Pump power	1,486	kWH	$ 0.095	$ (141)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,741)**
TOTAL ANNUAL O&M COSTS				**$ 26,817**

Table C.14

PWS Name *Falling Water Subdivision*
Alternative Name *New Well at 5 Miles*
Alternative Number *FW-14*

Distance from PWS to new well location	5.0	miles
Estimated well depth	400	feet
Number of wells required	2	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	3	n/a	n/a	n/a
Number of Crossings, open cut	6	n/a	n/a	n/a
PVC water line, Class 200, 06"	26,400	LF	$ 32	$ 844,800
Bore and encasement, 10"	1,800	LF	$ 60	$ 108,000
Open cut and encasement, 10"	100	LF	$ 35	$ 3,500
Gate valve and box, 06"	5	EA	$ 490	$ 2,587
Air valve	5	EA	$ 1,000	$ 5,000
Flush valve	5	EA	$ 750	$ 3,960
Metal detectable tape	26,400	LF	$ 0.15	$ 3,960
Subtotal				**$ 971,807**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 06"	1	EA	$ 4,000	$ 4,000
Gate valve, 06"	4	EA	$ 590	$ 2,360
Check valve, 06"	2	EA	$ 810	$ 1,620
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 62,875**
Well Installation				
Well installation	800	LF	$ 25	$ 20,000
Water quality testing	4	EA	$ 1,500	$ 6,000
Well pump	2	EA	$ 7,500	$ 15,000
Well electrical/instrumentation	2	EA	$ 5,000	$ 10,000
Well cover and base	2	EA	$ 3,000	$ 6,000
Piping	2	EA	$ 2,500	$ 5,000
Subtotal				**$ 62,000**
Subtotal of Component Costs				**$ 1,096,682**
Contingency	20%			$ 219,336
Design & Constr Management	25%			$ 274,171
TOTAL CAPITAL COSTS				**$ 1,590,189**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	5.0	mile	$ 200	$ 1,000
Subtotal				**$ 1,000**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.095	$ 1,121
Pump Power	20,770	kWH	$ 0.095	$ 1,973
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 16,244**
Well O&M				
Pump power	1,486	kWH	$ 0.095	$ 141
Well O&M matl	2	EA	$ 1,200	$ 2,400
Well O&M labor	360	Hrs	$ 30	$ 10,800
Subtotal				**$ 13,341**
O&M Credit for Existing Well Closure				
Pump power	1,486	kWH	$ 0.095	$ (141)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,741)**
TOTAL ANNUAL O&M COSTS				**$ 23,844**

Table C.15

PWS Name *Falling Water Subdivision*
Alternative Name *New Well at 1 Mile*
Alternative Number *FW-15*

Distance from PWS to new well location	1.0	miles
Estimated well depth	400	feet
Number of wells required	2	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	0	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	1	n/a	n/a	n/a
Number of Crossings, open cut	1	n/a	n/a	n/a
PVC water line, Class 200, 06"	5,280	LF	$ 32	$ 168,960
Bore and encasement, 10"	200	LF	$ 60	$ 12,000
Open cut and encasement, 10"	50	LF	$ 35	$ 1,750
Gate valve and box, 06"	1	EA	$ 490	$ 517
Air valve	1.00	EA	$ 1,000	$ 1,000
Flush valve	1	EA	$ 750	$ 792
Metal detectable tape	5,280	LF	$ 0.15	$ 792
Subtotal				**$ 185,811**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 06"	-	EA	$ 4,000	$ -
Gate valve, 06"	-	EA	$ 590	$ -
Check valve, 06"	-	EA	$ 810	$ -
Electrical/Instrumentation	-	EA	$ 10,000	$ -
Site work	-	EA	$ 2,000	$ -
Building pad	-	EA	$ 4,000	$ -
Pump Building	-	EA	$ 10,000	$ -
Fence	-	EA	$ 5,870	$ -
Tools	-	EA	$ 1,000	$ -
Storage Tank - 5,000 gals	-	EA	$ 7,025	$ -
Subtotal				**$ -**
Well Installation				
Well installation	800	LF	$ 25	$ 20,000
Water quality testing	4	EA	$ 1,500	$ 6,000
Well pump	2	EA	$ 7,500	$ 15,000
Well electrical/instrumentation	2	EA	$ 5,000	$ 10,000
Well cover and base	2	EA	$ 3,000	$ 6,000
Piping	2	EA	$ 2,500	$ 5,000
Subtotal				**$ 62,000**
Subtotal of Component Costs				**$ 247,811**
Contingency	20%			$ 49,562
Design & Constr Management	25%			$ 61,953
TOTAL CAPITAL COSTS				**$ 359,327**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	1.0	mile	$ 200	$ 200
Subtotal				**$ 200**
Pump Station(s) O&M				
Building Power	-	kWH	$ 0.095	$ -
Pump Power	-	kWH	$ 0.095	$ -
Materials	-	EA	$ 1,200	$ -
Labor	-	Hrs	$ 30	$ -
Tank O&M	-	EA	$ 1,000	$ -
Subtotal				**$ -**
Well O&M				
Pump power	1,486	kWH	$ 0.095	$ 141
Well O&M matl	2	EA	$ 1,200	$ 2,400
Well O&M labor	360	Hrs	$ 30	$ 10,800
Subtotal				**$ 13,341**
O&M Credit for Existing Well Closure				
Pump power	1,486	kWH	$ 0.095	$ (141)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,741)**
TOTAL ANNUAL O&M COSTS				**$ 6,800**

