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

CITY OF MELVIN
PWS ID# 1540003, CCN# P0727

Prepared for:

THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Prepared by:

THE UNIVERSITY OF TEXAS BUREAU OF ECONOMIC GEOLOGY

AND

PARSONS

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

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AUGUST 2006

EXECUTIVE SUMMARY

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 analysis report provides an evaluation of water supply alternatives for the City of Melvin PWS, ID# 1540003, Certificate of Convenience and Necessity (CCN) # P0727, located in McCulloch County, Texas (the City of Melvin PWS). The City of Melvin PWS recorded sample results above MCLs for combined radium (radium 226 and radium 228) and gross alpha particle activity (gross alpha). The MCLs are 5 picoCuries per liter (pCi/L) for combined radium and 15 pCi/L for gross alpha. Sample results for combined radium were recorded for the period November 1999 to November 2004 and ranged from 8.0 to 11.0 pCi/L (above the MCL of 5 pCi/L). Sample results for gross alpha were recorded for the period August 2001 through November 2004 and ranged from 19.7 to 30.9 pCi/L (above the MCL of 15 pCi/L). Radium and gross alpha are members of the radionuclides group. The PWS also recorded concentrations of iron above the secondary drinking water standard of 0.3 milligrams per liter (mg/L). Iron concentrations ranged from 0.427 to 0.55 mg/L for sample results recorded between March 1998 and November 2004.

Basic system information for the City of Melvin PWS is shown in Table ES.1.

Table ES.1
City of Melvin PWS
Basic System Information

Population served	200
Connections	126
Average daily flow rate	0.019 million gallons per day (mgd)
Peak demand flow rate	0.076 mgd
Water system peak capacity	0.164 mgd
Combined radium results	8.0 – 11.0 pCi/L
Gross alpha results	19.7 – 30.9 pCi/L
Iron results	0.427 – 0.55 mg/L

STUDY METHODS

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

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

1. Gather data from the TCEQ and Texas Water Development Board databases, from TCEQ files, and from information maintained by the PWS;

2. Conduct financial, managerial, and technical (FMT) evaluations of the PWS;

3. Perform a geologic and hydrogeologic assessment of the study area (the City of Melvin PWS groundwater supply is the Wilberns formation of the Ellenburger-San Saba aquifer – the system includes one operational well in the Cambrian System, and one backup well in the Point Peak Shale Member of Wilberns formation);

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 City of Melvin PWS groundwater supply is the Wilberns formation of the Ellenburger-San Saba aquifer. The system includes one operational well in the Cambrian System, and one backup well in the Point Peak Shale Member of Wilberns formation. Since radionuclide concentrations can vary between well that are relatively close to each other and most of the routine monitoring data is from the active well, samples were collected and analyzed from both of the City of Melvin wells to investigate whether the backup well might have better water quality. The sample results did not suggest the backup well would produce compliant water. It may be possible to do down-hole testing on the 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 City of Melvin PWS serves approximately 200 people through 126 connections. Overall, the system had an inadequate 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 positive aspects, including knowledgeable and dedicated staff. Areas of concern for the system included lack of compliance, inability to fully cover operating expenses, inadequate rate setting process, leaking storage tank, and water losses.

There are several PWSs within 30 miles of the City of Melvin. Many of these nearby systems also have problems with radionuclides, 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 City of Melvin PWS well field.

A number of centralized treatment alternatives for radionuclide removal have been developed and were considered for this report, including ion exchange, Water Remediation Technologies, Inc. (WRT) adsorption, and $KMnO_4$ greensand 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 near the City of Melvin would likely be an attractive solution if compliant groundwater can be found. It should be noted that few wells with good quality water were found within 5 mile of the City of Melvin. Having a new well located near the City of Melvin would likely be one of the lower cost alternatives since the City of Melvin 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. A significant effort is required for clients to fill their containers at the central dispenser.

FINANCIAL ANALYSIS

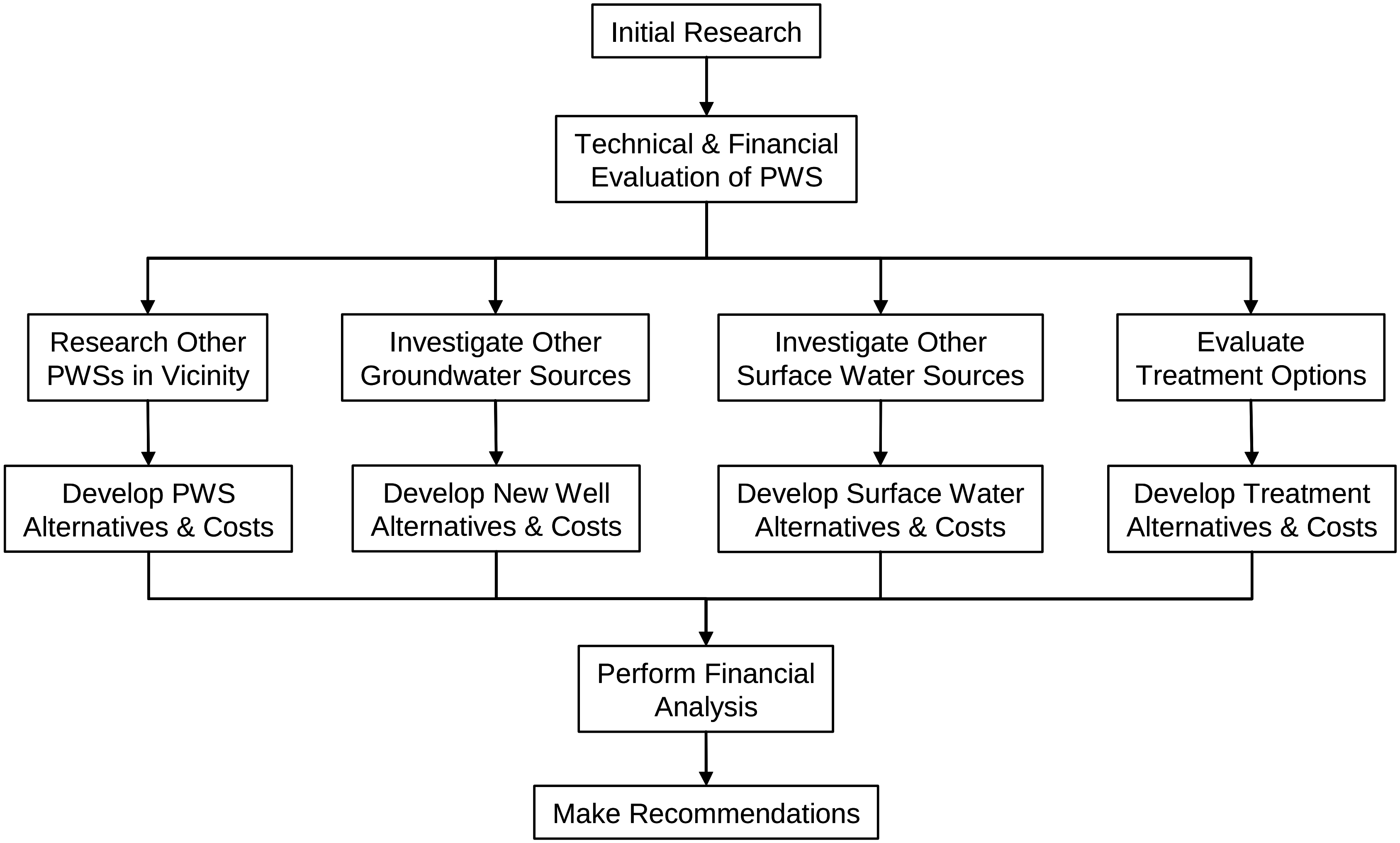
Financial analysis of the City of Melvin PWS indicated that current water rates are funding operations, and are also funding other services provided by the City. A rate increase or finding other funding sources for the City would likely be required for implementation of a compliance alternative. The current average water bill of $329 represents approximately 1.4 percent of the median household income (MHI). Table ES.2 provides a summary of the financial impact of implementing selected compliance alternatives, including the rate increase necessary to meet current operating expenses. The alternatives were selected to highlight results for the best alternatives from each different type or category.

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

Table ES.2
Selected Financial Analysis Results

Alternative	Funding Option	Average Annual Water Bill	Percent of MHI
Current	NA	$329	1.4
Purchase water from Millerview-Doole	100% Grant	$486	2.1
	Loan/Bond	$940	4.0
Central treatment – WRT Z-88	100% Grant	$606	2.6
	Loan/Bond	$800	3.4
Point-of-use	100% Grant	$991	4.2
	Loan/Bond	$1,045	4.4

Figure ES-1
Summary of Project Methods



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ACRONYMS AND ABBREVIATIONS

μ/L	micrograms per liter
AFY	acre-feet per year
BEG	Bureau of Economic Geology
BV	bed volume
CA	chemical analysis
CCN	Certificate of Convenience and Necessity
CCR	Consumer Credit Report
CFR	Code of Federal Regulations
CO	Correspondence
ED	Electrodialysis
EDR	electrodialysis reversal
FM	farm-to-market road
FMT	financial, managerial, and technical
ft^2	square foot
GAM	Groundwater Availability Model
gpm	gallons per minute
IX	Ion exchange
$KMnO_4$	hydrous manganese oxide
MCL	Maximum contaminant level
mg/L	milligrams per Liter
mgd	million gallons per day
MHI	median household income
MnO_2	Manganese dioxide
MOR	monthly operating report
NMEFC	New Mexico Environmental Financial Center
NSF	NSF International
O&M	operation and maintenance
Parsons	Parsons Infrastructure and Technology Group Inc.
pCi/L	picoCuries per liter
POE	Point-of-entry
POU	Point-of-use
PSOC	potential sources of contamination
PWS	public water system
RO	Reverse osmosis
RR	ranch road
RWHA	R.W. Harden Associates, Inc.
SDWA	Safe Drinking Water Act

SH	state highway
TCEQ	Texas Commission on Environmental Quality
TDS	Total dissolved solids
TSS	Total suspended solids
TWDB	Texas Water Development Board
USEPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey
WAM	Water Availability Model
WRT	Water Remediation 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 (PWS) to meet and maintain Texas drinking water standards.

The overall goal of this project is to promote compliance using sound engineering and financial methods and data for PWSs that 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 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 City of Melvin PWS, PWS ID# 1540003, Certificate of Convenience and Necessity (CCN) # P0727, located in McCulloch County, Texas (the City of Melvin PWS). The City of Melvin PWS recorded sample results above MCLs for combined radium (radium 226 and radium 228) and gross alpha. The MCLs are 5 picoCuries per liter (pCi/L) for combined radium and 15 pCi/L for gross alpha (USEPA 2006; TCEQ 2004a). Sample results for combined radium were recorded from November 1999 through November 2004 and ranged from 8.0 to 11.0 pCi/L (above the MCL of 5 pCi/L). Results for gross alpha and were recorded between March 2001 and November 2004 and ranged from 19.7 to 30.9 pCi/L (above the MCL of 15 pCi/L). The PWS also recorded concentrations of iron above the secondary drinking water standard of 0.3 milligrams per liter (mg/L) (USEPA 2006; TCEQ 2004a). Iron concentrations ranged from 0.427 to 0.55 mg/L for sample results recorded between March 1998 and November 2004.

The location of the City of Melvin PWS is shown in 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 Melvin PWS had recorded sample results exceeding MCLs for combined radium and gross alpha. The PWS also had recorded sample results above the secondary standard for iron. In general, contaminant(s) in drinking water above the MCL(s) can have both short-term (acute) and long-term or lifetime (chronic) effects. Long-term ingestion of drinking water containing any of the radionuclides (radium 226, radium 228, and/or gross alpha particle emitters) above the MCL may increase the risk of cancer (USEPA 2006). Iron above the secondary drinking water standard is not a safety concern. However, due to the potential interference of iron with treatment designs, high iron levels need to be considered when evaluating treatment options.

1.2 METHOD

The method 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 U.S. Environmental Protection Agency (USEPA) and Texas drinking water standards. Three PWSs were evaluated in the pilot study to develop the method (*i.e.*, decision tree approach) for analyzing options for provision of compliant drinking water. This project is performed using the decision tree approach developed in the pilot study.

Other tasks of the feasibility study are as follows:

- Identifying available data sources;
- Gathering and compiling data;
- Conducting 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 abatement options for radium and gross alpha particle emitters. Section 2 describes the method used to develop and assess compliance alternatives. The groundwater sources of radionuclides are addressed in Section 3. Findings for the City of Melvin PWS, along with compliance alternatives development and evaluation, can be found in Section 4. Section 5 references the sources used in this report.

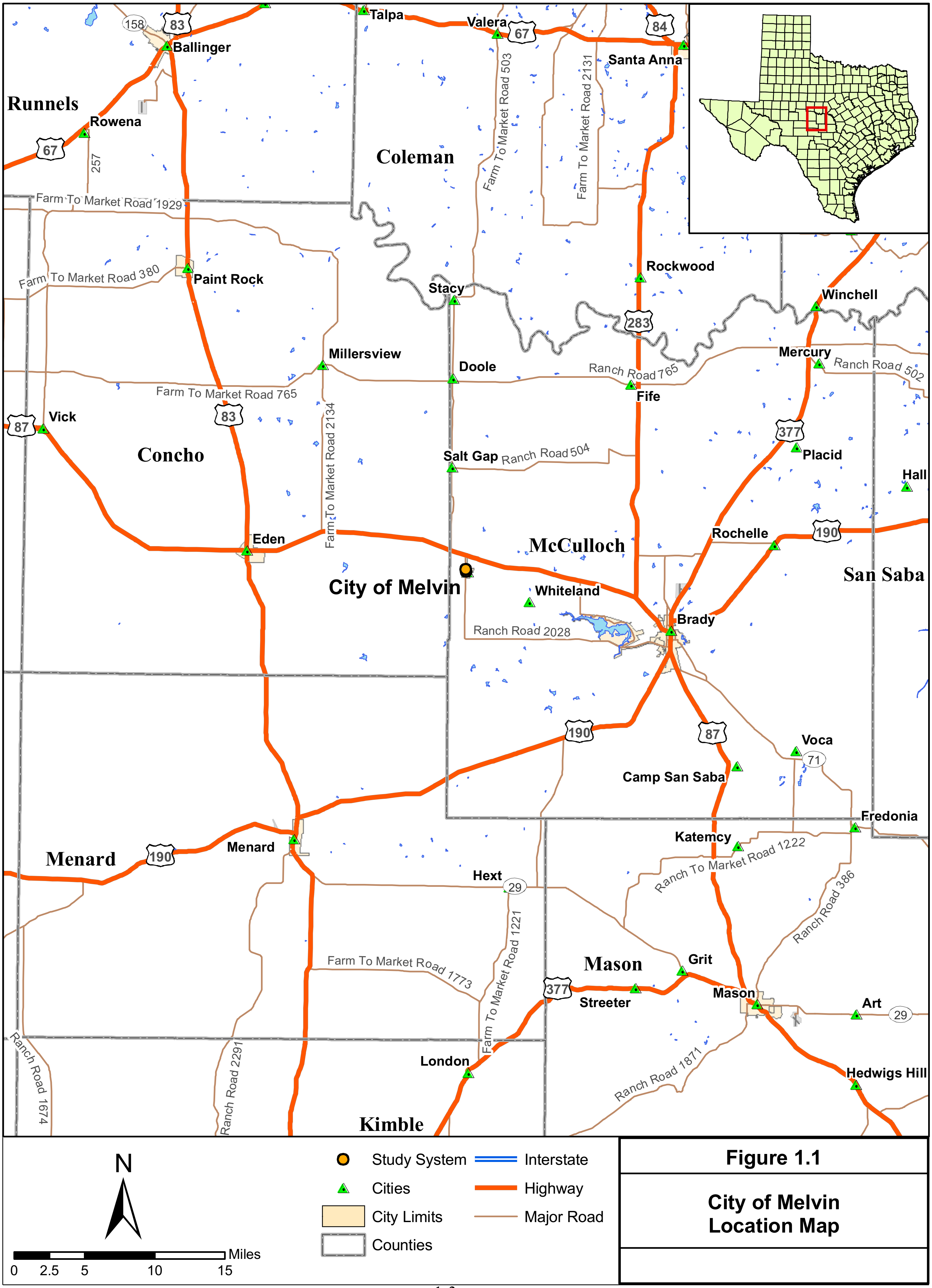

Figure 1.1

City of Melvin Location Map

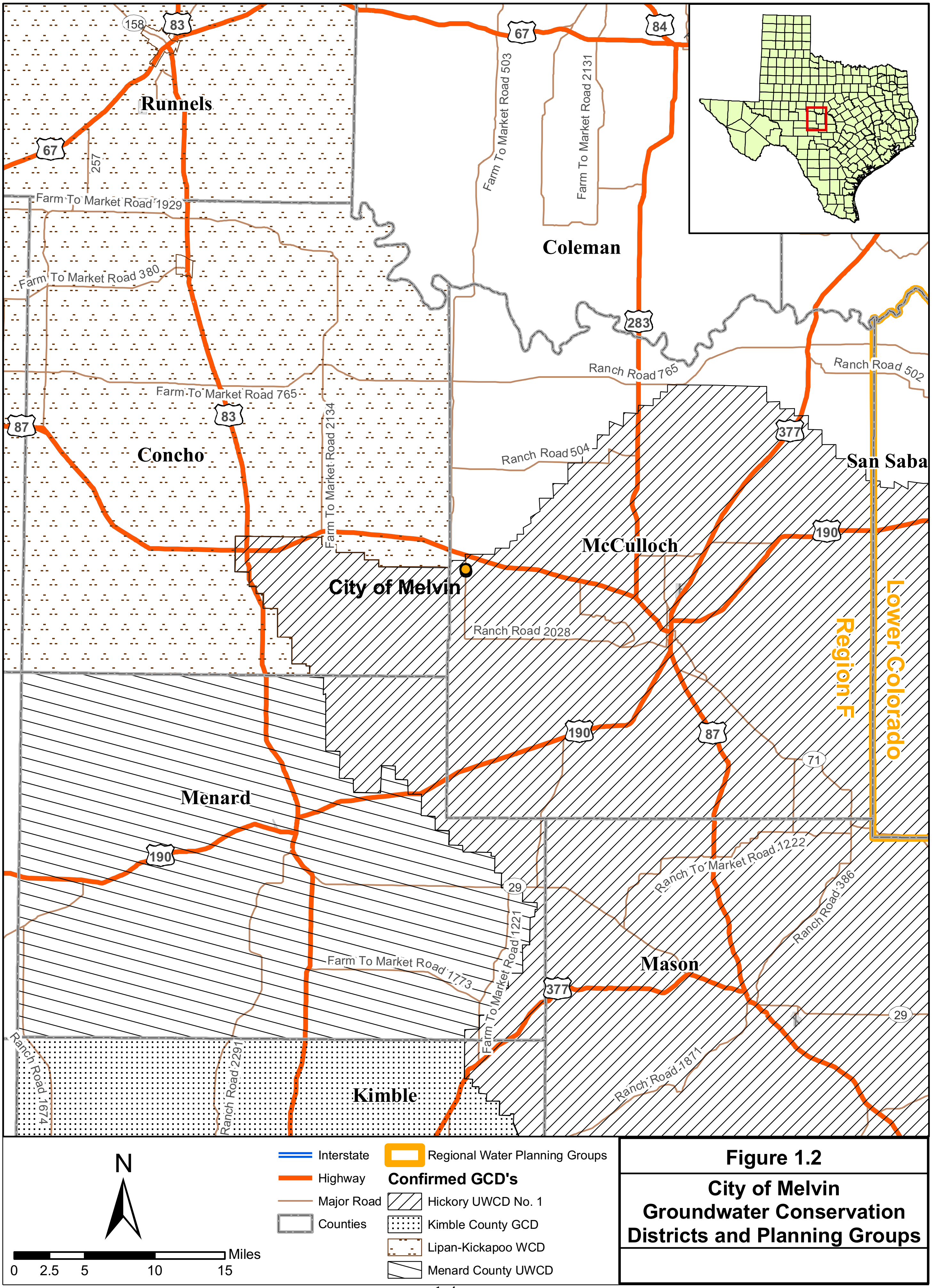

Figure 1.2
City of Melvin Groundwater Conservation Districts and Planning Groups

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1.3 REGULATORY PERSPECTIVE

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

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

This project was conducted to assist in achieving these responsibilities.

1.4 ABATEMENT OPTIONS

When a PWS exceeds a regulatory MCL, the PWS must take action to correct the violation. The MCL exceedances at the City of Melvin PWS are for radium and gross alpha. The following subsections explore alternatives considered as potential options for obtain/providing compliant drinking water.

1.4.1 Existing Public Water Supply Systems

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

1.4.1.1 Quantity

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

Implementation of blending will require a control system to ensure the blended water is compliant.

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

- Additional wells;
- Developing a new surface water supply;
- Additional or larger-diameter piping;
- Increasing a 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 City of Melvin, the following standards could be used in a rough screening to identify compliant groundwater in surrounding systems:
  - Total radium concentrations (radium 226 and radium 228) less than 4 pCi/L (below the MCL of 5 pCi/L);
  - Gross alpha concentrations less than 12 pCi/L (below the MCL of 15 pCi/L);
  - Iron concentrations less than 0.24 mg/L (below the MCL of 0.3 mg/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, flowrates, and other well characteristics.
- After collecting as much information as possible from cooperative owners, the PWS would then narrow the selection of wells and sample and analyze them for quality. Wells with good quality would then be potential candidates for test pumping. In some cases, a particular well may need to be refurbished before test pumping. Information obtained from test pumping would then be used in combination with

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

- It is recommended that new wells be installed instead of using existing wells to ensure the well characteristics are known and the well meets construction standards.
- Permit(s) would then be obtained from the groundwater control district or other regulatory authority, and an agreement with the owner (purchase or lease, access easements, *etc*.) would then be negotiated.

1.4.2.2 Develop New Wells

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

1.4.3 Potential for Surface Water Sources

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

1.4.3.1 Existing Surface Water Sources

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

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

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

1.4.3.2 New Surface Water Sources

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

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

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

1.4.4 Identification of Treatment Technologies

Various treatment technologies were also investigated as compliance alternatives for treatment of radium to regulatory level *(i.e.*, MCL). The removal of radium would also remove gross alpha activity as the radium appears to be responsible for most of the gross alpha activity of the groundwater. 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 ion exchange (IX), reverse osmosis (RO), electrodialysis/electrodialysis reversal (ED/EDR), lime softening, greensand filtration, re-formed hydrous manganese oxide filtration ($KMnO_4$-filtration), and co-precipitation with barium sulfate. A relatively new process using the WRT Z-88™ media that is specific for radium adsorption has been demonstrated to be an effective radium technology. Lime softening and co-precipitation with barium sulfate are technologies that are relatively complex and require chemistry skills that are not practical for small systems with limited resources and hence they are not evaluated further.

1.4.5 Description of Treatment Technologies

The application radium removal treatment technologies include IX, WRT-Z88™ media adsorption, RO, ED/EDR, and $KMnO_4$-greensand filtration. A description of these technologies follows.

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. Operation begins 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 will be necessary prior to disposal, especially for radium removal resins which have elevated radioactivity.

For radium removal, a strong acid cation exchange resin in the sodium form can remove 99 percent of the radium. The strong acid resin has less capacity for radium on water with high hardness and it has the following adsorption preference: $Ra^{2+} > Ba^{2+} > Ca^{2+} > Mg^{2+} > Na^{+}$. Because of the selectivity radium and barium are much more difficult to remove from the resin during regeneration than calcium and magnesium. Economical regeneration removes most of the hardness ions, but radium and barium buildup on the resin after repeated cycles to the point where equilibrium is reached and then radium and barium will begin to breakthrough shortly after hardness. Regeneration of the sodium form strong acid resin for water with 200 mg/L of hardness with application of 6.5 pounds NaCl/ft^3 resin would produce 2.4 bed volumes (BV) of 16,400 mg/L TDS brine per 100 BV of product water (2.4%). The radium concentration in the regeneration waste would be approximately 40 times the influent radium concentration in groundwater.

Pretreatment – Pretreatment guidelines are available on accepted limits 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.

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

Waste Disposal – Approval from local authorities is usually required for disposal of concentrate from the regeneration cycle (highly concentrated salt solution with radioactivity); occasional solids wastes (in the form of broken resin beads) which are backwashed 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 will 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 will 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 of upon exhaustion. The Z-88 does not remove calcium and magnesium and thus it can last for a long time (2-3 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 gpm/ft^2. Pilot testing of this technology has been conducted successfully for radium removal in many locations including in the State of Texas. Seven full-scale systems with capacities of 750 to 1,200 gpm have been constructed in the Village of Oswego, Illinois since July 2005. The treatment equipment is owned by WRT and the ownership of spent media would be transferred to an approved disposal site. The customer pays WRT based on an agreed upon treated water unit cost (*e.g.*, $1.00-6.70/kgal depending on water quality, capacity and annual production of the water systems).

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. Periodical water quality monitoring and inspection of mechanical equipment are required.

Waste Disposal – The Z-88 media would be disposed of in an approved low level radioactive waste landfill by WRT once every 2-3 years. No liquid waste is generated for this process. However, if pretreatment filters are used then spent filters and backwash wastewater disposal is 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) effort is minimal and no regular liquid waste is generated. However, this technology is very new and without long-term full-scale operating experience. But since the equipment is owned by WRT and the performance is guaranteed by WRT the risk to the utilities 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 needs to prevent membranes from fouling, scaling or other membrane degradation. 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 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 required approved disposal methods. The 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.
- Concentrate disposal.

RO is an expensive alternative to remove 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 – 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 to reduce the formation of scale and fouling films and thus a higher water recovery can be achieved. EDR has been the dominant form of ED system 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.

Pretreatment – Guidelines are available on acceptable limits on 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. MF could be used in place of flocculation, sedimentation, and filtration.

Maintenance – EDR membranes are durable, can tolerate pH from 1-10, and temperatures to 115^{o}F for cleaning. The 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 spacer. If the chlorine is not removed, toxic chlorine gas may form. Depending on raw water characteristics, the membranes will require regular maintenance or replacement. If used, pretreatment filter replacement and backwashing will be required. The EDR stack must be disassembled, mechanically cleaned, and reassembled at regular intervals.

Waste Disposal – Highly concentrated reject flows, electrode cleaning flows, and spent membranes require approved disposal methods. 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 the energy it uses. 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

Process – 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 $KMnO_4$ 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 making sure that some MnO_2 is still available for radium sorption. The $KMnO_4$-greensand filtration process can accomplish this purpose as the greensand is coated with MnO2 which is regenerated by the continuous feeding of $KMnO_4$. Many operating treatment systems utilizing continuous feed $KMnO_4$, 30-minute contact time, 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 the 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 rid of suspended materials and metal oxides. $KMnO_4$ is usually supplied in the 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 distribution system and household fixtures.

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

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 iron and manganese removal process and is effective for radium removal. 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 and gross alpha particle emitter removal, these systems typically use small 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 radium and gross alpha particle emitters 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 has issued product standards for a specific type of POU or POE treatment unit, only those units that have been independently certified according to those standards may be used as part of a compliance strategy.

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

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

1.4.7 Water Delivery or Central Drinking Water Dispensers

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

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

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

Water delivery programs require consumer participation to a varying degree. Ideally, consumers would have to do no more than they currently do for a piped-water delivery system. Least desirable are those systems that require maximum effort on the part of the customer (*e.g.*, customer has to travel to get the water, transport the water, and physically handle the bottles). 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 that when one is empty, the other is being used over a time period sufficient to allow the utility to change out the empty bottle).
- Provide for regularly scheduled delivery so the customer would not have to notify the utility when the supply is low.
- Use utility personnel and equipment to handle water containers, without requiring customers to lift or handle bottles with water in them.
- Be sanitary (*e.g.*, where an outside connection is made, contaminants from the environment must be eliminated).
- Be vandal-resistant.
- Avoid heating the water due to exterior temperatures and solar radiation.
- Avoid freezing the water.

SECTION 2
EVALUATION METHOD

2.1 DECISION TREE

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

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

2.2 DATA SOURCES AND DATA COLLECTION

2.2.1 Data Search

2.2.1.1 Water Supply Systems

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

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

Figure 2.1
TREE 1 – EXISTING FACILITY ANALYSIS

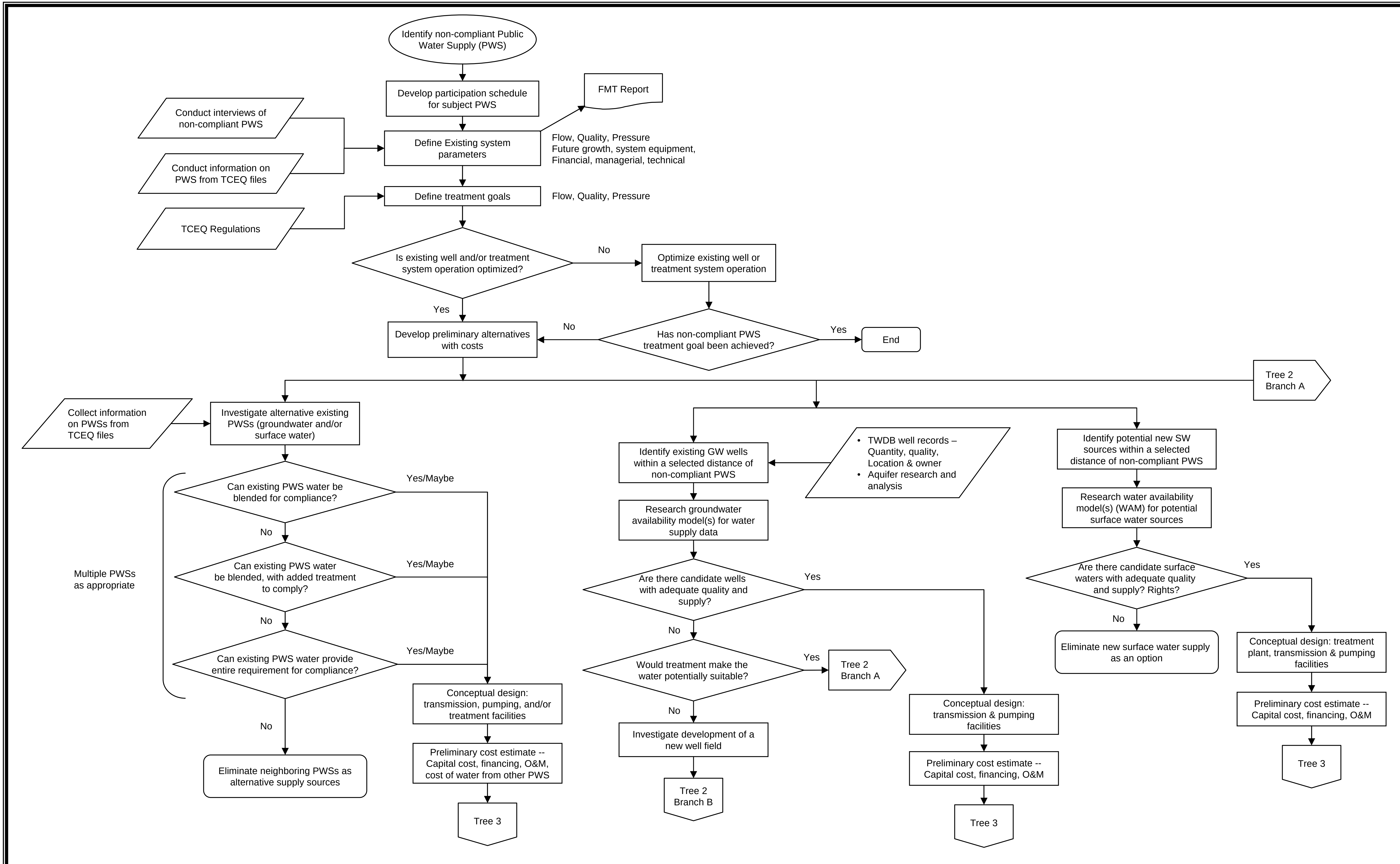
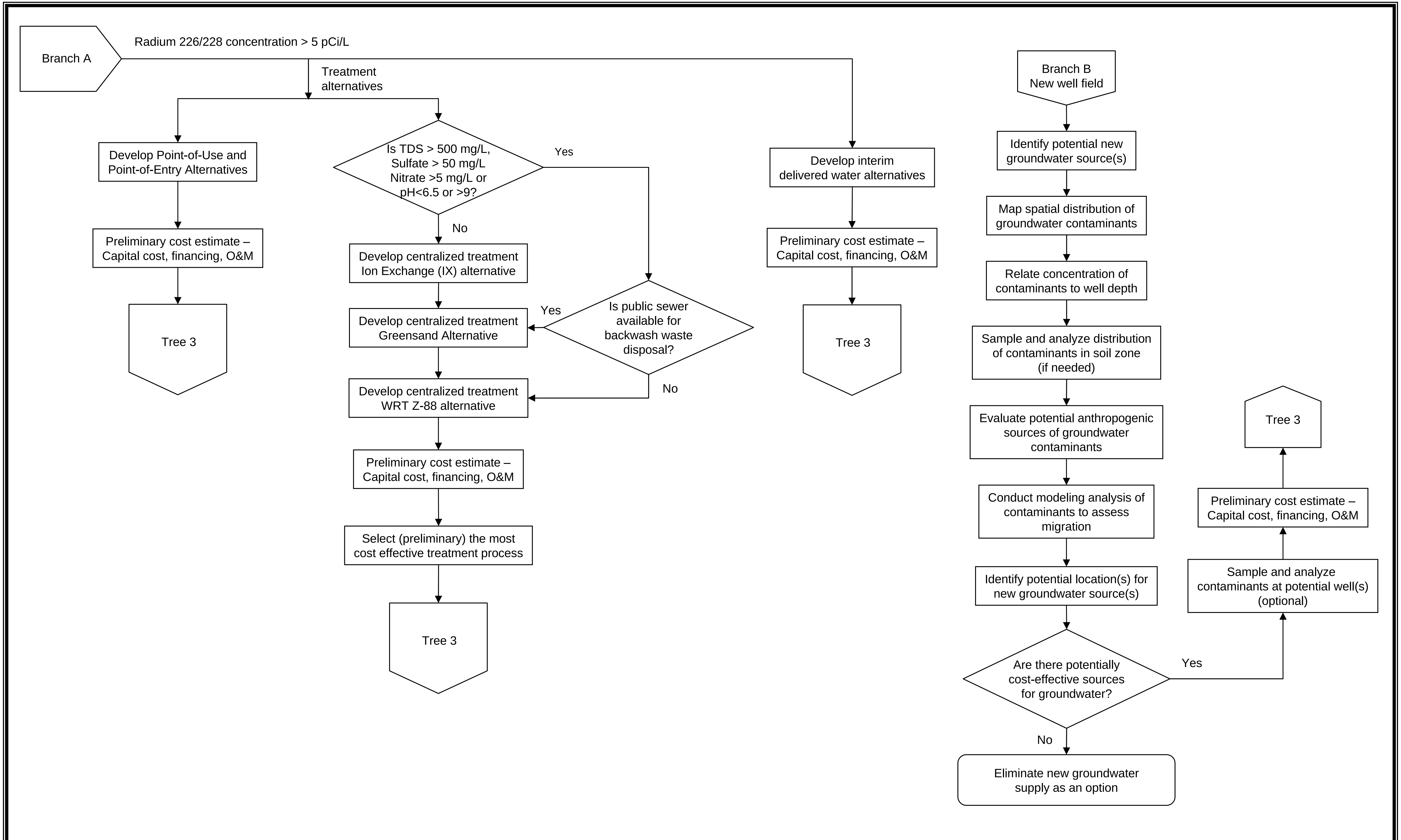


Figure 2.2
TREE 2 – DEVELOP TREATMENT ALTERNATIVES



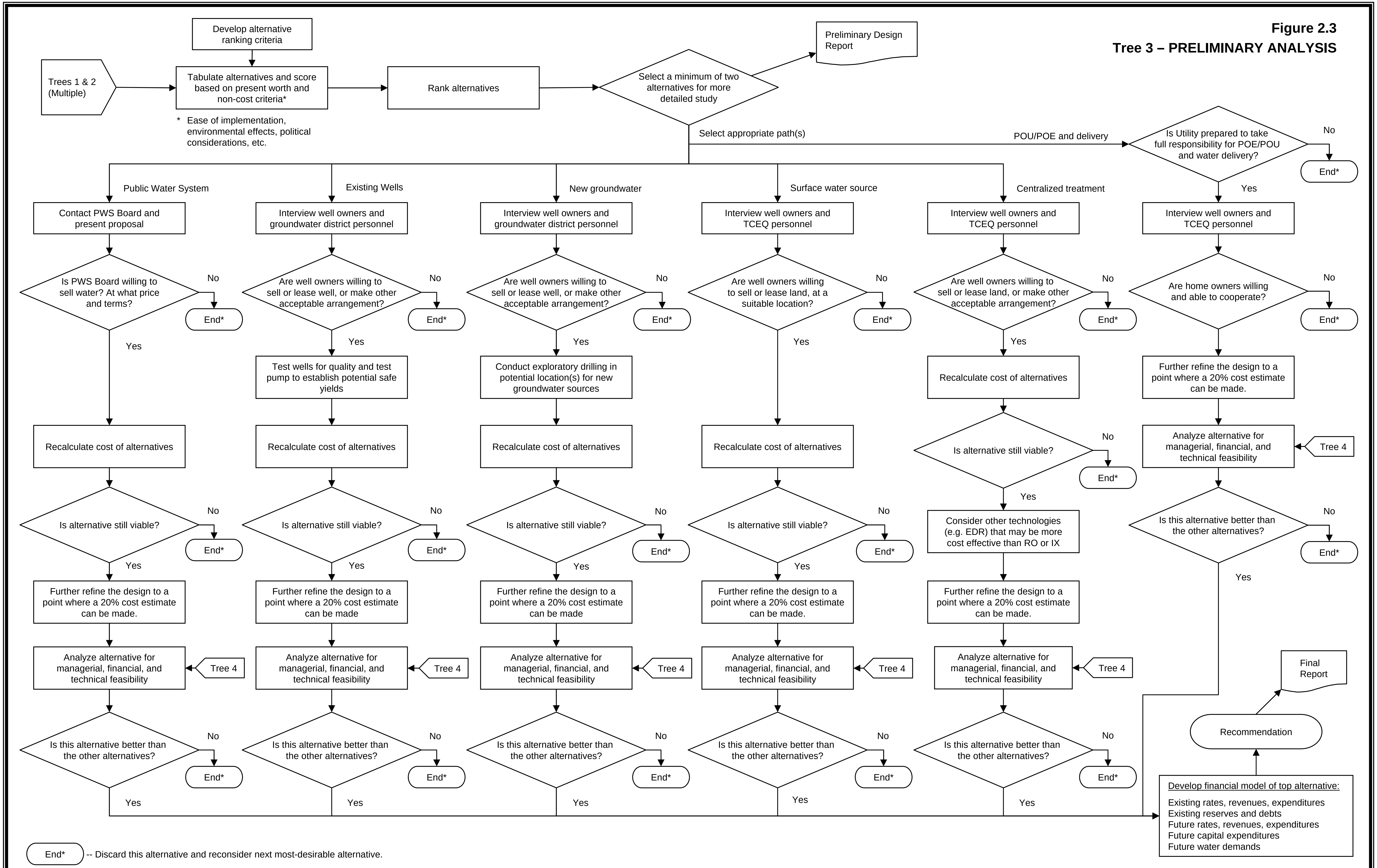
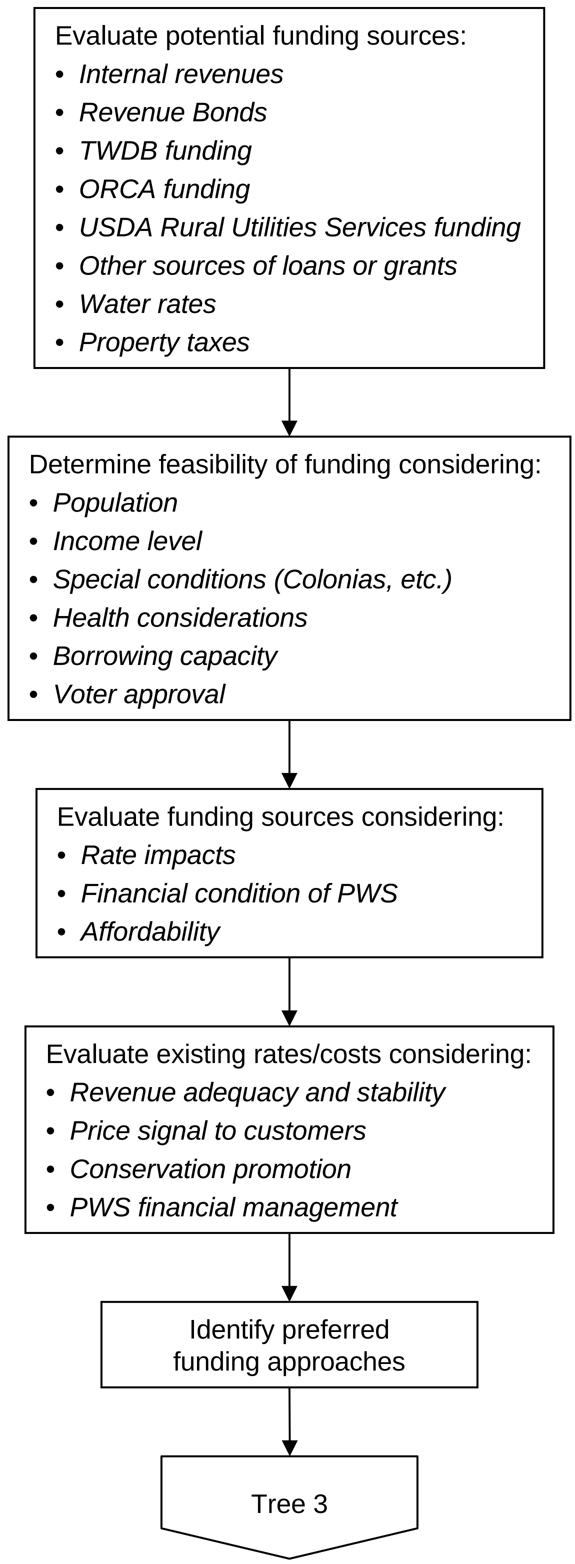


Figure 2.3
Tree 3 – PRELIMINARY ANALYSIS
Develop alternative ranking criteria
Trees 1 & 2 (Multiple)
Tabulate alternatives and score based on present worth and non-cost criteria*
* Ease of implementation, environmental effects, political considerations, etc.
Rank alternatives
Select a minimum of two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

Figure 2.4
TREE 4 – FINANCIAL



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

These files were reviewed for the PWS and surrounding systems.