Table C.16

PWS Name ***Falling Water Subdivision***
Alternative Name ***Public Dispenser for Treated Drinking Water***
Alternative Number ***FW-16***

Number of Treatment Units Recommended 1

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Public Dispenser Unit Installation				
POE-Treatment unit(s)	1	EA	$ 3,000	$ 3,000
Unit installation costs	1	EA	$ 5,000	$ 5,000
Subtotal				**$ 8,000**
Subtotal of Component Costs				**$ 8,000**
Contingency	20%			$ 1,600
Design & Constr Manageme	25%			$ 2,000
TOTAL CAPITAL COSTS				**11,600**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Treatment unit O&M, 1 per unit	1	EA	$ 500	$ 500
Contaminant analysis, 1/wk per unit	52	EA	$ 100	$ 5,200
Sampling/reporting, 1 hr/day	365	HRS	$ 30	$ 10,950
Subtotal				**$ 16,650**
TOTAL ANNUAL O&M COSTS				**$ 16,650**

Table C.17

PWS Name *Falling Water Subdivision*
Alternative Name *Supply Bottled Water to Population*
Alternative Number *FW-17*

Service Population	768	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	280,320	gallons

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Implementation				
Initial program set-up	500	hours	$ 40	$ 19,950
Subtotal				**$ 19,950**
Subtotal of Component Costs				**$ 19,950**
Contingency	20%			$ 3,990
TOTAL CAPITAL COSTS				**$ 23,940**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water purchase costs	280,320	gals	$ 1.60	$ 448,512
Program admin, 9 hrs/wk	468	hours	$ 40	$ 18,673
Program materials	1	EA	$ 5,000	$ 5,000
Subtotal				**$ 472,185**
TOTAL ANNUAL O&M COSTS				**$ 472,185**

Table C.18

PWS Name	***Falling Water Subdivision***
Alternative Name	***Central Trucked Drinking Water***
Alternative Number	***FW-18***

Service Population	768	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	280,320	gallons
Travel distance to compliant water source (roundtrip)	22	miles

Capital Costs

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

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water delivery labor, 4 hrs/wk	208	hrs	$ 30	$ 6,240
Truck operation, 1 round trip/wk	1,144	miles	$ 1.00	$ 1,144
Water purchase	280	1,000 g	$ 1.60	$ 449
Water testing, 1 test/wk	52	EA	$ 100	$ 5,200
Sampling/reporting, 2 hrs/wk	104	hrs	$ 30	$ 3,120
Subtotal				**$ 16,153**
TOTAL ANNUAL O&M COSTS				**$ 16,153**

APPENDIX D
EXAMPLE FINANCIAL MODEL

Table D.1 Example Financial Model

Step 1

Water System: Falling Water Subdivision

Step 2

Click Here to Update Verification and Raw

Water System	Falling Water Subdivision
Alternative Description	New Well at 1 Mile