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

- TCEQ Water Utility Database: 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 flowrate, and nature of the surrounding formation. The "Water Quality Table" provides information on the aquifer and the various chemical concentrations in the water.

2.2.1.3 Surface Water Sources

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

2.2.1.4 Groundwater Availability Model

GAMs, developed by the TWDB, are planning tools and should be consulted as part of a search for new or supplementary water sources. Two minor aquifers, the Ellenburger-San Saba and Hickory, are the primary groundwater sources throughout most of McCulloch County where the PWS is located. According to TCEQ records, the City of Melvin PWS groundwater supply is the Wilberns formation of the Ellenburger-San Saba aquifer. The GAM for this area of groundwater was investigated as a potential tool for identifying available and suitable groundwater resources.

2.2.1.5 Water Availability Model

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

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

2.2.1.6 Financial Data

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

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

2.2.1.7 Demographic Data

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

2.2.2 PWS Interviews

2.2.2.1 PWS Capacity Assessment Process

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

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

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

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

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

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

Assessment of the FMT capacity of the PWS was based on an approach developed by the New Mexico Environmental Finance Center (NMEFC), which is consistent with TCEQ FMT assessment process. This method was developed from work the NMEFC did while assisting USEPA Region 6 in developing and piloting groundwater comprehensive performance evaluations. The NMEFC developed a standard list of questions that could be asked of water system personnel (the 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. The interviewees were not given the questions in advance. 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 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. Interview forms were completed during each interview.

2.3 ALTERNATIVE DEVELOPMENT AND ANALYSIS

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

2.3.1 Existing PWS

The neighboring PWSs were identified, and the extents of their systems were investigated. PWSs farther than 30 miles from the non-compliant PWSs were not considered because the length of the pipeline required would make the alternative cost prohibitive. The quality of water provided was also investigated. For neighboring PWSs with compliant water, options for water purchase and/or expansion of existing well fields were considered. The neighboring PWSs with non-compliant water were considered as possible partners in sharing the cost for obtaining compliant water either through treatment or developing an alternate source.

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

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

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

2.3.2 New Groundwater Source

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

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

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

2.3.3 New Surface Water Source

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

2.3.4 Treatment

Treatment technologies considered potentially applicable to radium removal are IX, WRT Z-88™ media, RO, EDR, and $KMnO_4$-greensand filtration. RO and EDR are membrane processes that produce a considerable amount of liquid waste: a reject stream from RO treatment and a concentrate stream from EDR treatment. As a result, the treated volume of water is less than the volume of raw water that enters the treatment system. The amount of raw water used increases to produce the same amount of treated water if RO or EDR treatment is implemented. Because the TDS is not high the use of RO or EDR would be considerably more expensive than the other potential technologies. And thus RO and EDR are not considered further. However, RO is considered for POU and POE alternatives. IX, WRT Z-88™ media, and $KMnO_4$-greensand filtration are considered as alternative central treatment technologies. The treatment units were sized based on flow rates, and capital and annual O&M cost estimates were made based on the size of the treatment equipment required. Neighboring non-compliant PWS's were identified to look for opportunities where the costs and benefits of central treatment could be shared between systems.

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

2.4 COST OF SERVICE AND FUNDING ANALYSIS

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

2.4.1 Financial Feasibility

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

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

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

2.4.2 Median Household Income

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

2.4.3 Annual Average Water Bill

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

2.4.4 Financial Plan Development

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

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

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

2.4.5 Financial Plan Results

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

2.4.5.1 Funding Options

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

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

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

- Grant funds for 100 percent of required capital. In this case, the PWS is only responsible for the associated O&M costs.
- Grant funds for 75 percent of required capital, with the balance treated as if revenue bond funded.
- Grant funds for 50 percent of required capital, with the balance treated as if revenue bond funded.
- State revolving fund loan at the most favorable available rates and terms applicable to the communities.
- If local MHI >75 percent of state MHI, standard terms, currently at 3.8 percent interest for non-rated entities. Additionally:
    - If local MHI = 70-75 percent of state MHI, 1 percent interest rate on loan.
    - If local MHI = 60-70 percent of state MHI, 0 percent interest rate on loan.
    - If local MHI = 50-60 percent of state MHI, 0 percent interest and 15 percent forgiveness of principal.
    - If local MHI less than 50 percent of state MHI, 0 percent interest and 35 percent forgiveness of principal.
- Terms of revenue bonds assumed to be 25-year term at 6.0 percent interest rate.

2.4.5.2 General Assumptions Embodied in Financial Plan Results

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

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

2.4.5.3 Interpretation of Financial Plan Results

Results from the financial plan model for each alternative are presented in Table 4.4 in Section 4 of this report. The model used six funding alternatives: paying cash up front (all revenue); 100 percent grant; 75 percent grant; 50 percent grant, State Revolving Fund; and obtaining a Loan/Bond. Table 4.4 shows the projected average annual water bill, the maximum percent of household income, and the percentage rate increase over current rates.

2.4.5.4 Potential Funding Sources

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

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

- 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:

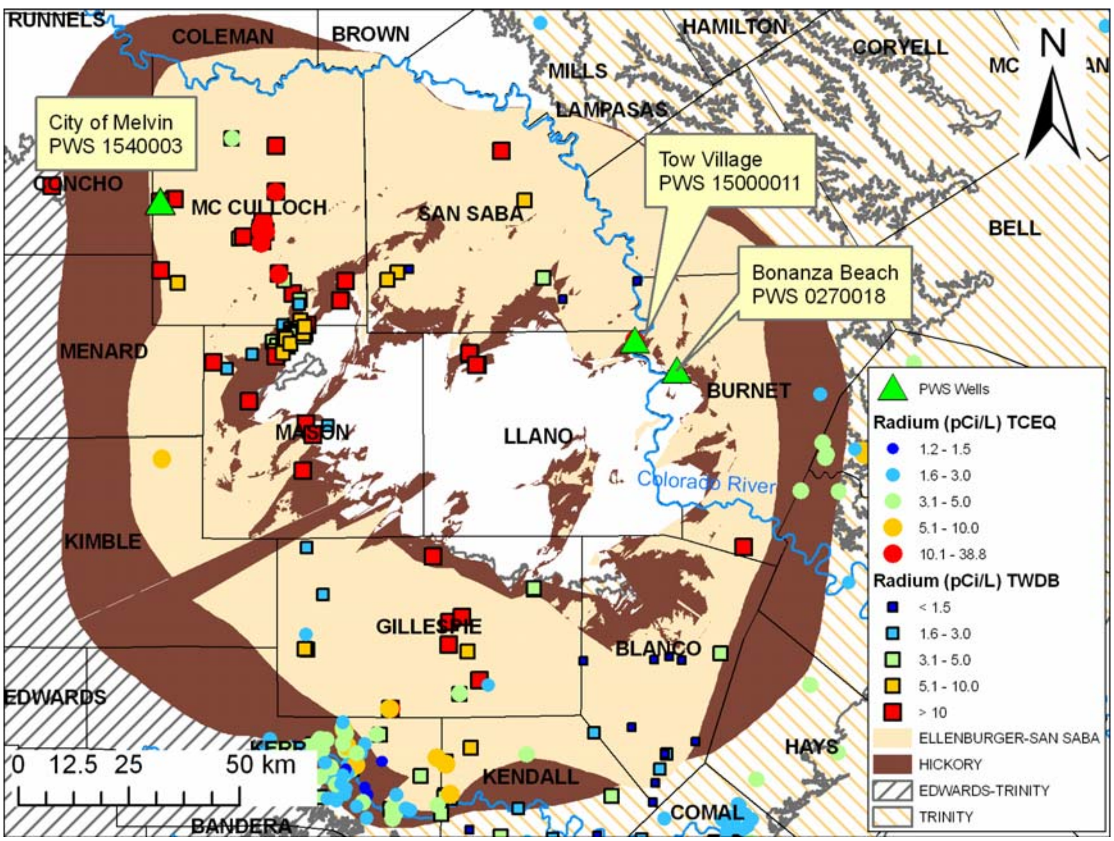
- United States Department of Agriculture, Rural Utilities Service, and
- United States Housing and Urban Development.

SECTION 3
UNDERSTANDING SOURCES OF CONTAMINANTS

3.1 RADIUM AND GROSS ALPHA IN CENTRAL TEXAS AQUIFERS

Aquifers in McCulloch, Llano, and Burnet counties include aquifers of Cretaceous age (mainly within the Trinity Group) but mostly of Paleozoic age (Hickory and Ellenburger - San Saba aquifers) as a result of the presence of the Llano uplift, which is made up of Precambrian granites and schists and covers most of Llano County (Bluntzer 1992). The PWS wells of concern are located in those three counties and the wells are completed in the Hickory aquifer (except for one well in the Ellenburger-San Saba aquifer). In general, radium levels are higher (>5 pCi/L) within the Hickory and Ellenburger-San Saba aquifers and lower (<5 pCi/L) in southern and eastern parts of the study area within the Trinity aquifer (Figures 3.1 and 3.2).

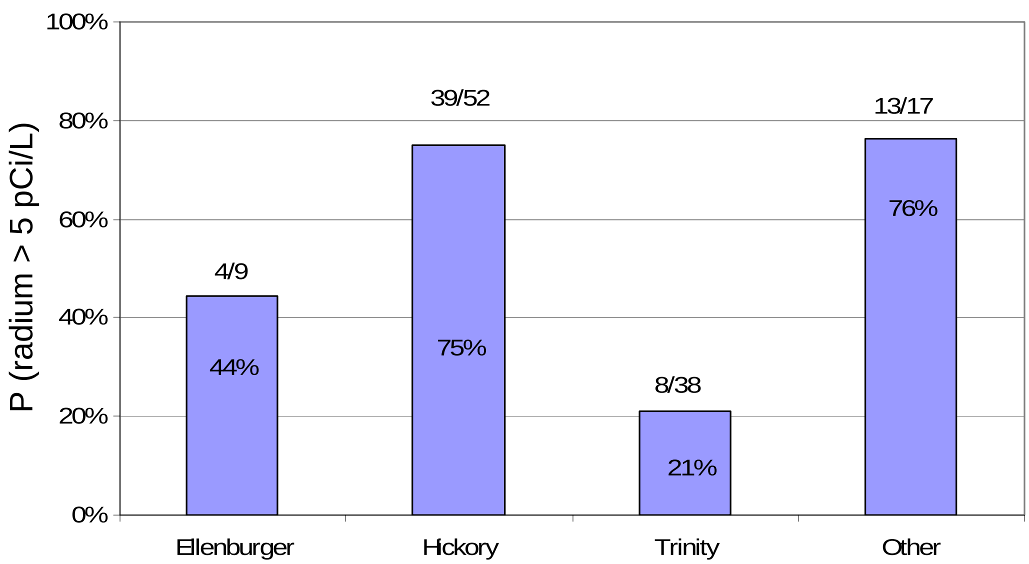
Figure 3.1 Radium Levels in Central Texas Aquifers



Data in Figure 3.1 show combined radium (radium 226 plus radium 228) from the TWDB groundwater database (storet codes 09503 and 81366) and TCEQ public water supply database (contaminant ID 4020 and 4030). The most recent values for wells in which both isotopes of radium were analyzed on the same day are shown. The data include raw samples from wells and samples from entry points which are connected to a single well.

In this study the terms *radium* or *radium combined* are generally used to refer to radium 226 plus radium 228, otherwise, radium 226 or radium 228 is specified. The values shown in Figure 3.1 generally represent the upper limit of the radium measurements because the detection limit was used for samples that are below the detection limit. Although TCEQ allows PWSs to subtract the reported error from the radium concentrations to assess compliance, the analysis of general trends used the most recent radium concentration and did not subtract the reported error.

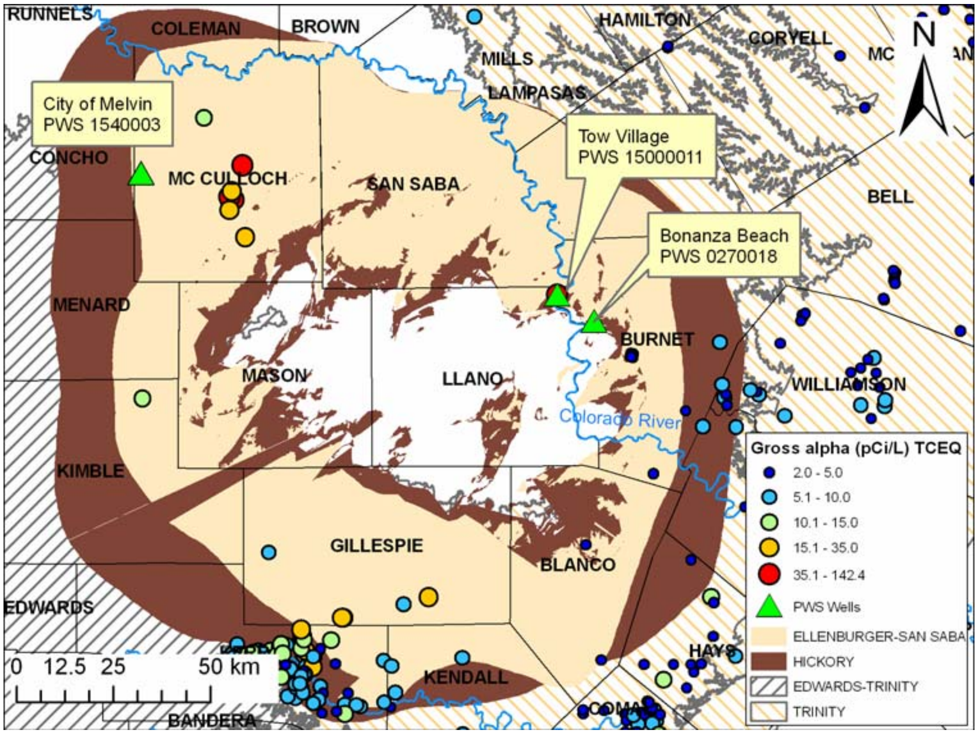
Figure 3.2 Percentage of Wells with Radium Exceeding the MCL (5 pCi/L) in Central Texas Aquifers



Data in Figure 3.2 are from the TWDB groundwater database. The most recent combined radium samples for each well are used in the analysis. Numbers on top of the graph bars show the number of samples >5 pCi/L and the total number of samples in each aquifer.

Gross alpha levels have a spatial distribution similar to radium. In general, levels of gross alpha in the Hickory and Ellenburger aquifers are higher than in the Trinity aquifer, and most of the gross alpha samples >15 pCi/L are from wells in the Hickory and Ellenburger-San Saba aquifers (Figure 3.3). The MCL for uranium is 30 micrograms per liter (µg/L), which is equivalent to 20 pCi/L (using a conservative factor of 0.67 pCi/µg for converting mass concentration to radiation concentration). Therefore, a gross alpha level of 35 pCi/L in a well reflects a level from which the well fails to comply with either the MCL for gross alpha minus alpha radiation due to uranium, which is 15 pCi/L, or with the uranium MCL (neglecting the activity due to radon which is rarely measured in PWS wells). Gross alpha >5 pCi/L requires analysis of radium 226. Radium 228 testing must be done regardless of gross alpha results (TCEQ 2004b).

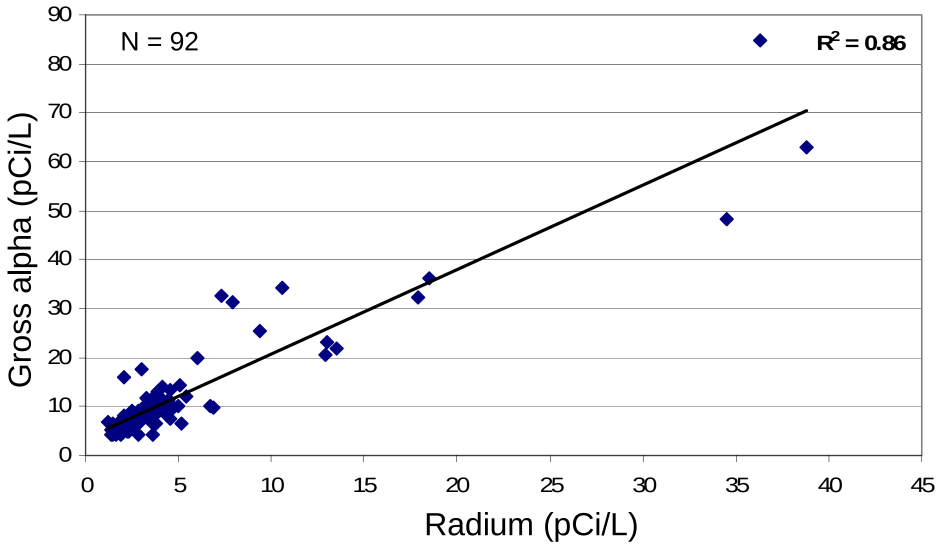
Figure 3.3 Gross Alpha in Groundwater in the Central Texas Aquifers



Data in Figure 3.3 are from the TCEQ public water supply database (contaminant ID 4109), and the most recent sample is shown for each well. The data include samples from entry points that are connected to a single well.

Correlation between radium and gross alpha is strong (R^2=0.86) and positive (Figure 3.4), showing that gross alpha in groundwater is mostly from radium.

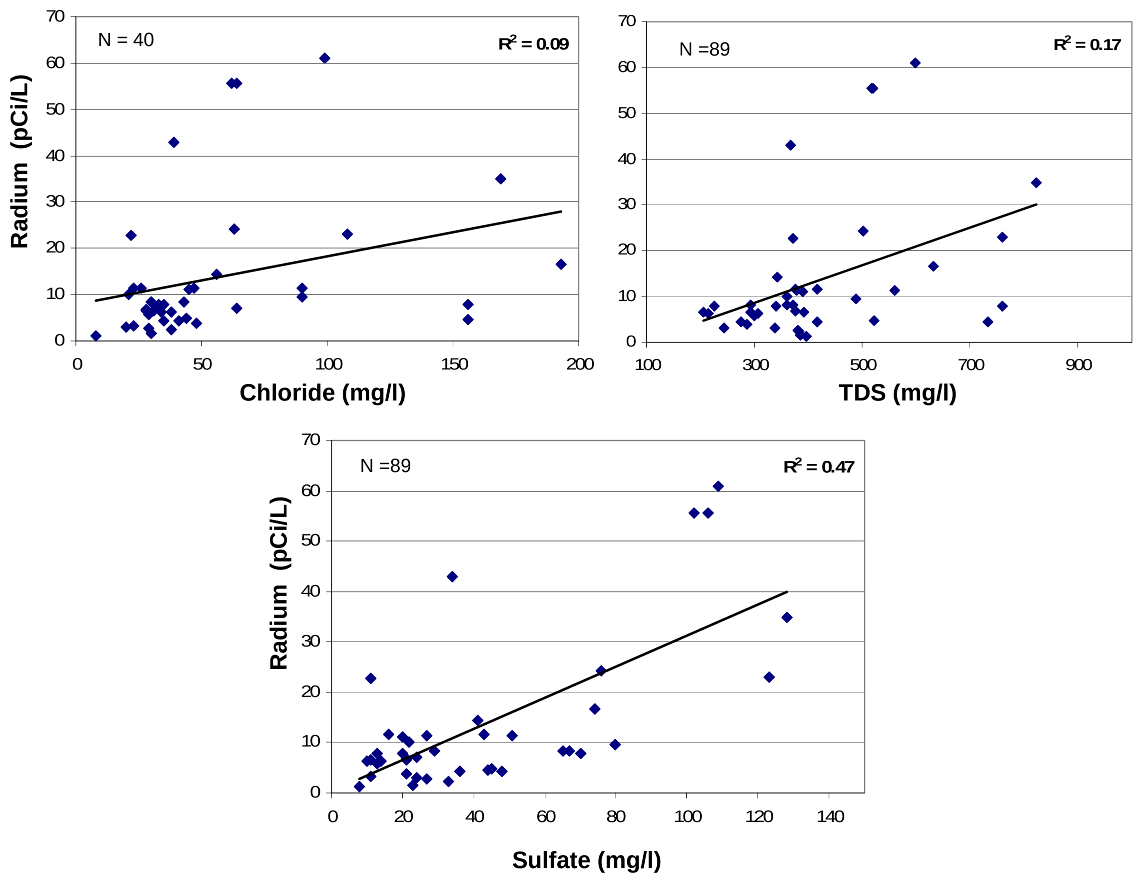
Figure 3.4 Relationship between Radium and Gross Alpha in Central Texas Aquifers



Data in Figure 3.4 are from the TCEQ PWS database, and include samples from entry points that are connected to a single well. For each well the most recent sample is used in the analysis (data include only samples where both parameters were analyzed on the same day). N represents the number of samples used in the analysis.

The correlation of radium in the Hickory aquifer with general water quality parameters was assessed: correlation with chloride and TDS are weak (R^2 <0.2) while correlation with sulfate is somewhat stronger (R^2 = 0.47) (Figure 3.5).

Figure 3.5 Relationships between Radium and Chloride, TDS, and Sulfate in the Hickory Aquifer



Data are from the TWDB groundwater database. The most recent radium samples for each well are used in the analysis with chloride, TDS, and sulfate samples taken on the same day as the radium. N represents the number of samples in the analysis.

3.2 REGIONAL GEOLOGY

McCulloch, Llano, and Burnet counties are centered on the Llano Uplift, a mostly granitic Precambrian core surrounded by rings of Paleozoic formations dipping away from it in all directions (Bluntzer 1992). Cretaceous formations, in direct contact with the Paleozoic sequence, complete the stratigraphic column in west McCulloch County (Anaya and Jones 2000) and east Burnet County (R.W. Harden Associates, Inc. [RWHA] 2004).

Llano County forms the core of the Llano Uplift where Precambrian igneous and metamorphic rock is exposed. The geology is complex and its details are not pertinent to this section. The Hickory Member (mainly sandstone) represents the first formation of Cambrian age covering the Precambrian basement. The Ellenburger Group (mostly carbonates) of Ordovician age, to which is added the San Saba Member of Upper Cambrian age, contains several fully hydraulically connected water bearing formations. Another water bearing formation, appropriately called the Mid-Cambrian aquifer (mostly sandstone), is present between them. This Mid-Cambrian aquifer is not recognized by the State of Texas, as opposed to the Hickory and Ellenburger / San Saba aquifers which are classified as minor aquifers by the state (Ashworth and Hopkins 1995). A fourth unit, the Marble Falls formation (mainly carbonates) of Pennsylvanian age, is also listed as a minor aquifer. The rest of the Paleozoic contains formations able to produce some water but not in significant quantity. The Paleozoic aquifers are compartmentalized by faults that became inactive before the deposition of the Cretaceous sediments. However, the stratigraphic section does not change much from one compartment to the next. The general dip is <2.3 percent (120 feet/mile) (Mason 1961). The next preserved layers present in eastern Burnet and western McCulloch counties are of Cretaceous age and were deposited on a mostly flat platform. The first described formation is the Travis Peak formation, itself part of the Trinity Group: the Hosston Sand and Hensell Sand with intermediate confining beds. The Hosston Sand pinches out around the uplift and to the northwest as well and have mostly disappeared or merged with the Hensell Sand in McCulloch County. The Travis Peak formation (also called Twin Mountains formation farther north) is overlain by the Glen Rose formation, which acts as a confining unit, then by the Paluxy Sand, which disappears just south of Burnet County (RWHA 2004) and does not exist in McCulloch County. Westward, the Trinity Group is much thinner (no or thin Glen Rose formation) and overall sandier and is called the Antlers Sand (Klemt, *et al.* 1975; Baker, *et al.* 1990). Covering the Trinity Group, the Fredericksburg Group (that includes the Edwards formation) completes the section. Mostly sandy units of the Trinity Group form the Trinity aquifer, a major aquifer according to the State of Texas (Ashworth and Hopkins 1995). Dip of the Cretaceous formations is generally small (<0.5%) and toward the south or east.

Precambrian rock of Llano County does not yield significant amount of water unless they are fractured or weathered (Bluntzer 1992) in which case the water is of good quality. Depth to the top of the Hickory aquifer ranges from zero at the outcrop to more than 2,500 feet. The aquifer varies in thickness because it was deposited on an irregular surface but its thickness can reach 400 feet and is at least 150 feet (Bluntzer 1992). Separated from the Hickory by 400-600 feet of confining layers, the Mid-Cambrian aquifer is 50-100 feet thick and can yield small quantities of water. Water quality in the Hickory (LBG-Guyton Associates 2003) and Mid-Cambrian (Mason 1961) aquifers is good. The thickness of the Ellenburger / San Saba aquifer ranges from 250 feet close to the outcrop to 2,000 feet in Burnet County and 750 feet (locally >1,250 feet) in McCulloch County (Core Laboratories Inc. 1972). The water is hard but otherwise of good quality (LBG-Guyton Associates 2003). More than 300 feet of limestone and shale separate the Ellenburger / San Saba aquifer from the Mid-Cambrian aquifer. The Marble Falls aquifer is about 400 feet thick and is separated from the Ellenburger/ San Saba aquifer by 50 feet of confining beds. The aquifer has good water quality in the outcrop (mainly in San Saba County) and also likely to have good quality water in its downdip areas. Water quality in aquifers of the Trinity Group is also good (LBG-Guyton Associates 2003). The uppermost water-bearing formation is the Edwards limestone under water-table conditions, unlike other aquifers which are mostly confined.

3.3 DETAILED ASSESSMENT OF THE CITY OF MELVIN PWS

3.3.1 Data Assessment

There are two wells in the City of Melvin PWS: G1540003A and G1540003B. The wells are designated as within the Hickory and Ellenburger-San Saba aquifers, and have depths of 2400 and 2510 feet (Table 3.1). Both wells are connected to the same entry point in the water supply system, thus samples taken at the entry point cannot be associated with a specific well.

Radium levels measured at the entry point of the PWS are above the 5 pCi/L MCL (Table 3.2), gross alpha are >20 pCi/L (Table 3.3), and uranium are <1.5 pCi/L (Table 3.4). Levels of gross alpha are above the 15 pCi/L MCL after deducting the activity from uranium.

Table 3.1 Well Depth and Screen Interval Depths for Wells of the City of Melvin PWS

Water source	Depth (ft)	Screen depth (ft)	Aquifer
G1540003A	2510	-	Hickory (Cambrian system code 370CMBR)
G1540003B	2400	well openings from 2002 - 2400	Ellenburger – San Saba (code 367EBSS)

Table 3.2 Radium Concentrations at the City of Melvin PWS

Date	Source	Radium 226 (pCi/L)	Radium 228 (pCi/L)	Radium Total (pCi/L)
8/2/2001	EP1	5.7	4.4	10.1
10/31/2002	EP1	5.5	3.9	9.4
10/15/2003	EP1	6.7	4.3	11
11/23/2004	EP1	6.2	2.8	9

Table 3.3 Gross Alpha Concentrations at the City of Melvin PWS

Date	Source	Gross alpha (pCi/L)
11/23/2004	EP1	26.3
10/15/2003	EP!	24.7
10/31/2002	EP1	22.4
8/2/2001	EP1	34.4

Table 3.4 Uranium Concentrations at the City of Melvin PWS

Date	Source	Total Uranium (pCi/L)
8/2/2001	EP1	<1.5
10/31/2002	EP1	<1.5
10/15/2003	EP1	<1.5
11/23/2004	EP1	<1.5

Data from the TWDB and TCEQ do not show any wells with radium <5 pCi/L in the vicinity of the City of Melvin PWS (Figure 3.6). Well 4252504 is 3 km east of the City of Melvin PWS and has radium >60 pCi/L. Even at distances of 10 km no wells are identified with radium <5 pCi/L and the nearest well, well 4245601 (which is also well G1540002A in PWS 1540002), with radium below the MCL, is over 25 km from the City of Melvin PWS. Levels of gross alpha show similar results and the nearest PWS with low gross alpha (which might indicate low radium) is PWS 1540007, which is about 14 km to the east of the City of Melvin PWS (Figure 3.7). This PWS has shallower wells (depths from 88 to 110 feet) designated in the Antlers aquifer.

Figure 3.6 Radium in the 5- and 10-km Buffers of the City of Melvin PWS Wells

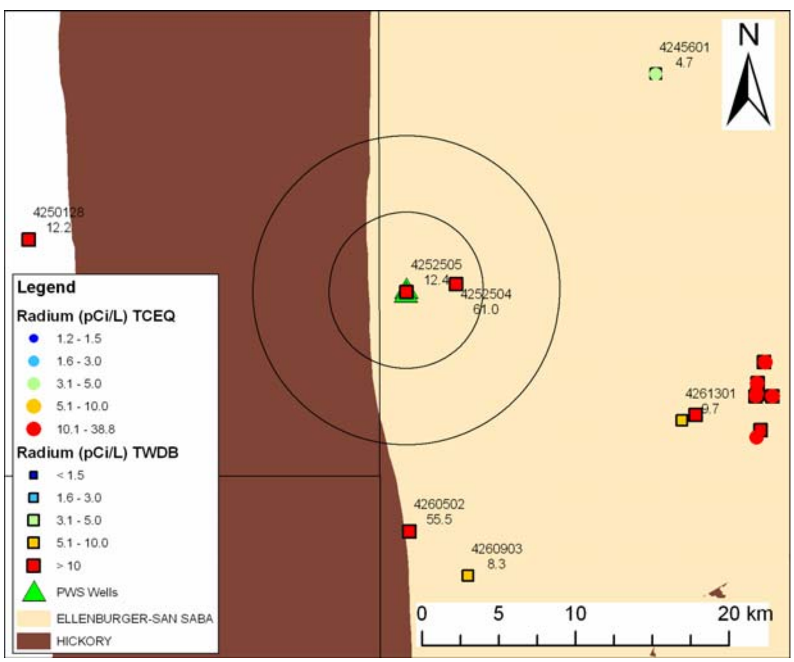
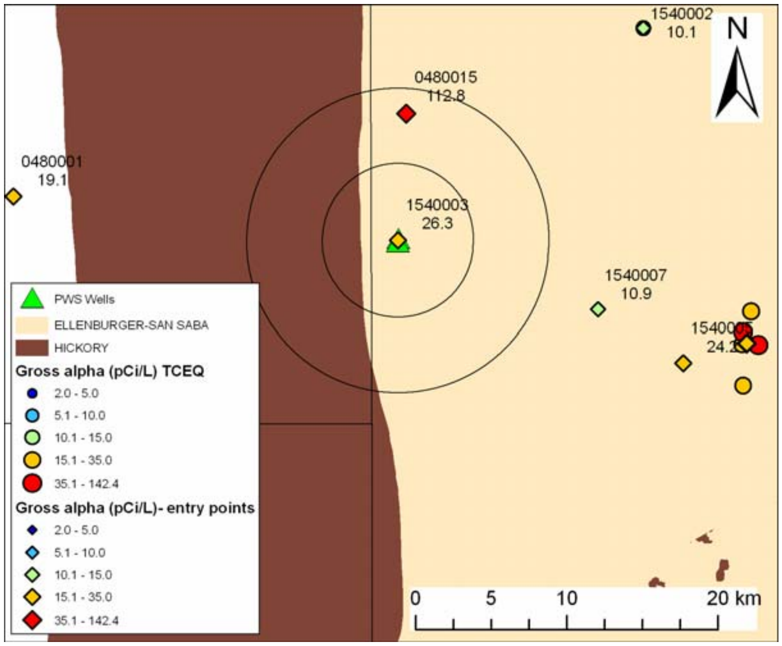


Figure 3.7 Gross Alpha in the 5- and 10-km Buffers of the City of Melvin PWS Wells



Potential Sources of Contamination (PSOC) are identified as part of TCEQ's Source Water Assessment Program. There are two radium PSOC sites identified in the vicinity of the City of Melvin PWS, these are waste sites located 3 and 6 km southeast of the PWS. Given the distance from the City of Melvin PWS wells and the depths of the wells (>2000 feet), these PSOCs are not expected to influence radium concentrations at the City of Melvin PWS.

The City of Melvin PWS has one primary use well and one backup well, and the radionuclide samples from routine monitoring are only for the primary use well. Since radionuclide concentrations can vary between wells, a decision was made to determine radionuclide concentrations for the backup well so that if the backup well was found to produce water with acceptable levels of radionuclides, as much production as possible could be shifted to that well.

With assistance from the City of Melvin, Parsons collected three water samples from each well for analysis. Detailed results of the analyses are presented in Appendix F. The results showed that the backup well also had radium concentrations above the MCL, with concentrations ranging between 7.0 and 8.0 pCi/L. Thus, this determined that system optimization would not be likely by adjusting well production. However, it still may be possible to identify natural deposits of materials that contain radium or alpha emitters through comparison of well logs or through sampling of water produced by various strata intercepted by the well screen.

3.3.2 Summary of Alternative Groundwater Sources

Data from TCEQ and TWDB databases do not show any wells in the vicinity (10 km) of the City of Melvin PWS with radium or gross alpha below the MCLs. Wells with better water quality are found at distances > 10 km and only one PWS well and one entry point are identified with radium and gross alpha below the MCL. The nearest PWS (PWS 1540007) with radium <5 pCi/L has shallower wells designated in the Antlers aquifer. This might indicate a possibility for finding alternative groundwater sources at shallower depths, although this is inconclusive given the limited number of samples.

SECTION 4
ANALYSIS OF THE CITY OF MELVIN PWS

4.1 DESCRIPTION OF EXISTING SYSTEM

4.1.1. Existing System

The City of Melvin PWS is shown on Figure 4.1. The PWS groundwater supply is the Wilberns formation of the Ellenburger-San Saba aquifer. The system includes one operational well and one backup well. The primary use well is 2,510 feet deep and draws water from the Cambrian System of the aquifer. The backup well is 2,400 feet deep and draws water from the Point Peak Shale of the Wilberns formation. The groundwater is treated by gas chlorination, as well as sequestration with polyphosphate for iron. Before distribution, water is pumped to a 50,000-gallon elevated storage tank.

The City of Melvin PWS has experienced issues with radionuclides in its drinking water over the past several years, with concentrations of combined radium (radium 226 and radium 228) and gross alpha above MCLs. Sample results for combined radium were recorded from November 1999 through November 2004 and ranged from 8.0 to 11.0 pCi/L (above the MCL of 5 pCi/L). Sample results for gross alpha were recorded between March 2001 and November 2004 and ranged from 19.7 to 30.9 pCi/L (above the MCL of 15 pCi/L). The PWS also recorded iron concentrations above the secondary drinking water standard. Iron concentrations recorded between March 1998 and November 2004 ranged from 0.427 to 0.55 mg/L (above the secondary standard of 0.3 mg/L).

The system has two wells (a primary use well and a backup well), and the radionuclide sample results from routine monitoring are for the primary use well only. Since radionuclide concentrations can vary between wells, the decision was made to determine radionuclide concentrations for the backup well. If the backup well was found to produce water with acceptable levels of radionuclides, as much production as possible could be shifted to that well to optimize the system and achieve compliance with minimal effort.

With the assistance of the City of Melvin, Parsons collected three water samples from each well and sent them for analysis. The detailed results of these analyses are presented in Appendix F. These results showed that water from the backup well, with radium concentrations ranging between 7.0 and 8.0 pCi/L, exceeded the MCL for radium. Consequently, system optimization is unlikely to be achieved by adjusting well production. However, it may still be possible to identify natural deposits of materials that contain radium or alpha emitters through comparison of well logs or through sampling of water produced by various strata intercepted by the well screen.

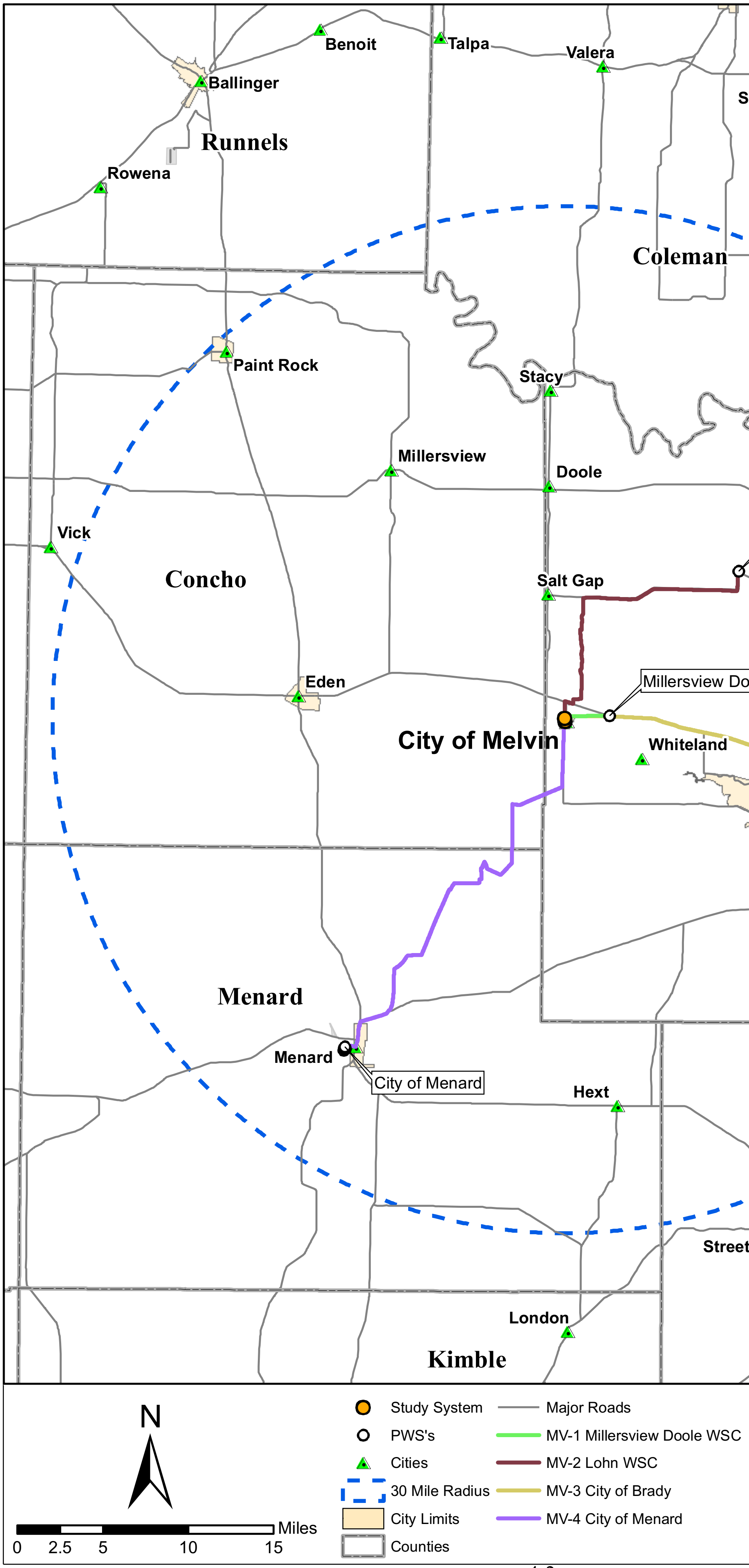


Figure 4.1

City of Melvin Pipeline Alternatives

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Basic system information is as follows:

- Population served: 200
- Connections: 126
- Average daily flow rate: 0.019 mgd
- Peak demand flow rate: 0.076 mgd
- Water system peak capacity: 0.164 mgd

<u>Raw Water Characteristics</u>:

- Typical total radium range: 8.0 to 11.0 pCi/L
- Typical gross alpha range: 19.7 to 30.9
- Typical iron range: 0.427 to 0.55 mg/L
- Typical TDS range: 356 to 383 mg/L
- Typical pH range: 7.4 to 7.9 s.u.
- Typical calcium range: 59.2 to 70 mg/L
- Typical magnesium range: 16 to 23.4 mg/L
- Typical sodium range: 44.3 to 62 mg/L
- Typical chloride range: 53 to 54 mg/L
- Typical bicarbonate (HCO_3) range: 295 to 303 mg/L
- Typical fluoride range: 0.8 to 0.8 mg/L
- Typical manganese range: 0.0091 to 0.011 mg/L

The City of Melvin PWS has investigated several possible solutions to its radiological issues, including installing a filter system and drilling a new groundwater well. However, the results indicated the system had an estimated capital cost of approximately $75,000, with operating costs ranging between $1.00 and $1.50 per 1,000 gallons of water treated. It was also indicated that the filter option that was investigated would produce a hazardous waste that would require disposal. The other 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.

The City of Melvin also worked with the TCEQ Regional Financial, Managerial and Technical Assistance Program to prepare Cost Options/Feasibility Study Checklist Surveys. An available FMT assessment was located in the TCEQ files. This assessment was performed in 2003 and indicated that the TCEQ and the City of Melvin had discussed several possible ways of reducing radionuclide levels, including the use of RO, IX, and EDR treatments, purchasing and blending water, or purchasing treated water. The FMT assessment noted that groundwater sources that meet all standards had not been identified within 5 miles of City of Melvin PWS. Surface water sources were also not considered to be a viable option.

The City also looked into purchasing water from Millersview Doole Water Supply Corporation (WSC). Millersville Doole is the nearest PWS to the City of Melvin (2.75 miles) and also has had radionuclide exceedances, but is currently pursuing a project to get surface water from Lake Ivie.

Additional discussions about possible sources for water have included the City of Brady and the Brady Lake PWS, which are being combined into one PWS. The City of Brady was constructing a surface water treatment plant. The City of Brady is 15 miles from the City of Melvin. The Brady Lake PWS is located 12.52 miles from the City of Melvin.

4.1.2 Capacity Assessment for the City of Melvin

The project team conducted a capacity assessment of the City of Melvin PWS. The results of this evaluation are separated into four categories: general assessment of capacity, positive aspects of capacity, capacity deficiencies, and capacity concerns. The general assessment of capacity describes the overall impression of technical, managerial, and financial capability of the water system. The positive aspects of capacity describe those factors the system is doing well. These factors should provide opportunities for the system to build on to improve capacity deficiencies. The capacity deficiencies noted are those aspects that are creating a particular problem for the system related to long-term sustainability. Primarily, these problems are related to the system's ability to meet current or future compliance, ensure proper revenue to pay the expenses of running the system, and to ensure the proper operation of the system. The last category is titled capacity concerns. These are items that in general are not causing significant problems for the system at this time. However, the system may want to address them before these issues have the opportunity to cause problems.