Sum of Amount		Year	Funding Alternative
		2007	
Group	Type	100% Grant	Bond
Capital Expenditures	Capital Expenditures-Funded from Bonds	$ -	$ 359,327
	Capital Expenditures-Funded from Grants	$ 359,327	$ -
	Capital Expenditures-Funded from Revenue/Reserves	$ -	$ -
	Capital Expenditures-Funded from SRF Loans	$ -	$ -
Capital Expenditures Sum		$ 359,327	$ 359,327
Debt Service	Revenue Bonds	$ -	$ 28,109
	State Revolving Funds	$ -	$ -
Debt Service Sum		$ -	$ 28,109
Non-Operating Income/Exper	Other Expense	$ 1,490	$ 1,490
Non-Operating Income/Expenditures Sum		$ 1,490	$ 1,490
Operating Expenditures	Administrative Expenses	$ 1,744	$ 1,744
	Chemicals, Treatment	$ 698	$ 698
	Contract Labor	$ 343	$ 343
	Insurance	$ 664	$ 664
	Other Operating Expenditures 1	$ 4,153	$ 4,153
	Other Operating Expenditures 2	$ 6,639	$ 6,639
	Repairs	$ 1,331	$ 1,331
	Salaries & Benefits	$ 6,641	$ 6,641
	Supplies	$ 1,331	$ 1,331
	Utilities	$ 2,860	$ 2,860
	Maintenance	$ 1,331	$ 1,331
	Accounting and Legal Fees	$ 688	$ 688
	Other Operating Expenditures 3	$ 8,121	$ 8,121
	Other Operating Expenditures 4	$ 638	$ 638
Operating Expenditures Sum		$ 37,181	$ 37,181
Residential Operating Revenu	Residential Base Monthly Rate	$ 14,647	$ 14,647
	Residential Tier 1 Monthly Rate	$ 25,536	$ 25,536
	Residential Tier2 Monthly Rate	$ 7,455	$ 7,455
	Residential Tier3 Monthly Rate	$ -	$ -
	Residential Tier4 Monthly Rate	$ -	$ -
	Residential Unmetered Monthly Rate	$ -	$ -
Residential Operating Revenues Sum		$ 47,638	$ 47,638

Location_Name	Falling Water Subdivision
Alt_Desc	Central Treatment - IX

		Current_Year
Funding_Alt	Data	2007
100% Grant	Sum of Beginning_Cash_Bal	$ 9,362
	Sum of Total_Expenditures	$ 483,636
	Sum of Total_Receipts	$ 494,093
	Sum of Net_Cash_Flow	$ 10,457
	Sum of Ending_Cash_Bal	$ 19,819
	Sum of Working_Cap	$ -
	Sum of Repl_Resv	$ 1,095
	Sum of Total_Reqd_Resv	$ 1,095
	Sum of Net_Avail_Bal	$ 18,724
	Sum of Add_Resv_Needed	$ -
	Sum of Rate_Inc_Needed	0%
	Sum of Percent_Rate_Increase	0%
Bond	Sum of Beginning_Cash_Bal	$ 9,362
	Sum of Total_Expenditures	$ 518,561
	Sum of Total_Receipts	$ 494,093
	Sum of Net_Cash_Flow	$ (24,468)
	Sum of Ending_Cash_Bal	$ (15,105)
	Sum of Working_Cap	$ -
	Sum of Repl_Resv	$ 1,095
	Sum of Total_Reqd_Resv	$ 1,095
	Sum of Net_Avail_Bal	$ (16,200)
	Sum of Add_Resv_Needed	$ (16,200)
	Sum of Rate_Inc_Needed	34%
	Sum of Percent_Rate_Increase	0%

APPENDIX E
RADIONUCLIDE GEOCHEMISTRY

Radionuclide impact on water quality is measured according to two scales: intrinsic measurement of radioactivity and impact on human beings. Activity or number of disintegrations per unit time is typically measured in pico Curies (pCi), whereas impact on living organisms is measured in mrem. Radioactive decay can generate alpha or beta particles, as well as gamma rays. Two radioactive elements with the same activity may have vastly different impacts on life, depending on the energy released during decay. Each radionuclide has a conversion factor from pCi to mrem as a function of exposure pathway. Activity is related to contaminant concentration and half-life. A higher concentration and a shorter half-life lead to increased activity. Given the ratio of the half-life of each (Table E.1), it is apparent that radium is approximately 1 million times more radioactive than uranium. Concentrations of gross alpha and beta emitters take into account the whole decay series and not just uranium and radium, as well as other elements such as K 40.