The project team interviewed the following individuals:

- Mike Hagan – City Administrator/Water Operator
- Abe Rodriguez – Outgoing City Mayor
- Bill Farris – Incoming City Mayor

4.1.2.1 General Structure of the Water System

The City of Melvin PWS serves approximately 200 people through 126 connections. With the exception of one business, all of the connections serve residential customers. The system consists of two wells and an elevated storage tank. Besides water service, the city only provides trash pickup. Revenues from water service account for 75-80 percent of the total city revenues. The city has only a part-time staff and a mayor.

4.1.2.2 General Assessment of Capacity

The system has an inadequate level of capacity. Although there are some positive aspects of the water system, there are some concerns, especially regarding managerial and financial capabilities.

4.1.2.3 Positive Aspects of Capacity

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

- **Knowledgeable and Dedicated Staff –** Although the city administrator/operator has only been with the system a short time, he has many years of experience as the Public Works Director in Brady. Both the outgoing mayor and the incoming mayor are very dedicated and knowledgeable about the water system and are familiar with the current Safe Drinking Water Act regulations. The city also participates on the Jicarilla Water Planning Group.

4.1.2.4 Capacity Deficiencies

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

- **Lack of Compliance –** The city received a compliance agreement from the TCEQ for exceeding the levels for combined radium 226 and 228 and gross alpha particle activity in 2005. Although they were in violation, they did not sign the agreement. They believed that since they did not have the funding available to install treatment, they could not agree to the conditions of the compliance agreement. They have, however, done extensive research into different treatment systems and associated costs. They have also sent out a questionnaire to all of their water customers asking that if 1 gallon of bottled water per person per day would be sufficient to provide for drinking water needs. Following the study, the city decided that it was not affordable to provide bottled water to residents. In addition, the questionnaire asked if customers would oppose or support a rate increase in order to install additional treatment. The system needs to commit to working toward compliance to avoid further escalation in enforcement actions.

- **Inability to Fully Cover Operating Expenses –** The revenues from the rates are insufficient to cover repair expenses. A recent water pump repair bill was $7,500 and the city had insufficient funds to cover the cost. They had to make arrangements to pay the costs over time.

- **Rate Setting Process –** Although the last water rate increase was in 2005, the previous increase was in 2000. Although rates are reviewed every year, they seem to be based on a comparison to neighboring cities rather than a through review of system expenses and needs. While it is reasonable to consider affordability and comparability, it is necessary to fully understand the cost of supplying water to customers and to set system specific rates that will provide for the system's long term needs. Additionally, the city budget does not separate water utility expenses from other city expenses, so there is insufficient information to determine how water system revenues compare to water expenses. Because the water system revenues fund other city services, the city is not able to fund a reserve account which could be used to address the current compliance issue.

- **Leaking Storage Tank –** The city received a grant of $174,900 from the Office of Rural Community Affairs to replace the deteriorated storage tank and to install water lines, a ground storage tank, fire hydrants, and valves. The original contractor who performed the work has filed for bankruptcy and the city is currently negotiating with the bonding company for the completion of the work with an alternate contractor.

- **Water Loss –** The water loss fluctuates from 2 to 41 percent a month. The city believes the loss is from unmetered water, the leaking overhead storage tank, and unauthorized use, which could account for the fluctuation. A reduction in water loss would significantly reduce the amount of water that must be pumped and/or treated. Reducing water losses could result in a cost savings depending on the compliance alternative implemented. In addition, there is no water conservation program. Conservation reduces the demand on the source, reduces chemical and electrical costs, and minimizes wear and tear on equipment such as pumps.

4.1.2.5 Potential Capacity Concerns

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

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

- **Written Operational Procedures –** According to the operator, there are only a few written operations procedures. The operator is very experienced and knowledgeable. However, if additional operators are hired, the lack of written operating procedures may cause problems.

4.2 ALTERNATIVE WATER SOURCE DEVELOPMENT

4.2.1 Identification of Alternative Existing Public Water Supply Sources

Using data drawn from the TCEQ drinking water and TWDB groundwater well databases, PWSs surrounding the City of Melvin PWS were reviewed with regard to reported drinking water quality and production capacity. PWSs without identified water quality issues were investigated further. PWSs that appeared to have water supplies with water quality issues were generally ruled. If it was determined those 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 existing PWSs within approximately 30 miles of the City of Melvin PWS. This distance was selected as the radius for the evaluation owing to the relatively small number of PWSs in proximity to the City of Melvin and because 30 miles was considered the upper limit of economic feasibility for construction of a new water line.

Table 4.1 Existing Public Water Systems Within 30 Miles of the City of Melvin PWS

System Name	Distance from City of Melvin PWS	Comments/Other Issues
Millersview Doole WSC (PWS 0480015)	2.8 miles	Large system that should have no WQ issues when surface water project is complete. ***Evaluate further***.
Lakeland Services (PWS 1540007)	8.7 miles	Small system . Secondary WQ issues due to sulfate and TDS ~ 2,000 mg/L.
Brady Lake Water System (PWS 1540005)	12 miles	Large system that should have no WQ issues when surface water project is complete. See City of Brady Below.
Lohn WSC (PWS 1540002)	13 miles	Small system. No WQ issues. **Evaluate further**.
City of Brady (PWS 1540001)	15 miles	Large system. that should have no WQ issues when surface water project is complete. **Evaluate further**.
City of Eden (PWS 0480001)	16 miles	Large system with WQ issues: radium and gross alpha.
Richland Special Utility District (SUD) Brady (PWS 1540008)	16 miles	Small system with WQ issues: radium and gross alpha.
Live Oak Hills Subdivision (PWS 1540012)	20 miles	Small system with WQ issues: radium and gross alpha.
Rochelle Water Supply Corp (PWS1540004)	22 miles	Small system with WQ issues: radium.

System Name	Distance from City of Melvin PWS	Comments/Other Issues
TXDOT Concho County Comfort (PWS 0480017)	23 miles	Small system. No radium data.
City of Menard (PWS 1640001)	23 miles	Large system. No WQ issues. Evaluate further.
Keeper's Kove Restaurant (PWS 0480018)	25 miles	Small system. No radium data.
Concho Park Inc (PWS 0480019)	25 miles	Small system. No radium data.
City of Paint Rock (PWS 0480012)	29 miles	Small system with WQ issues: radium.

Based on the initial screening summarized in Table 4.1, several alternatives were selected for further evaluation. PWSs with good water quality were carried forward for further evaluation. These alternatives are summarized in Table 4.2.

Table 4.2 Public Water Systems Within the Vicinity of the City of Melvin Selected for Further Evaluation

System Name	Pop	Conn	Total Production (mgd)	Ave Daily Usage (mgd)	Approx. Dist. from City of Melvin PWS	Comments/Other Issues
Millersview Doole WSC (PWS 0480015)	3,455	1,382	1.224	0.665	2.8 miles	Large water provider that would be interested in selling water.
Lohn WSC (PWS 1540002)	200	66	0.112	0.023	13 miles	No excess capacity. However, based on WQ data, this PWS may provide a suitable location for a new well.
City of Brady (PWS 1540001)	5,433	2,854	5.695	1.430	15 miles	Once treatment plant is complete, may have sufficient capacity to sell water.
City of Menard (PWS 1640001)	1,653	823	1.512	0.210	23	No excess capacity at present. However, if the plant was expanded, the current water allocation might be sufficient for selling water

4.2.1.1 Millersview Doole WSC (PWS 0480015)

Millersville Doole is the nearest PWS to the City of Melvin (2.75 miles) and also has had radionuclide exceedances, but is currently pursuing a project to get surface water from Lake Ivie. It is expected that Millersview-Doole WSC will have treated surface water in 2008.

The Millersville Doole community PWS serves parts of rural Concho, McCulloch, Runnels, and Tom Green counties. There are 1,382 retail connections (including 1,255 well accounts, one wholesale account at Paint Rock, and 127 purchased water accounts at Tyler-Terrace). The retail population is estimated at 3,455.

The Millersview-Doole PWS will have sufficient capacity to supply water to the City of Melvin PWS, and is considered as a possible alternative for purchasing compliant water.

4.2.1.3 Lohn WSC (PWS 1540002)

Lohn WSC is located in the City of Lohn, approximately 13.38 miles northeast of the City of Melvin. The system is supplied by a single groundwater well completed in the Hickory Sandstone formation. The well is 2,746 feet deep and has a total production of 0.112 million gallons per day (mgd). Water is disinfected with chlorine before being sent to two 2,500-gallon storage tanks. Total service pump capacity is 0.576 mgd, and total storage is 0.050 million gallons. The system serves a population of 200, and has an approximate average daily usage of 0.023 mgd to 66 metered connections.

This WSC does not have sufficient excess capacity to supplement the City of Melvin PWS; however, based on the available water quality data, the location may be a suitable point for a new groundwater well.

4.2.1.4 City of Brady (PWS 1540001)

The City of Brady is located approximately 15 miles southeast of the City of Melvin. The City of Brady PWS has five active and one inactive groundwater wells. The wells are approximately 2,060–2,250 feet deep with production capacity of 350–650 gpm. The groundwater has elevated levels of radium. The City has a water allocation of 1,000 acre-feet per year (AFY) from the Brady Lake Reservoir and is currently building a water treatment plant with a capacity of 1.5 mgd to treat the surface water and blend with the groundwater. Average groundwater production is approximately 1.45 mgd, with a peak use of 3.5 mgd during drought conditions; normal peak use is 2.5 mgd in 2004.

The City plans to initially mix the water in a 50/50 ratio to provide finished water that meets standards. After contaminant concentrations are measured, the mix will be adjusted to minimize the use of the surface water. When the water treatment plant is completed, there will be excess production capacity within the system. There is an interconnection with the City of Richland for emergency purposes.

The City does not currently have sufficient capacity at this time to sell water outside of their community. After the plant is completed, they will determine the amount of excess capacity based on a blending optimization study. They used grants and loans from the Texas Water Development Board, to cover the costs of the upgrades.

4.2.1.5 City of Menard (PWS 1640001)

The City of Menard is located approximately 23 miles southwest of the City of Melvin. The City of Menard has four active wells and one inactive shallow groundwater well approximately 20–25 feet bgs with a production capacity of 250–300 gpm. The wells are located close to the San Saba River and are subject to flooding and infiltration, as is the City's water treatment plant. The City has a water allocation of 1,000 AFY (which equates to approximately 0.89 mgd) from the San Saba River, though the City is not currently using all of the allocation.

Surface water is treated by sedimentation and rapid sand filtration prior to chlorination and blending with the groundwater. The City of Menard's maximum daily water use is 0.56 mgd, with an average of approximately 0.30 mgd. The system currently has a capacity to produce up to 0.70 mgd, although the City does not consider it has sufficient capacity to sell water outside its community.

The City of Menard does not have sufficient storage capacity and is currently in the planning/financing stage of building a new storage tank and four pump stations, upgrading its distribution system, and flood-proofing the groundwater wells and water treatment plant. In addition, the City plans on adding a 3,500-foot deep well to the Hickory aquifer it estimates would cost approximately $150,000. The City has used grants and loans obtained from the U.S. Department of Agriculture Rural Utility Service, which authorized a 75 percent grant and 25 percent low interest rate loan to cover the costs of these improvements.

The City currently charges residential customers $10.00 for their first 2,000 gallons of water and $2.00 per 1,000 additional gallons. The City finds it helpful to list the groundwater well water levels in its monthly billing statements to help with water conservation.

While the City of Menard does not presently have sufficient capacity to sell water to other entities, its current water allocation might be sufficient to supply the City of Melvin with treated water if the City of Menard's water treatment plant was expanded and a pipeline was constructed to transfer the purchased water.

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 and gross alpha, 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 a water well. As a result, existing nearby wells with good water quality should be investigated. Re-sampling and test pumping would be required to verify and determine the quality and quantity of water at those wells.

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

Some of the alternatives suggest new wells be drilled in areas where existing wells are compliant. In developing the cost estimates, it is assumed the aquifer in these areas would produce the required amount of water with only one well. Site investigations and geological research, which are beyond the scope of this study, could indicate whether the aquifer at a particular site and depth would provide the amount of water needed or if more than one well would need to be drilled in separate areas. Two wells are used in cases where the PWS is large enough that two wells are required by TCEQ rules.

4.2.2.2 Results of Groundwater Availability Modeling

Two minor aquifers, the Ellenburger-San Saba and Hickory, are the primary groundwater sources in throughout most of McCulloch County where the PWS is located. According to TCEQ records, the City of Melvin PWS groundwater supply is the Wilberns formation of the Ellenburger-San Saba aquifer.

The Ellenburger-San Saba aquifer crops out from Llano County in a circular pattern and dips radially into the subsurface of 12 adjacent counties. According to the spatial distribution provided by the 2002 Texas Water Plan, the aquifer outcrop covers the southeast section McCulloch County, while its downdip extends throughout the entire county, including the City of Melvin. Wells completed in the aquifer commonly yield between 200 and 500 gallons per minute (gpm) (U.S. Geological Survey [USGS] 2006). No GAM has yet been developed for the Ellenburger-San Saba aquifer. The 2002 Texas Water Plan estimates that current supply of this aquifer will remain near its current value of 22,580 acre-feet per year over the next 50 years.

The Hickory aquifer, similarly to the Ellenburger-San Saba aquifer, radiates from Llano County into McCulloch County. The aquifer downdip extends throughout the entire county, including the City of Melvin, underlain by the Ellenburger-San Saba aquifer. Wells completed in the aquifer commonly yield as much as 1,000 gpm(USGS 2006). A GAM is under development by the TWDB for the Hickory aquifer but simulation data are not yet available. The 2002 Texas Water Plan indicates that the groundwater supply from the Hickory aquifer will steadily decline over several decades. The estimated supply decline is 9 percent, from 50,699 acre-feet per year in 2000 to 46,133 AFY in 2050.

The City of Melvin PWS overlays a third, shallower groundwater source, the Antlers Sand formation of the Trinity aquifer. Current aquifer utilization in the PWS vicinity is minimum, but some shallow wells are located sources within 10 miles of the City of Melvin. The Trinity aquifer 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.

4.2.3 Potential for New Surface Water Sources

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

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

The vicinity of the City of Melvin PWS has a minimum availability of surface water for new uses as indicated by the TCEQ's availability maps for the Colorado Basin. In the site vicinity, and over the entire McCulloch County, unappropriated flows for new uses are available at most 25 percent of the time. This supply is inadequate as the TCEQ requires 100 percent supply availability for a PWS.

4.2.4 Options for Detailed Consideration

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

1. Millersview Doole WSC. Negotiate with the City of Millersview Doole to purchase water (Alternative MV-1).

2. Lohn WSC. A new groundwater well would be completed in the vicinity of the well at Lohn WSC. A pipeline would be constructed and the water would be piped to the City of Melvin PWS (Alternative MV-2).

3. City of Brady. Water would be purchased from the City of Brady. A pipeline would be constructed to convey water from the City of Brady's water treatment plant to the City of Melvin PWS (Alternative MV-3).

4. City of Menard. Negotiate with the City of Menard to expand its surface water treatment facility and sell excess water. A pipeline would be constructed to transport water from Menard to the City of Melvin PWS (Alternative MV-4).

5. Installing a new well within 10, 5, or 1 mile of the City of Melvin PWS that would produce compliant water (Alternatives MV-5, MV-6, and MV-7).

4.3 TREATMENT OPTIONS

4.3.1 Centralized Treatment Systems

Centralized treatment of well field water is identified as a potential for the City of Melvin PWS. Ion exchange, WRT Z-88 adsorption, and $KMnO_4$-greensand filtration are potential applicable processes. The central IX treatment alternative is Alternative MV-8, the central Z-88 treatment process alternative is Alternative MV-9, and the central $KMnO_4$-greensand treatment alternative is Alternative MV-10.

4.3.3 Point-of-Use Systems

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

4.3.4 Point-of-Entry Systems

POE treatment using resin based adsorption technology or RO is valid for total radium removal. The POE treatment alternative is MV-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 MV-13, MV-14, and MV-15.

4.5 ALTERNATIVE DEVELOPMENT AND ANALYSIS

A number of potential alternatives for compliance with the MCL for total radium and gross alpha 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 MV-1: Purchase Water from Millersview-Doole

This alternative involves purchasing compliant water from the Millersview-Doole WSC, which would be used to supply the City of Melvin PWS. Millersview-Doole WSC will have excess production capacity and might be willing to consider selling water.

This alternative would require construction of a storage tank at a point adjacent to the Millersview-Doole WSC water system, and a pipeline from the tank to the City of Melvin PWS. A pump station would also be required to overcome pipe friction and the elevation differences between Millersview-Doole WSC and the City of Melvin. From Millersview-Doole to Melvin, the required pipeline would be constructed of 4-inch pipe and would follow farm-to-market road (FM) 138 to McGee Street. Using this route, the length of pipe required would be approximately 2.7 miles. The required pump horsepower is 2 hp.

The pump station would include one pump, and would be housed in a building. It is assumed the pump and piping would be installed with capacity to meet all water demand for the City of Melvin PWS even if blending is planned, since the incremental cost would be relatively small, and it would provide operational flexibility.

This alternative involves regionalization by definition, since the City of Melvin PWS would be obtaining drinking water from an existing larger supplier. It is possible the City of Melvin PWS could turn over provision of drinking water to Millersview-Doole WSC instead of purchasing water.

The estimated capital cost for this alternative includes constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the purchase price for the water minus the cost that Midway MHP PWS currently pays to operate its well, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $694,495, and the alternative's estimated annual O&M cost is $19,432. 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 Millersview-Doole WSC has adequate O&M resources. From the perspective of the City of Melvin, 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 they currently operate wells and pipelines. If the decision was made to perform blending, the operational complexity would increase.

The feasibility of this alternative is dependent on an agreement being reached with the Millersview-Doole WSC to purchase compliant drinking water.

4.5.2 Alternative MV-2: New Well in the Vicinity of Lohn WSC

This alternative involves the completion of a new well in the vicinity of Lohn WSC, and the construction of a pump station and pipeline to transfer the pumped groundwater to the City of Melvin PWS. Based on the water quality data in the TCEQ database, it is expected groundwater from this well would be compliant with drinking water MCLs. An agreement would need to be negotiated with Lohn WSC to expand its well field.

This alternative would require completion of a new well and storage tank at Lohn WSC, and construction of a pipeline from that well to the existing intake point for the City of Melvin PWS. A pump station would also be required to overcome pipe friction and the elevation differences between Lohn WSC and the City of Melvin. From Lohn WSC to the City of Melvin PWS, the required pipeline would be constructed of 4-inch pipe and would follow Ranch Road (RR) 504, FM 350, FM 146, FM 128, Highway 87 and RR 2028. Using this route, the pipeline required would be approximately 18.75 miles in length. The pipeline would terminate at the existing storage tank owned by the City of Melvin PWS. The required pump horsepower would be 6 hp.

The pump station would include two pumps, 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 City of Melvin PWS even if blending is planned, since the incremental cost would be relatively small, and it would provide operational flexibility.

This alternative presents a limited regional solution since Lohn WSC and the City of Melvin PWS would be working together. The may be other potential water users located along the pipeline route that would be willing to share the cost of this alternative.

The estimated capital cost for this alternative includes completing the new well, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the maintenance cost for the pipeline, power, and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $4,205,084, and the alternative's estimated annual O&M cost is $20,229.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of the City of Melvin, 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 the PWS currently operates pipelines and a pump station.

The feasibility of this alternative is dependent on the City of Melvin being able to reach an agreement with Lohn WSC with regard to completing a new groundwater well.

4.5.3 Alternative MV-3: Purchase Water from the City of Brady

This alternative involves purchasing compliant water from the City of Brady, which would be used to supply the City of Melvin PWS. The City indicated there is excess production capacity within its PWS following completion of its water treatment plant. It is possible this excess might be sufficient to supply the City of Melvin PWS, assuming an agreement could be negotiated.

This alternative would require construction of a storage tank at a point adjacent to the City of Brady water system, and a pipeline from the tank to the existing intake point for the City of Melvin PWS. A pump station would also be required to overcome pipe friction and elevation differences between Brady and Melvin. From Brady to Melvin, the required pipeline would be constructed of 4-inch pipe and would follow, White Street, Highway 87, FM 138, and

McGee St. Using this route, the length of pipe required would be approximately 15.5 miles. The pipeline would terminate at the existing storage tank owned by the City of Melvin. The required pump horsepower would be 5 hp

The pump station would include one pump, and would be housed in a building. It is assumed the pump and piping would be installed with capacity to meet all water demand for the City of Melvin PWS even if blending is planned, since the incremental cost would be relatively small, and would provide operational flexibility.

This alternative involves regionalization by definition, since the City of Melvin PWS would be obtaining drinking water from an existing larger supplier.

The estimated capital cost for this alternative includes constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost the City of Melvin PWS currently pays to operate its well field, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $3,438,062, and the alternative's estimated annual O&M cost is $22,824. If the purchased water was used for blending rather than for 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 Brady already supplies groundwater on a fairly large scale, and has adequate O&M resources. From the perspective of the City of Melvin, 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 the City currently operates pipelines and a pump station. If the decision was made to perform blending then the operational complexity would increase.