Uranium and thorium (atomic numbers 92 and 90, respectively), both radium sources, are common trace elements and have a crustal abundance of 2.6 and 10 ppm, respectively. They are abundant in acidic rocks. A study of the Cambrian aquifers in the Llano Uplift area suggests an average whole-rock concentration of 4 and 14 ppm for uranium and thorium, respectively (Kim, *et al*. 1995). Uranium and thorium do not fit readily into the structure of rock-forming minerals and are concentrated in melt during the series of fractionations leading to major rock types (acidic, intermediate, basic). Intrusive rocks such as granites will partly sequester uranium and thorium in erosion-resistant accessory minerals (*e.g.*, monazite, thorite), whereas uranium in volcanic rocks is much more labile and can be leached by surface and groundwater. Lattice substitution in minerals (*e.g.*, Ca^{+2} and U^{+4}, have almost the same ionic radius), as well as micrograins of uranium and thorium minerals, are other possibilities. In sedimentary rocks, uranium and thorium aqueous concentrations are controlled mainly by the sorbing potential of the rocks (metal oxides, clays, and organic matter). In the Cambrian aquifers of Central Texas, uranium concentrations are high in accessory minerals and cannot readily be mobilized. Uranium is also present in phosphatic and hematitic cements (Kim, *et al*. 1995), with which the aqueous concentration is most likely in equilibrium.

The geochemistry of uranium is complicated but can be summarized by the following. Uranium(VI) in oxidizing conditions exists as the soluble positively charged uranyl UO_2^{+2}. Solubility is higher at acid pHs, decreases at neutral pHs, and increases at alkaline pHs. The uranyl ion can easily form aqueous complexes, including with hydroxyl, fluoride, carbonate, and phosphate ligands. Hence, in the presence of carbonates, uranium solubility is considerably enhanced in the form of uranyl-carbonate (UO_2CO_3) and other higher order carbonate complexes: uranyl-di-carbonate ($UO_2(CO_3)_2^{-2}$ and uranyl-tri-carbonates $UO_2(CO_3)_3^{-4}$). Adsorption of uranium is inversely related to its solubility and is highest at neutral pH's (De Soto 1978). Uranium sorbs strongly to metal oxides and clays. Uranium(IV) is the other commonly found redox state. In that state, however, uranium is not very soluble and precipitates as uraninite, UO_2, coffinite,

$USiO_4.nH_2O$ (if SiO_2>60 mg/L, Henry, *et al*. 1982, p.18), or related minerals. In most aquifers, no mineral controls uranium solubility in oxidizing conditions. However, uranite and coffinite are the controlling minerals if Eh drops below 0-100 mV.

Thorium exists naturally only in one redox state Th(IV). Th^{+4} forms complexes with most common aqueous anions. However, thorium solubility remains low except perhaps at higher pH when complexed by carbonate ions (USEPA 1999). Thorium sorbs strongly to metal oxides in a way similar to uranium.

Radium has an atomic number of 88. Radium originates from the radioactive decay of uranium and thorium. Ra226 is an intermediate product of U238 (the most common uranium isotope >99%, Table A-1) decay, whereas Ra228 belongs to the Th232 (~100% of natural thorium) decay series. Both radium isotopes further decay to radon and, ultimately, to lead. Radon is a gas and tends to volatilize from shallower units. Ra223 and Ra224 isotopes are also naturally present but in minute quantities. Ra224 belongs to the thorium decay series, whereas Ra223 derives from the much rarer U235 (~0.7%). Radium is an alkaline Earth element and belongs to the same group (2A in periodic table) as magnesium, calcium, strontium, and barium. It most resembles barium chemically, as evidenced by removal technologies such as ion exchange with Na and lime softening. Sorption on iron and manganese oxides is also a common trait of alkaline Earth elements. Radium exists only under one oxidation state, the divalent cation Ra^{+2}, similar to other alkaline Earth elements (Ca^{+2}, Mg^{+2}, Sr^{+2}, and Ba^{+2}). $RaSO_4$ is extremely insoluble (more so than barium sulfate), with a log K solubility product of -10.5, compared to that of barium sulfate at ~-10. Radium solubility is mostly controlled by sulfate activity.

Table E.1 Uranium, Thorium, and Radium Abundance and Half-Lives

Decay series	Uranium/thorium	Radium	Radon
U238	U238 – ~99.3% (4.47×10^9 yrs)	Ra226 - (1,599 yrs)	Rn222 - (3.8 days)
	U234 – 0.0055% (0.246×10^9 yrs)	Intermediate product of U238 decay	
U235	U235 - ~0.7% (0.72×10^9 yrs)	Ra223 – (11.4 days)	Rn219 - (4 seconds)
Th232	Th232 – ~100% (14.0×10^9 yrs)	Ra228 - (5.76 yrs) Ra224 - (3.7 days)	Rn220 - (~1 min)

NOTE: half-life from Parrington et al. (1996)

EPA Maximum Contaminant Levels

- Uranium: 30 ppb
- Gross alpha: 15 pCi/L
- Beta particles and photon emitters: 4 mrem/yr
- Radium 226 and radium 228: 5 pCi/L

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