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

4.5.4 Alternative MV-4: Purchase Water from the City of Menard

This alternative involves purchasing compliant water from the City of Menard, which would be used to supply the City of Melvin PWS . While the City of Menard does not currently have excess capacity, it is in the process of expanding its system. Once these modifications are complete, the City indicated it may have sufficient excess capacity and would be amenable to negotiating an agreement to supply water to other local PWSs.

This alternative would require construction of a storage tank at a point adjacent to the City of Menard PWS, and a pipeline from the tank to the existing intake point for the City of Melvin PWS. A pump station would also be required to overcome pipe friction and any elevation differences between Menard and Melvin. From Menard to Melvin, the required pipeline would be constructed of 4-inch pipe and would follow FM 2092, San Saba Avenue, state highway

(SH) 83, SH 190, Callan Lane., County Road. 3326, RR 2028, and Noyes Ave. Using this route, the length of pipe required would be 28.9 miles. The pipeline would terminate at the existing storage tank owned by the City of Melvin.

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 City of Melvin PWS even if blending is planned, since the incremental cost would be relatively small, and it would provide operational flexibility.

This alternative involves regionalization by definition, since the City of Melvin PWS would be obtaining drinking water from an existing larger supplier.

The estimated capital cost for this alternative includes constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost the City of Melvin currently pays to operate its well field, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $6,233,807, and the alternative's estimated annual O&M cost is $26,635. If the purchased water was used for blending rather than for 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 as the City of Menard should have adequate O&M resources. From the perspective of the City of Melvin, 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 the City currently operates pipelines and a pump station. If the decision was made to perform blending then the operational complexity would increase.

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

4.5.5 Alternative MV-5: New Well at 10 miles

This alternative consists of installing a new well within 10 miles of the City of Melvin that would produce compliant water in place of the water currently produced by the City of Melvin PWS. At this level of study, it is not possible to positively identify existing wells or the locations where new wells could be installed.

This alternative would require construction of a new 250-foot well, a new pump station with storage tank near the new well, and a pipeline from the new well/tank to the existing intake point for the City of Melvin PWS. The pump station and storage tank would be necessary to overcome pipe friction and changes in land elevation. For this alternative, the pipeline is assumed to be 10 miles long, and would be a4-inch line that discharges to the existing storage tank at the City of Melvin 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 options for a more regional solution. It may be possible to share water and costs with another nearby system.

The estimated capital cost for this alternative includes installing the well and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes O&M for the pipeline and pump station. The estimated capital cost for this alternative is $2,255,875, and the estimated annual O&M cost for this alternative is $17,099.

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

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

4.5.6 Alternative MV-6: New Well at 5 miles

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

This alternative would require constructing a new 250-foot well, a new pump station with storage tank near the new well, and a pipeline from the new well/tank to the existing intake point for the City of Melvin PWS. The pump station and storage tank would be necessary to overcome pipe friction and changes in land elevation. For this alternative, the pipeline is assumed to be 5 miles long, and would be a 4-inch line that discharges to the existing storage tank at the City of Melvin. 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 well and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the cost for O&M for the pipeline and pump station. The estimated capital cost for this alternative is $1,316,122, and the estimated annual O&M cost for this alternative is $15,719.

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

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

4.5.7 Alternative MV-7: New Well at 1 mile

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

This alternative would require construction of a new 250-foot well, , and a pipeline from the new well to the existing intake point for the City of Melvin PWS. For this alternative, the pipeline is assumed to be 1 mile long, and would be a 4-inch line that discharges to the existing storage tank at the City of Melvin PWS.

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

The estimated capital cost for this alternative includes installing the well and constructing the pipeline. The estimated O&M cost for this alternative includes the cost for O&M for the pipeline. The estimated capital cost for this alternative is $249,286 and the estimated annual O&M cost saving for this alternative is $548.

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

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

4.5.8 Alternative MV-8: Central IX Treatment

The system would continue to pump water from the City of Melvin PWS Well No. 1, and would treat the water through an IX system prior to distribution. For this option, a fraction (*i.e.*, 70%) of the raw water would be treated and then blended with the untreated stream to obtain overall compliant water as the radium concentration is not very high. 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 fenced City of Melvin PWS Well No. 1 site, features a 400 square feet (ft^2) building with a paved driveway; the pre-constructed IX equipment on a skid, a 24"x50" commercial brine drum with regeneration equipment, two transfer pumps, a 5,000-gallon tank for storing the treated water, a 2,000-gallon tank for storing spent backwash water, and a 2,000 gallon tank for storing regenerant waste. The backwash would be equalized in the backwash tank and recycled to the IX treatment unit at a very low rate. Accumulated sludge would be trucked off-site periodically for disposal along with the regenerant waste. The treated water would be chlorinated and stored in the new treated water tank prior to being pumped into the distribution system.

The estimated capital cost for this alternative is $303,920, and the estimated annual O&M cost is $39,950.

Reliability of supply of adequate amounts of compliant water under this alternative is good, since IX treatment is a common and well-understood treatment 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 MV-9: WRT Z-88 Treatment

The system would continue to pump water from the City of Melvin PWS Well No. 1, 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 of by WRT in an approved low-level radioactive waste landfill after 1-2 years of operation.

This alternative consists of constructing the Z-88™ treatment system at the existing fenced City of Melvin PWS Well No. 1 site. WRT owns the Z-88™ equipment and the City pays for the installation of the system and auxiliary facilities. The plant comprises of a 400 ft^2 building with a paved driveway; the pre-constructed Z-88 adsorption system (2-54" diameter x 115" tall vessels) owned by WRT; and piping system. The treated water will be chlorinated prior to distribution. It is assumed the well pumps have adequate pressure to pump the water through the Z-88 system and to the existing storage tank without requiring new pumps.

The estimated capital cost for this alternative is $296,380 and the annual O&M cost is estimated to be $33,890.

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 is the treated water fee charged by WRT. One concern with this technology is the potential health effect of the level of radioactivity accumulated in the Z-88™ vessel on O&M personnel when the media have been operating for a long time.

4.5.10 Alternative MV-10: $KMnO_4$-Greensand Filtration

The system would continue to pump water from the City of Melvin PWS Well No. 1, and would treat the water through a greensand filter system prior to distribution. For this option, the entire flow of the raw water will be treated and the flow will be decreased when one of the two 50 percent filters is being backwashed by raw water. It is assumed the existing well pumps have adequate pressure to pump the water through the greensand filters and into the existing storage tanks.

The greensand plant, located at the fenced City of Melvin PWS Well No. 1 site, features a 400 ft^2 building with a paved driveway; the pre-constructed filters and a $KMnO_4$ solution tank on a skid; a 4,000 gallon spent backwash tank, and piping systems. The backwash would be equalized in the backwash tank and recycled to the treatment unit at a very low rate. Accumulated sludge would be trucked off-site periodically for disposal.

The estimated capital cost for this alternative is $408,030 and the annual O&M is estimated to be $33,880.

Reliability of supply 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 is moderate and the operating personnel needs to ensure that $KMnO_4$ is not overfed. The spent backwash water contains MnO_2 particles with sorbed radium and the level of radioactivity in the backwash is relatively low.

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

This alternative consists of the continued operation of the City of Melvin PWS, plus treatment of water to be used for drinking or food preparation at the point of use to remove radium and gross alpha particle emitters. 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 installation of the POU treatment units in residences and other buildings that provide drinking or cooking water. The City of Melvin PWS would be responsible for purchasing and maintaining 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 would require entry by City or contract personnel into the houses of customers. As a result, the cooperation of customers would be important for success in implementing this alternative. The treatment units could be installed so 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 radium and gross alpha particle 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 regional 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 $83,160, and the estimated annual O&M cost for this alternative is $79,897. For the cost estimate, it is assumed that one POU treatment unit will be required for each of the 126 connections for the City of Melvin PWS. It should be noted that the POU treatment units would need to be more complex than units typically found in commercial retail outlets in order to meet regulatory requirements, making purchase and installation more expensive.

The reliability of adequate amounts of compliant water under this alternative is fair, since it relies on the active cooperation of the customers for system installation, use, and maintenance, and only provides compliant water to single tap within a house. Additionally, the O&M efforts required for the POU systems would be significant, and the City of Melvin PWS personnel are inexperienced in this type of work. From the perspective of the City of Melvin, this alternative would be characterized as more difficult to operate due to the in-home requirements and 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 MV-12: Point-of-Entry Treatment

This alternative consists of the continued operation of the City of Melvin PWS, plus treatment of water as it enters residences to remove radionuclides. The purchase, installation, and maintenance of the treatment systems at the POE to a household would be necessary for this alternative. Blending is not an option in this case.

This alternative would require installation of the POE treatment units at residences and other buildings that provide drinking or cooking water. The City of Melvin PWS 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 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 regional solution.

The estimated capital cost for this alternative includes purchasing and installing the POE treatment systems. The estimated O&M cost for this alternative includes purchasing and replacing filters and media or membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $1,455,300, and the estimated annual O&M cost for this alternative is $177,547. For the cost estimate, it is assumed that one POE treatment unit would be required for each of the 126 existing connections to the City of Melvin PWS.

The reliability of adequate amounts of compliant water under this alternative is fair, but better than POI systems since it relies less on the active cooperation of customers for system installation, use, and maintenance, and compliant water is supplied to all taps within a house. Additionally, O&M efforts required for the POE systems would be significant, and the City of Melvin PWS personnel are inexperienced in this type of work. From the perspective of the City of Melvin, this alternative would be characterized as more difficult to operate due 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 MV-13: Public Dispenser for Treated Drinking Water

This alternative consists of the continued operation of the City of Melvin PWS, 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 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.

The City of Melvin would be responsible for maintaining the treatment units, including media or membrane replacement, periodic sampling, and necessary repairs. The spent media or membranes would require disposal. This alternative relies on a great deal of cooperation and action from customers to be effective.

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing and installing the treatment system to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes purchasing and replacing filters and 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 $16,982.

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

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

4.5.14 Alternative MV-14: 100 Percent Bottled Water Delivery

This alternative consists of the continued operation of the City of Melvin PWS, but compliant drinking water would be delivered in containers to customers. This alternative involves setting up and operating a bottled water delivery program to serve all customers in the system. It is expected the City of Melvin PWS 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 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 would be provided to 100 percent of the City of Melvin PWS's customers.

This alternative does not present options for a regional solution.

The estimated O&M cost for this alternative includes program administration and purchase of the bottled water, including costs for periodic sampling and record keeping. The estimated capital cost for this alternative is $24,666, and the estimated annual O&M cost for this alternative is $141,040. For the cost estimate, it is assumed 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 would require attention from the City of Melvin PWS.

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

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

This alternative consists of continued operation of the City of Melvin PWS, plus dispensing compliant water for drinking and cooking at a publicly accessible location. The compliant water would be purchased from the City of Brady, and would be 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.

The City of Melvin PWS would purchase a truck 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 does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing a water truck and constructing 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 $102,986, and the estimated annual O&M cost for this alternative is $16,781.

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. The City of Melvin PWS has not provided this type of service in the past. From the perspective of the City of Melvin, 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.

4.5.17 Summary of Alternatives

Table 4.3 provides a summary of the key features of each alternative for the City of Melvin PWS.

Table 4.3 Summary of Compliance Alternatives for the City of Melvin

Alt No.	Alternative Description	Major Components	Capital Cost [1]	Annual O&M Cost	Total Annualized Cost [2]	Reliability	System Impact	Remarks
MV-1	Purchase water from Millersview-Doole WSC	- Pump station - 2.7-mile pipeline	$694,495	$19,432	$79,981	Good	N	Agreement must be successfully negotiated with Millersview-Doole WSC. Blending may be possible.
MV-2	New well at Lohn WSC	- New well - Pump station (2 pumps) - 18.75-mile pipeline	$4,205,084	$20,229	$386,848	Good	N	Agreement must be successfully negotiated with Lohn WSC. Blending may be possible.
MV-3	Purchase water from City of Brady	- Pump station - 15.5-mile pipeline	$3,438,062	$22,824	$322,570	Good	T	Agreement must be successfully negotiated with the City of Brady. Blending may be possible.
MV-4	Purchase water from City of Menard	- Pump station - 28.9-mile pipeline	$6,233,807	$26,635	$570,127	Good	T	Agreement must be successfully negotiated with the City of Menard. Blending may be possible.
MV-5	Install new compliant well within 10 miles	- New well - 10-mile pipeline	$2,255,875	$17,099	$213,777	Good	N	May be difficult to find well with good water quality.
MV-6	Install new compliant well within 5 miles	- New well - 5-mile pipeline	$1,316,122	$15,719	$130,465	Good	N	May be difficult to find well with good water quality.
MV-7	Install new compliant well within 1 mile	- New well - 1-mile pipeline	$249,286	$(548)	$21,186	Good	N	May be difficult to find well with good water quality.
MV-8	Continue operation of City of Melvin PWS wells with central IX treatment	- Central IX treatment plant	$303,920	$39,950	$66,447	Good	T	No nearby system to possibly share treatment plant cost.
MV-9	Continue operation of City of Melvin PWS wells with central WRT Z-88™ treatment	- Central WRT Z-88™ treatment plant	$296,380	$33,890	$59,729	Good	T	No nearby system to possibly share treatment plant cost.
MV-10	Continue operation of City of Melvin PWS wells with central $KMnO_4$ greensand filtration treatment	- Central $KMnO_4$ greensand filtration treatment plant	$408,030	$33,880	$69,494	Good	T	No nearby system to possibly share treatment plant cost.
MV-11	Continue operation of City of Melvin PWS wells, and POU treatment	- POU treatment units	$83,160	$79,897	$87,147	Fair	T, M	Only one compliant tap in home. Cooperation of residents required for installation, maintenance, and testing.
MV-12	Continue operation of City of Melvin PWS wells, and POE treatment	- POE treatment units	$1,455,300	$177,547	$304,426	Fair (*better than POU*)	T, M	All home taps compliant and less resident cooperation required.

Alt No.	Alternative Description	Major Components	Capital Cost [1]	Annual O&M Cost	Total Annualized Cost [2]	Reliability	System Impact	Remarks
MV-13	Continue operation of City of Melvin PWS wells, but furnish public dispenser for treated drinking water	- Water treatment and dispenser unit	$11,600	$16,982	$17,993	Fair/interim measure	T	Does not provide compliant water to all taps, and requires a lot of effort by customers.
MV-14	Continue operation of City of Melvin PWS wells, but furnish bottled drinking water for all customers	- Set up bottled water system	$24,666	$141,040	$143,190	Fair/interim measure	T, M	Does not provide compliant water to all taps, and requires customers to order and use. Management of program may be significant.
MV-15	Continue operation of City of Melvin PWS wells, but furnish public dispenser for trucked drinking water.	- Construct storage tank and dispenser - Purchase potable water truck	$102,986	$16,781	$25,760	Fair/interim measure	T, M	Does not provide compliant water to all taps, and requires a lot of effort by customers.

Notes: *N – No significant increase required in technical or management capability*
T – Implementation of alternative would require increase in technical capability
M – Implementation of alternative would 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. Information that was available to complete the financial analysis included the 2004 Report of Audit for the City of Melvin with revenues and expenses for the water district, as well as the "Capacity Assessment" document prepared after conducting interviews with the City of Melvin PWS personnel.

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

Although operating revenue from water service is treated separately within the financial statements, operating expenses are consolidated and include all the city services. Therefore expenditures for the water system were estimated based on expenditures for other systems of similar size. Water revenues represent more than 70 percent of total revenues for the City of Melvin, and are used to fund other City expenditures. The City has no outstanding water system bond indebtedness or notes payable.

Total revenues generated by water sales and service reported by the City of Melvin were $65,238. Based on water sales, it was estimated that the average monthly water bill per customer amounted to $42.72. This value was entered into the financial model. Total Operating Expenses reported by the City of Melvin PWS were estimated to be $38,700

4.6.2 Current Financial Condition

4.6.2.1 Cash Flow Needs

The City of Melvin PWS customers are currently charged a base rate of $25 per month for the first 3,000 gallons; and $1.50 per 1,000 gallons for more than 3,000 gallons. Customers outside the City Limits are charge an additional $7 flat fee. Using the estimated water usage rates as noted above, the current average annual water bill for the City of Melvin PWS customers is estimated to be $513 or about 2.2 percent of the Zip Code 76858 Tract MHI of $23,611.

The City of Melvin's 2004 financial data reveal that the water sales revenues are greater than the operating expenses. Overall, the City had excess revenues of $2,000, which indicates the excess revenues from the water system are funding other City expenditures. The report also indicates that City of Melvin has a cash reserve of approximately $17,000, which is sufficient to maintain total PWS operations for 2 months, based on current expenditures. Depending on the cost of the treatment alternative selected, it is likely the City of Melvin PWS will need to raise water rates or increase another source of revenues to pay for any capital improvements for the various alternatives that may be implemented to address the water quality compliance issues concerning radium.

4.6.2.2 Ratio Analysis

Current Ratio= 1.0+

The Current Ratio is a measure of liquidity. A Current Ratio for the water system could not be determined since current assets and liabilities are consolidated on the balance sheet. However, the Current Ratio exceeds 1.0 for the current assets and liabilities of the City or Melvin. Therefore, it is assumed that a similar Current Ratio is applicable to the City's water system. This Current Ratio indicates that the City of Melvin's PWS is able to meet its current obligations.

Debt to Net Worth Ratio=<1.0

A Debt-to-Net-Worth Ratio could not be determined because of the lack of appropriate financial data to determine this ratio. However, considering that the City of Melvin has no outstanding bond indebtedness or long-term notes payable, the PWS's Debt-to-Net-Worth Ratio is very favorable, indicating a financially healthy enterprise.

Operating Ratio = 1.7

In 2004 City of Melvin had operating revenues of $64,596 and operating expenses were estimated to be $38,700 resulting in an Operating Ratio equal to 1.7. Thus, in fiscal year 2004 the water system operating revenues were sufficient to cover the water system operating expenses.

4.6.3 Financial Plan Results

Each of the compliance alternatives for the Melvin PWS 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 Subsection 2.4.

For State Revolving Fund (SRF) funding options, customer MHI compared to the state average determines the availability of subsidized loans. According the 2000 U.S. Census data, the Zip Code MHI for customers of the City of Melvin PWS was $23,611, which is less than 60 percent of the statewide income average of $39,927. As a result, the City of Melvin PWS would likely qualify for a loan at an interest rate of 0 percent and forgiveness of 15 percent from the SRF. In the event SRF funds would be unavailable, City of Melvin would need to rely on the use of revenue bonds as a funding alternative.

Results of the financial impact analysis are provided in Table 4.4 and Figure 4.2. Table 4.4 presents rate impacts assuming that any deficiencies in reserve accounts are funded immediately in the year following the occurrence of the deficiency, which would cause the first few years' water rates to be higher than they would be if the reserve account was built-up over a longer period of time. Figure 4.2 provides a bar chart that in terms of the yearly billing to an average customer (4,587 gallons/month consumption), shows the following:

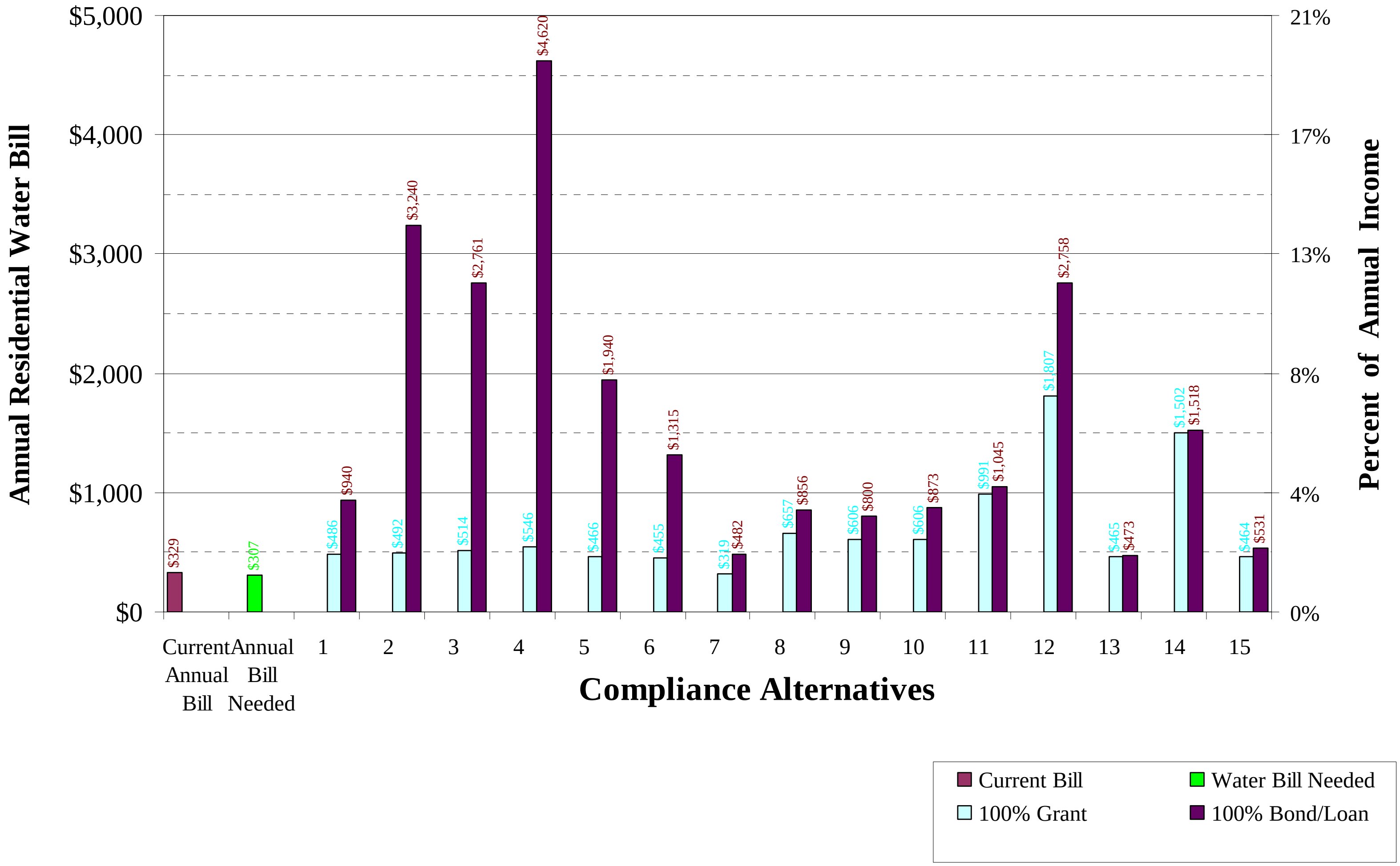
- Current annual average bill,
- Projected annual average bill including rate increase, if needed, to match existing expenditures, and
- Projected annual bill including rate increases needed to fund implementation of a compliance alternative (this does not include funding for reserve accounts).

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

Table 4.4 Financial Impact on Households

Alternative	Description		All Revenue	100% Grant	75% Grant	50% Grant	SRF	Bond
1	Purchase Water from Millersview-Doole	Max % of HH Income	27%	4%	5%	6%	6%	7%
		Max % Rate Increase Compared to Current	1871%	161%	230%	300%	312%	438%
		Average Water Bill Required by Alternative	$ 6,072	$ 804	$ 1,013	$ 1,222	$ 1,258	$ 1,639
2	New Well at Lohn WSC	Max % of HH Income	152%	4%	10%	15%	16%	27%
		Max % Rate Increase Compared to Current	10800%	166%	584%	1003%	1075%	1839%
		Average Water Bill Required by Alternative	$ 33,515	$ 818	$ 2,081	$ 3,345	$ 3,563	$ 5,871
3	Purchase Water from City of Brady	Max % of HH Income	125%	4%	9%	13%	14%	23%
		Max % Rate Increase Compared to Current	8858%	182%	523%	865%	925%	1549%
		Average Water Bill Required by Alternative	$ 27,544	$ 863	$ 1,896	$ 2,929	$ 3,107	$ 4,994
4	Purchase Water from City of Menard	Max % of HH Income	224%	4%	13%	21%	23%	39%
		Max % Rate Increase Compared to Current	15978%	204%	824%	1444%	1551%	2684%
		Average Water Bill Required by Alternative	$ 49,427	$ 929	$ 2,802	$ 4,674	$ 4,999	$ 8,420
5	New Well at 10 Miles	Max % of HH Income	83%	3%	7%	10%	10%	16%
		Max % Rate Increase Compared to Current	5835%	148%	372%	596%	635%	1045%
		Average Water Bill Required by Alternative	$ 18,254	$ 764	$ 1,442	$ 2,119	$ 2,237	$ 3,475
6	New Well at 5 Miles	Max % of HH Income	49%	3%	5%	7%	7%	11%
		Max % Rate Increase Compared to Current	3441%	139%	270%	401%	424%	663%
		Average Water Bill Required by Alternative	$ 10,898	$ 740	$ 1,135	$ 1,531	$ 1,599	$ 2,322
7	New Well at 1 Mile	Max % of HH Income	11%	2%	2%	3%	3%	3%
		Max % Rate Increase Compared to Current	680%	46%	71%	96%	100%	145%
		Average Water Bill Required by Alternative	$ 2,417	$ 469	$ 543	$ 618	$ 631	$ 768
8	Central Treatment - IX	Max % of HH Income	14%	5%	6%	6%	6%	7%
		Max % Rate Increase Compared to Current	939%	283%	313%	344%	349%	404%
		Average Water Bill Required by Alternative	$ 3,200	$ 1,159	$ 1,250	$ 1,342	$ 1,358	$ 1,524
9	Central Treatment - WRT Z-88	Max % of HH Income	14%	5%	5%	6%	6%	6%
		Max % Rate Increase Compared to Current	902%	247%	277%	306%	311%	365%
		Average Water Bill Required by Alternative	$ 3,088	$ 1,054	$ 1,143	$ 1,232	$ 1,248	$ 1,410
10	Central Treatment - KMnO4	Max % of HH Income	18%	5%	5%	6%	6%	7%
		Max % Rate Increase Compared to Current	1186%	247%	288%	328%	335%	409%
		Average Water Bill Required by Alternative	$ 3,960	$ 1,054	$ 1,177	$ 1,299	$ 1,321	$ 1,544
11	Point-of-Use Treatment	Max % of HH Income	9%	9%	9%	9%	9%	9%
		Max % Rate Increase Compared to Current	520%	520%	528%	537%	538%	553%
		Average Water Bill Required by Alternative	$ 1,895	$ 1,850	$ 1,875	$ 1,900	$ 1,904	$ 1,950
12	Point-of-Entry Treatment	Max % of HH Income	61%	17%	19%	21%	21%	25%
		Max % Rate Increase Compared to Current	4275%	1100%	1244%	1389%	1414%	1678%
		Average Water Bill Required by Alternative	$ 13,410	$ 3,538	$ 3,976	$ 4,413	$ 4,489	$ 5,287
13	Public Dispenser for Treated Drinking Water	Max % of HH Income	3%	3%	3%	3%	3%	3%
		Max % Rate Increase Compared to Current	147%	147%	148%	149%	149%	151%
		Average Water Bill Required by Alternative	$ 768	$ 762	$ 765	$ 769	$ 770	$ 776
14	Supply Bottled Water to 100% of Population	Max % of HH Income	14%	14%	14%	14%	14%	14%
		Max % Rate Increase Compared to Current	883%	883%	885%	888%	888%	893%
		Average Water Bill Required by Alternative	$ 2,920	$ 2,907	$ 2,915	$ 2,922	$ 2,923	$ 2,937
15	Central Trucked Drinking Water	Max % of HH Income	6%	3%	4%	4%	4%	4%
		Max % Rate Increase Compared to Current	360%	146%	156%	166%	168%	187%
		Average Water Bill Required by Alternative	$ 1,426	$ 758	$ 789	$ 820	$ 826	$ 882

Figure 4-2 Alternative Cost Summary



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SECTION 5
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APPENDIX A
PWS INTERVIEW FORMS

CAPACITY DEVELOPMENT ASSESSMENT FORM

*Prepared By*___________________________________ *Date*___________________________

Section 1. Public Water System Information

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

3. County [ ]

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

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

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

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

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

11. Source Type [ ]

12. Total PWS Annual Water Used [ ]

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

Total Coliform [ ] Chemical/Radiological [ ]

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

A. Basic Information

1. Name of Water System:

2. Name of Person Interviewed:

3. Position:

4. Number of years at job:

5. Number of years experience with drinking water systems:

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

7. Certified Water Operator (Yes or No):

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

   7b. How long have you been certified?

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

B. Organization and Structure

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

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

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

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

    3b. May we see a copy?

C. Personnel

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

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

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

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

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

D. Communication

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

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

3. How are your work priorities set?

4. How are work tasks delegated to staff?

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

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

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

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

9. Describe communication between utility and customers.

E. Planning and Funding

1. Describe the rate structure for the utility.

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

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

3. How often are the rates reviewed?

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

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

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

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

8. How is the budget approved or adopted?

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

    9a. How are budget shortfalls handled?

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

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

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

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

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

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

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

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

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

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

F. Policies, Procedures, and Programs

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

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

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

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

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

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

7. Approximately how many complaints are there per month?

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

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

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

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

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

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

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

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

G. Operations and Maintenance

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

    a. Process Control

    b. Purchases of supplies or small equipment

    c. Compliance sampling/reporting

    d. Staff scheduling

2. Describe your utility's preventative maintenance program.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

H. SDWA Compliance

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

2. How were the violations handled?

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

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

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

I. Emergency Planning

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

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

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

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

Attachment A

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

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

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

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

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

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

   YES ☐ NO ☐

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

   _____NM Small System _____Class 2

   _____NM Small System Advanced _____Class 3

   _____Class 1 _____Class 4

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

   YES ☐ NO ☐ No Deficiencies ☐

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

   Source ☐ Storage ☐

   Treatment ☐ Distribution ☐

   Other _____

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

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

   Radionuclides YES ☐ NO ☐ Doesn't Apply ☐

   Arsenic YES ☐ NO ☐ Doesn't Apply ☐

   Stage 1 Disinfectants and Disinfection By-Product (DBP)

   YES ☐ NO ☐ Doesn't Apply ☐

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

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

   YES ☐ NO ☐

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

YES ☐ NO ☐

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

Drought _____ Limited Supply _____

System Failure _____ Other _____

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

YES ☐ NO ☐ Don't Know ☐

If YES, please complete the following table.

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

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

YES ☐ NO ☐

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

Source ☐ Storage ☐

Treatment ☐ Distribution ☐

Other ☐ _____

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

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

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

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

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

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

YES ☐ NO ☐

14. Does the system have a flushing program?

YES ☐ NO ☐

If YES, please describe.

15. Are there any pressure problems within the system?

YES ☐ NO ☐

If YES, please describe.

16. Does the system disinfect the finished water?

YES ☐ NO ☐

If yes, which disinfectant product is used? ______

Interviewer Comments on Technical Capacity:

B. Managerial Capacity Assessment Questions

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

YES ☐ NO ☐

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

YES ☐ NO ☐

18. Does the system have written operating procedures?

YES ☐ NO ☐

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

YES ☐ NO ☐

20. Does the system have:

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

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

Water quality violations
YES ☐ NO ☐

Public notification
YES ☐ NO ☐

Sampling exemptions
YES ☐ NO ☐

22. Please describe how the above records are maintained:

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

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

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

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

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

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

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

If yes, from which agency and how much?

Describe the project?

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

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

YES ☐ NO ☐

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

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

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

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

Interviewer Comments on Managerial Capacity:

C. Financial Capacity Assessment

30. Does the system have a budget?

YES ☐ NO ☐

If YES, what type of budget?

Operating Budget ☐

Capital Budget ☐

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

YES ☐ NO ☐

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

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

YES ☐ NO ☐

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

34. Are rates reviewed annually?

YES ☐ NO ☐

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

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

Operation & Maintenance ☐

Infrastructure Repair & replacement ☐

Staffing ☐

Emergency/Reserve fund ☐

Debt payment ☐

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

YES ☐ NO ☐

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

YES ☐ NO ☐

If yes, is this policy implemented?

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

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

[Convert to % of active connections

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

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

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

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

YES ☐ NO ☐

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

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

YES ☐ NO ☐

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

YES ☐ NO ☐

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

YES ☐ NO ☐

If yes, please describe.

41. Has the system ever had a financial audit?

YES ☐ NO ☐

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

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

Interviewer Comments on Financial Assessment:

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

APPENDIX B
COST BASIS

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

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

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

Unit costs for pipeline components are based on 2006 RS Means Building Construction Cost Data. The number of borings and encasements and open cuts and encasements is estimated by counting the road, highway, railroad, stream, and river crossings for a conceptual routing of the pipeline. The number of air release valves is estimated by examining the land surface profile along the conceptual pipeline route. It is assumed gate valves and flush valves would be installed, on average, every 5,000 feet along the pipeline. Pipeline cost estimates are based on use of C-900 PVC pipe. Other pipe materials could be considered for more detailed development of attractive alternatives.

Pump station unit costs are based on experience with similar installations. The cost estimate for the pump stations include two pumps, station piping and valves, station electrical and instrumentation, minor site improvement, installation of a concrete pad, fence and building, and tools. Construction cost of a storage tank is based on 2006 RS Means Building Construction Cost Data.

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

Electrical power cost is estimated to be $0.128 per kWH. The annual cost for power to a pump station is calculated based on the pumping head and volume, and includes 11,800 kWH for pump building heating, cooling, and lighting, as recommended in USEPA publication, *Standardized Costs for Water Supply Distribution Systems* (1992).

In addition to the cost of electricity, pump stations have other maintenance costs. These costs cover: materials for minor repairs to keep the pumps operating; purchase of a maintenance vehicle, fuel costs, and vehicle maintenance costs; utilities; office supplies, small tools and equipment; and miscellaneous materials such as safety, clothing, chemicals, and paint. The non-power O&M costs are estimated based on the USEPA publication, *Standardized Costs for Water Supply Distribution Systems* (1992), which provides cost curves for O&M components. Costs from the 1992 report are adjusted to 2006 dollars based on the ENR construction cost index.

Pipeline maintenance costs include routine cleaning and flushing, as well as minor repairs to lines. The unit rate for pipeline maintenance is calculated based on the USEPA technical report, *Innovative and Alternate Technology Assessment Manual MCD 53* (1978). Costs from the 1978 report are adjusted to 2006 dollars based on the ENR construction cost index.

Storage tank maintenance costs include cleaning and renewal of interior lining and exterior coating. Unit costs for storage tank O&M are based on USEPA publication *Standardized Costs for Water Supply Distribution Systems* (1992). Costs from the 1992 report are adjusted to 2006 dollars based on the ENR construction cost index.

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

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

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

Well installation costs are based on quotations from drillers for installation of similar depth wells in the area. Well installation costs include drilling, a well pump, electrical and instrumentation installation, well finishing, piping, and water quality testing. O&M costs for water wells include power, materials, and labor. It is assumed that new wells located more than 1 mile from the intake point of an existing system would require at least one storage tank and pump station.

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

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

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

APPENDIX REFERENCES

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

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

Table B.1
Summary of General Data
City of Melvin
PWS #1540003
General PWS Information

Service Population	200		**Number of Connections**	126
Total PWS Daily Water Usage	0.019 (mgd)		**Source**	Calculated using assumed 75 gpcd

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, 04"	LF	$ 27
Bore and encasement, 10"	LF	$ 60
Open cut and encasement, 10"	LF	$ 35
Gate valve and box, 04"	EA	$ 395
Air valve	EA	$ 1,000
Flush valve	EA	$ 750
Metal detectable tape	LF	$ 0.15
Bore and encasement, length	Feet	200
Open cut and encasement, length	Feet	50

Pump Station Unit Costs	**Unit**	**Unit Cost**
Pump	EA	$ 7,500
Pump Station Piping, 04"	EA	$ 4,000
Gate valve, 04"	EA	$ 460
Check valve, 04"	EA	$ 540
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 - 10,000 gals	EA	$ 19,900
Electrical Power	$/kWH	$ 0.136
Building Power	kWH	11,800
Labor	$/hr	$ 31
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	$ 31

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	$ 41
Bottled water cost (inc. delivery)	gallon	$ 1.60
Water use, per capita per day	gpcd	1.0
Bottled water program materials	EA	$ 5,000
Storage Tank - 5,000 gals	EA	$ 7,025
Site improvements	EA	$ 4,000
Potable water truck	EA	$ 60,000
Water analysis, per sample	EA	$ 100
Potable water truck O&M costs	$/mile	$ 1.00

Central Treatment Unit Costs	**Unit**	**Unit Cost**
General		
Site preparation	acre	$ 4,000
Slab	CY	$ 1,000
Building	SF	$ 60
Building electrical	SF	$ 8.00
Building plumbing	SF	$ 8.00
Heating and ventilation	SF	$ 7.00
Fence	LF	$ 15
Paving	SF	$ 2.00
Chlorination point	EA	$ 2,000
Building power	kwh/yr	$ 0.136
Equipment power	kwh/yr	$ 0.136
Labor, O&M	hr	$ 31
Analyses	test	$ 200
Ion exchange		
Electrical	JOB	$ 50,000
Piping	JOB	$ 20,000
Ion exchange package plant	UNIT	$ 30,000
Transfer pumps (10 hp)	EA	$ 5,000
Clean water tank	gal	$ 1.00
Regenerant tank	gal	$ 1.50
Backwash tank	gal	$ 2.00
Sewer connection fee	EA	$ 15,000
Ion exchange materials	year	$ 1,000
Ion exchange chemicals	year	$ 1,000
Backwash discharge to sewer	kgal/year	$ 5.00
Waste haulage truck rental	days	$ 700
Mileage charge	mile	$ 1.00
Waste disposal fee	kgal/yr	$ 200
WRT Z-88 package		
Electrical	JOB	$ 50,000
Piping	JOB	$ 20,000
WRT Z-88 package plant	UNIT	$ 65,000
(Initial setup *cost for WRT Z-88 package*)		
WRT treated water charge	1,000 gal/yr	$ 1.16
KMnO4-greensand package		
Electrical	JOB	$ 50,000
Piping	JOB	$ 20,000
KMnO4-greensand package plant	UNIT	$ 120,000
Backwash tank	gal	$ 2.00
Sewer connection fee	EA	$ 15,000
KMnO4-greensand materials	year	$ 2,000
KMnO4-greensand chemicals	year	$ 1,500
Backwash discharge to sewer	1,000 gal/yr	$ 5.00
Sludge truck rental	days	$ 700
Sludge truck mileage fee	miles	$ 1.00
Sludge disposal fee	1,000 gal/yr	$ 200.00

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.15. The cost estimates are conceptual in nature (+50%/-30%), and are intended for making comparisons between compliance options and to provide a preliminary indication of possible water rate impacts. Consequently, these costs are pre-planning level and should not be viewed as final estimated costs for alternative implementation.

Table C.1

PWS Name ***City of Melvin***
Alternative Name ***Purchase Water from Millersview-Doole***
Alternative Number ***MV-1***

Distance from Alternative to PWS (along pipe)	2.7	miles
Total PWS annual water usage	6.935	MG
Treated water purchase cost	$ 1.60	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	1	n/a	n/a	n/a
Number of Crossings, open cut	4	n/a	n/a	n/a
PVC water line, Class 200, 04"	14,501	LF	$ 27	$ 384,277
Bore and encasement, 10"	200	LF	$ 60	$ 12,000
Open cut and encasement, 10"	200	LF	$ 35	$ 7,000
Gate valve and box, 04"	3	EA	$ 395	$ 1,146
Air valve	3	EA	$ 1,000	$ 3,000
Flush valve	3	EA	$ 750	$ 2,175
Metal detectable tape	14,501	LF	$ 0.15	$ 2,175
Subtotal				**$ 411,772**
Pump Station(s) Installation				
Pump	1	EA	$ 7,500	$ 7,500
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 460	$ 1,840
Check valve, 04"	2	EA	$ 540	$ 1,080
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 - 10,000 gals	1	EA	$ 19,900	$ 19,900
Subtotal				**$ 67,190**
Subtotal of Component Costs				**$ 478,962**
Contingency	20%			$ 95,792
Design & Constr Management	25%			$ 119,741
TOTAL CAPITAL COSTS				**$ 694,495**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	2.7	mile	$ 200	$ 549
Subtotal				**$ 549**
Water Purchase Cost				
From Source	6,935	1,000 gal	$ 1.60	$ 11,096
Subtotal				**$ 11,096**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	2,161	kWH	$ 0.136	$ 294
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 31	$ 11,282
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 15,381**
O&M Credit for Existing Well Closure				
Pump power	6,107	kWH	$ 0.136	$ (831)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 31	$ (5,564)
Subtotal				**$ (7,594)**
TOTAL ANNUAL O&M COSTS				**$ 19,432**

Table C.2

PWS Name	***City of Melvin***
Alternative Name	***New Well at Lohn WSC***
Alternative Number	***MV-2***

Distance from PWS to new well location	18.75	miles
Estimated well depth	2700	feet
Number of wells required	1	
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	2	n/a	n/a	n/a
Number of Crossings, open cut	19	n/a	n/a	n/a
PVC water line, Class 200, 04"	98,985	LF	$ 27	$ 2,623,103
Bore and encasement, 10"	400	LF	$ 60	$ 24,000
Open cut and encasement, 10"	950	LF	$ 35	$ 33,250
Gate valve and box, 04"	20	EA	$ 395	$ 7,820
Air valve	19	EA	$ 1,000	$ 19,000
Flush valve	20	EA	$ 750	$ 14,848
Metal detectable tape	98,985	LF	$ 0.15	$ 14,848
Subtotal				**$ 2,736,868**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 460	$ 1,840
Check valve, 04"	2	EA	$ 540	$ 1,080
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 - 10,000 gals	1	EA	$ 19,900	$ 19,900
Subtotal				**$ 74,690**
Well Installation				
Well installation	2,700	LF	$ 25	$ 67,500
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 88,500**
Subtotal of Component Costs				**$ 2,900,058**
Contingency	20%			$ 580,012
Design & Constr Management	25%			$ 725,014
TOTAL CAPITAL COSTS				**$ 4,205,084**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	18.7	mile	$ 200	$ 3,749
Subtotal				**$ 3,749**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	9,780	kWH	$ 0.136	$ 1,330
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 31	$ 11,282
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 16,417**
Well O&M				
Pump power	6,569	kWH	$ 0.136	$ 893
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 31	$ 5,564
Subtotal				**$ 7,657**
O&M Credit for Existing Well Closure				
Pump power	6,107	kWH	$ 0.136	$ (831)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 31	$ (5,564)
Subtotal				**$ (7,594)**
TOTAL ANNUAL O&M COSTS				**$ 20,229**

Table C.3

PWS Name *City of Melvin*
Alternative Name *Purchase Water from City of Brady*
Alternative Number *MV-3*

Distance from Alternative to PWS (along pipe)	15.5	miles
Total PWS annual water usage	6.935	MG
Treated water purchase cost	$ 1.60	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	4	n/a	n/a	n/a
Number of Crossings, open cut	21	n/a	n/a	n/a
PVC water line, Class 200, 04"	81,965	LF	$ 27	$ 2,172,073
Bore and encasement, 10"	800	LF	$ 60	$ 48,000
Open cut and encasement, 10"	1,050	LF	$ 35	$ 36,750
Gate valve and box, 04"	16	EA	$ 395	$ 6,475
Air valve	16	EA	$ 1,000	$ 16,000
Flush valve	16	EA	$ 750	$ 12,295
Metal detectable tape	81,965	LF	$ 0.15	$ 12,295
Subtotal				**$ 2,303,887**
Pump Station(s) Installation				
Pump	1	EA	$ 7,500	$ 7,500
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 460	$ 1,840
Check valve, 04"	2	EA	$ 540	$ 1,080
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 - 10,000 gals	1	EA	$ 19,900	$ 19,900
Subtotal				**$ 67,190**
Subtotal of Component Costs				**$ 2,371,077**
Contingency	20%			$ 474,215
Design & Constr Management	25%			$ 592,769
TOTAL CAPITAL COSTS				**$ 3,438,062**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	15.5	mile	$ 200	$ 3,105
Subtotal				**$ 3,105**
Water Purchase Cost				
From Source	6,935	1,000 gal	$ 1.60	$ 11,096
Subtotal				**$ 11,096**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	8,316	kWH	$ 0.136	$ 1,131
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 31	$ 11,282
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 16,218**
O&M Credit for Existing Well Closure				
Pump power	6,107	kWH	$ 0.136	$ (831)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 31	$ (5,564)
Subtotal				**$ (7,594)**
TOTAL ANNUAL O&M COSTS				**$ 22,824**

Table C.4

PWS Name	***City of Melvin***
Alternative Name	***Purchase Water from City of Menard***
Alternative Number	***MV-4***

Distance from Alternative to PWS (along pipe)	28.9	miles
Total PWS annual water usage	6.935	MG
Treated water purchase cost	$ 1.60	per 1,000 gals
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	34	n/a	n/a	n/a
PVC water line, Class 200, 04"	152,814	LF	$ 27	$ 4,049,571
Bore and encasement, 10"	600	LF	$ 60	$ 36,000
Open cut and encasement, 10"	1,700	LF	$ 35	$ 59,500
Gate valve and box, 04"	31	EA	$ 395	$ 12,072
Air valve	29	EA	$ 1,000	$ 29,000
Flush valve	31	EA	$ 750	$ 22,922
Metal detectable tape	152,814	LF	$ 0.15	$ 22,922
Subtotal				**$ 4,231,988**
Pump Station(s) Installation				
Pump	1	EA	$ 7,500	$ 7,500
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 460	$ 1,840
Check valve, 04"	2	EA	$ 540	$ 1,080
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 - 10,000 gals	1	EA	$ 19,900	$ 19,900
Subtotal				**$ 67,190**
Subtotal of Component Costs				**$ 4,299,178**
Contingency	20%			$ 859,836
Design & Constr Management	25%			$ 1,074,794
TOTAL CAPITAL COSTS				**$ 6,233,807**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	28.9	mile	$ 200	$ 5,788
Subtotal				**$ 5,788**
Water Purchase Cost				
From Source	6,935	1,000 gal	$ 1.60	$ 11,096
Subtotal				**$ 11,096**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	16,603	kWH	$ 0.136	$ 2,258
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 31	$ 11,282
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 17,345**
O&M Credit for Existing Well Closure				
Pump power	6,107	kWH	$ 0.136	$ (831)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 31	$ (5,564)
Subtotal				**$ (7,594)**
TOTAL ANNUAL O&M COSTS				**$ 26,635**

Table C.5

PWS Name *City of Melvin*
Alternative Name *New Well at 10 Miles*
Alternative Number *MV-5*

Distance from PWS to new well location	10.0	miles
Estimated well depth	250	feet
Number of wells required	1	
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	2	n/a	n/a	n/a
Number of Crossings, open cut	12	n/a	n/a	n/a
PVC water line, Class 200, 04"	52,800	LF	$ 27	$ 1,399,200
Bore and encasement, 10"	400	LF	$ 60	$ 24,000
Open cut and encasement, 10"	600	LF	$ 35	$ 21,000
Gate valve and box, 04"	11	EA	$ 395	$ 4,171
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				**$ 1,474,211**
Pump Station(s) Installation				
Pump	1	EA	$ 7,500	$ 7,500
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 460	$ 1,840
Check valve, 04"	2	EA	$ 540	$ 1,080
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 - 10,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 54,315**
Well Installation				
Well installation	250	LF	$ 25	$ 6,250
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 27,250**
Subtotal of Component Costs				**$ 1,555,776**
Contingency	20%			$ 311,155
Design & Constr Management	25%			$ 388,944
TOTAL CAPITAL COSTS				**$ 2,255,875**

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	$ 0.136	$ 1,605
Pump Power	5,588	kWH	$ 0.136	$ 760
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 31	$ 11,282
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 15,847**
Well O&M				
Pump power	608	kWH	$ 0.136	$ 83
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 31	$ 5,564
Subtotal				**$ 6,847**
O&M Credit for Existing Well Closure				
Pump power	6,107	kWH	$ 0.136	$ (831)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 31	$ (5,564)
Subtotal				**$ (7,594)**
TOTAL ANNUAL O&M COSTS				**$ 17,099**

Table C.6

PWS Name *City of Melvin*
Alternative Name *New Well at 5 Miles*
Alternative Number *MV-6*

Distance from PWS to new well location	5.0	miles
Estimated well depth	250	feet
Number of wells required	1	
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	1	n/a	n/a	n/a
Number of Crossings, open cut	6	n/a	n/a	n/a
PVC water line, Class 200, 04"	26,400	LF	$ 27	$ 699,600
Bore and encasement, 10"	1,800	LF	$ 60	$ 108,000
Open cut and encasement, 10"	100	LF	$ 35	$ 3,500
Gate valve and box, 04"	5	EA	$ 395	$ 2,086
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				**$ 826,106**
Pump Station(s) Installation				
Pump	1	EA	$ 7,500	$ 7,500
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 460	$ 1,840
Check valve, 04"	2	EA	$ 540	$ 1,080
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 - 10,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 54,315**
Well Installation				
Well installation	250	LF	$ 25	$ 6,250
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 27,250**
Subtotal of Component Costs				**$ 907,671**
Contingency	20%			$ 181,534
Design & Constr Management	25%			$ 226,918
TOTAL CAPITAL COSTS				**$ 1,316,122**

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	$ 0.136	$ 1,605
Pump Power	2,794	kWH	$ 0.136	$ 380
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 31	$ 11,282
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 15,467**
Well O&M				
Pump power	608	kWH	$ 0.136	$ 83
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 31	$ 5,564
Subtotal				**$ 6,847**
O&M Credit for Existing Well Closure				
Pump power	6,107	kWH	$ 0.136	$ (831)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 31	$ (5,564)
Subtotal				**$ (7,594)**
TOTAL ANNUAL O&M COSTS				**$ 15,719**

Table C.7

PWS Name *City of Melvin*
Alternative Name *New Well at 1 Mile*
Alternative Number *MV-7*

Distance from PWS to new well location	1.0	miles
Estimated well depth	250	feet
Number of wells required	1	
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	-	n/a	n/a	n/a
Number of Crossings, open cut	1	n/a	n/a	n/a
PVC water line, Class 200, 04"	5,280	LF	$ 27	$ 139,920
Bore and encasement, 10"	-	LF	$ 60	$ -
Open cut and encasement, 10"	50	LF	$ 35	$ 1,750
Gate valve and box, 04"	1	EA	$ 395	$ 417
Air valve	1	EA	$ 1,000	$ 1,000
Flush valve	1	EA	$ 750	$ 792
Metal detectable tape	5,280	LF	$ 0.15	$ 792
Subtotal				**$ 144,671**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 460	$ -
Check valve, 04"	-	EA	$ 540	$ -
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 - 10,000 gals	-	EA	$ 7,025	$ -
Subtotal				**$ -**
Well Installation				
Well installation	250	LF	$ 25	$ 6,250
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 27,250**
Subtotal of Component Costs				**$ 171,921**
Contingency	20%			$ 34,384
Design & Constr Management	25%			$ 42,980
TOTAL CAPITAL COSTS				**$ 249,286**

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	$ 0.136	$ -
Pump Power	-	kWH	$ 0.136	$ -
Materials	-	EA	$ 1,200	$ -
Labor	-	Hrs	$ 31	$ -
Tank O&M	-	EA	$ 1,000	$ -
Subtotal				**$ -**
Well O&M				
Pump power	608	kWH	$ 0.136	$ 83
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 31	$ 5,564
Subtotal				**$ 6,847**
O&M Credit for Existing Well Closure				
Pump power	6,107	kWH	$ 0.136	$ (831)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 31	$ (5,564)
Subtotal				**$ (7,594)**
TOTAL ANNUAL O&M COSTS				**$ (548)**

Table C.8

PWS Name *City of Melvin*
Alternative Name *Central Treatment - IX*
Alternative Number *MV-8*

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Ion Exchange Unit Purchase/Installation				
Site preparation	0.75	acre	$ 4,000	$ 3,000
Slab	30	CY	$ 1,000	$ 30,000
Building	400	SF	$ 60	$ 24,000
Building electrical	400	SF	$ 8	$ 3,200
Building plumbing	400	SF	$ 8	$ 3,200
Heating and ventilation	400	SF	$ 7	$ 2,800
Fence	-	LF	$ 15	$ -
Paving	3,200	SF	$ 2	$ 6,400
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 20,000	$ 20,000
Ion exchange package including:				
Regeneration system				
Brine tank				
IX resins & FRP vessels	1	UNIT	$ 30,000	$ 30,000
Transfer pumps (10 hp)	2	EA	$ 5,000	$ 10,000
Clean water tank	5,000	gal	$ 1.00	$ 5,000
Regenerant tank	2,000	gal	$ 1.50	$ 3,000
Backwash Tank	2,000	gal	$ 2.00	$ 4,000
Sewer Connection Fee	1	EA	$ 15,000	$ 15,000
Subtotal of Component Costs				**$ 209,600**
Contingency	20%			$ 41,920
Design & Constr Management	25%			$ 52,400
TOTAL CAPITAL COSTS				**$ 303,920**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Ion Exchange Unit O&M				
Building Power	12,000	kwh/yr	$ 0.095	$ 1,140
Equipment power	10,000	kwh/yr	$ 0.095	$ 950
Labor	600	hrs/yr	$ 40	$ 24,000
Materials	1	year	$ 1,000	$ 1,000
Chemicals	1	year	$ 1,000	$ 1,000
Analyses	24	test	$ 200	$ 4,800
Backwash discharge to sewer	20	kgal/yr	$ 5.00	$ 100
Subtotal				**$ 32,990**
Haul Regenerant Waste and Brine				
Waste haulage truck rental	6	days	$ 700	$ 4,200
Mileage charge	360	miles	$ 1.00	$ 360
Waste disposal	12	kgal/yr	$ 200.00	$ 2,400
Subtotal				**$ 6,960**
TOTAL ANNUAL O&M COSTS				**$ 39,950**

Table C.9

PWS Name *City of Melvin*
Alternative Name *Central Treatment - WRT Z-88*
Alternative Number *MV-9*

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Coagulation/Filtration Unit Purchase/Installation				
Site preparation	0.75	acre	$ 4,000	$ 3,000
Slab	30	CY	$ 1,000	$ 30,000
Building	400	SF	$ 60	$ 24,000
Building electrical	400	SF	$ 8	$ 3,200
Building plumbing	400	SF	$ 8	$ 3,200
Heating and ventilation	400	SF	$ 7	$ 2,800
Fence	-	LF	$ 15	$ -
Paving	1,600	SF	$ 2	$ 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	$ 65,000	$ 65,000
(Initial Setup Cost for WRT Z-88 package plant)				
Subtotal of Component Costs				**$ 204,400**
Contingency	20%			$ 40,880
Design & Constr Management	25%			$ 51,100
TOTAL CAPITAL COSTS				**$ 296,380**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Coagulation/Filtration Unit O&M				
Building Power	6,000	kwh/yr	$ 0.095	$ 570
Equipment power	5,000	kwh/yr	$ 0.095	$ 475
Labor	500	hrs/yr	$ 40	$ 20,000
Analyses	24	test	$ 200	$ 4,800
WRT treated water charge	6,935	kgal/yr	$ 1.16	$ 8,045
Subtotal				**$ 33,890**
TOTAL ANNUAL O&M COSTS				**$ 33,890**

Table C.10

PWS Name *City of Melvin*
Alternative Name *Central Treatment - KMnO4*
Alternative Number *MV-10*

Capital Costs

Cost Item	Quantity	Unit	Unit Cost		Total Cost	
Coagulation/Filtration Unit Purchase/Installation						
Site preparation	0.50	acre	$	4,000	$	2,000
Slab	30	CY	$	1,000	$	30,000
Building	400	SF	$	60	$	24,000
Building electrical	400	SF	$	8	$	3,200
Building plumbing	400	SF	$	8	$	3,200
Heating and ventilation	400	SF	$	7	$	2,800
Fence	-	LF	$	15	$	-
Paving	1,600	SF	$	2	$	3,200
Electrical	1	JOB	$	50,000	$	50,000
Piping	1	JOB	$	20,000	$	20,000
KMnO4-Greensand package including:						
Greensand filters						
Solution tank	1	UNIT	$	120,000	$	120,000
Backwash tank	4,000	gal	$	2.00	$	8,000
Sewer connection fee	1	EA	$	15,000	$	15,000
Subtotal of Component Costs					**$**	**281,400**
Contingency	20%				$	56,280
Design & Constr Management	25%				$	70,350
TOTAL CAPITAL COSTS					**$**	**408,030**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost		Total Cost	
Coagulation/Filtration Unit O&M						
Building Power	6,000	kwh/yr	$	0.095	$	570
Equipment power	6,000	kwh/yr	$	0.095	$	570
Labor	500	hrs/yr	$	40	$	20,000
Materials	1	year	$	2,000	$	2,000
Chemicals	1	year	$	1,500	$	1,500
Analyses	24	test	$	200	$	4,800
Backwash discharge to sewer	40	kgal/yr	$	5.00	$	200
Subtotal					**$**	**29,640**
Sludge Disposal						
Truck rental	4.0	days	$	700	$	2,800
Mileage	240	miles	$	1.00	$	240
Disposal fee	6	kgal/yr	$	200	$	1,200
Subtotal					**$**	**4,240**
TOTAL ANNUAL O&M COSTS					**$**	**33,880**

Table C.11

PWS Name *City of Melvin*
Alternative Name *Point-of-Use Treatment*
Alternative Number *MV-11*

Number of Connections for POU Unit Installation 126

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POU-Treatment - Purchase/Installation				
POU treatment unit purchase	126	EA	$ 250	$ 31,500
POU treatment unit installation	126	EA	$ 150	$ 18,900
Subtotal				**$ 50,400**
Subtotal of Component Costs				**$ 50,400**
Contingency	20%			$ 10,080
Design & Constr Management	25%			$ 12,600
Procurement & Administration	20%			$ 10,080
TOTAL CAPITAL COSTS				**$ 83,160**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POU materials, per unit	126	EA	$ 225	$ 28,350
Contaminant analysis, 1/yr per unit	126	EA	$ 100	$ 12,600
Program labor, 10 hrs/unit	1,260	hrs	$ 31	$ 38,947
Subtotal				**$ 79,897**
TOTAL ANNUAL O&M COSTS				**$ 79,897**

Table C.12

PWS Name ***City of Melvin***
Alternative Name ***Point-of-Entry Treatment***
Alternative Number ***MV-12***

Number of Connections for POE Unit Installation 126

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POE-Treatment - Purchase/Installation				
POE treatment unit purchase	126	EA	$ 3,000	$ 378,000
Pad and shed, per unit	126	EA	$ 2,000	$ 252,000
Piping connection, per unit	126	EA	$ 1,000	$ 126,000
Electrical hook-up, per unit	126	EA	$ 1,000	$ 126,000
Subtotal				**$ 882,000**
Subtotal of Component Costs				**$ 882,000**
Contingency	20%			$ 176,400
Design & Constr Management	25%			$ 220,500
Procurement & Administration	20%			$ 176,400
TOTAL CAPITAL COSTS				**$ 1,455,300**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POE materials, per unit	126	EA	$ 1,000	$ 126,000
Contaminant analysis, 1/yr per unit	126	EA	$ 100	$ 12,600
Program labor, 10 hrs/unit	1,260	hrs	$ 31	$ 38,947
Subtotal				**$ 177,547**
TOTAL ANNUAL O&M COSTS				**$ 177,547**

Table C.13

PWS Name *City of Melvin*
Alternative Name *Public Dispenser for Treated Drinking Water*
Alternative Number *MV-13*

Number of Treatment Units Recommended 1

Capital Costs

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

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Treatment unit O&M, 1 per unit	1	EA	$ 500	$ 500
Contaminant analysis, 1/wk per ur	52	EA	$ 100	$ 5,200
Sampling/reporting, 1 hr/day	365	HRS	$ 31	$ 11,282
Subtotal				**$ 16,982**
TOTAL ANNUAL O&M COSTS				**$ 16,982**

Table C.14

PWS Name *City of Melvin*
Alternative Name *Supply Bottled Water to Population*
Alternative Number *MV-14*

Service Population	200	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	73,000	gallons

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Implementation				
Initial program set-up	500	hours	$ 41	$ 20,555
Subtotal				**$ 20,555**
Subtotal of Component Costs				**$ 20,555**
Contingency	20%			$ 4,111
TOTAL CAPITAL COSTS				**$ 24,666**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water purchase costs	73,000	gals	$ 1.60	$ 116,800
Program admin, 9 hrs/wk	468	hours	$ 41	$ 19,240
Program materials	1	EA	$ 5,000	$ 5,000
Subtotal				**$ 141,040**
TOTAL ANNUAL O&M COSTS				**$ 141,040**

Table C.15

PWS Name *City of Melvin*
Alternative Name *Central Trucked Drinking Water*
Alternative Number *MV-15*

Service Population	200	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	73,000	gallons
Travel distance to compliant water source (roundtrip)	35	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	$ 31	$ 6,429
Truck operation, 1 round trip/wk	1820	miles	$ 1.00	$ 1,820
Water purchase	73	1,000 gals	$ 1.60	$ 117
Water testing, 1 test/wk	52	EA	$ 100	$ 5,200
Sampling/reporting, 2 hrs/wk	104	hrs	$ 31	$ 3,215
Subtotal				**$ 16,781**
TOTAL ANNUAL O&M COSTS				**$ 16,781**

APPENDIX D
EXAMPLE FINANCIAL MODEL

Table D.1 Example Financial Model

Water System	Melvin
Funding Alternative	Bond
Alternative Description	Purchase Water from Millersview-Doole

Sum of Amount		Year																					
Group	Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Capital Expenditures	Capital Expenditures-Funded from Bonds	$ -	$ -	$ -	$694,495	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from Grants	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from Revenue/Reserves	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from SRF Loans	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Expenditures Sum		$ -	$ -	$ -	$694,495	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt Service	Revenue Bonds				$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328
	State Revolving Funds				$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt Service Sum					$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328	$ 54,328
Operating Expenditures	Administrative Expenses			$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500
	Chemicals, Treatment			$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200
	Insurance			$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000
	Other Operating Expenditures 1			$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000
	Repairs			$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000
	Salaries & Benefits			$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000
	Supplies			$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
	Utilities			$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500	$ 4,500
	O&M Associated with Alternative					$ 19,432	$ 19,432	$ 19,432	$ 19,432	$ 19,432	$ 19,432	$ 19,432	$ 19,432	$ 19,432	$ 19,432	$ 19,432	$ 19,432	$ 19,432	$ 19,432	$ 19,432	$ 19,432	$ 19,432	$ 19,432
	Maintenance			$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000
Operating Expenditures Sum				$ 38,700	$ 38,700	$ 58,132	$ 58,132	$ 58,132	$ 58,132	$ 58,132	$ 58,132	$ 58,132	$ 58,132	$ 58,132	$ 58,132	$ 58,132	$ 58,132	$ 58,132	$ 58,132	$ 58,132	$ 58,132	$ 58,132	$ 58,132
Residential Operating Revenues	Residential Base Monthly Rate			$ 35,910	$ 35,910	$ 94,437	$173,026	$193,087	$193,087	$193,087	$193,087	$193,087	$193,087	$193,087	$193,087	$193,087	$ 193,087	$ 193,087	$ 193,087	$ 193,087	$ 193,087	$ 193,087	$ 193,087
	Residential Tier 1 Monthly Rate			$ 3,419	$ 3,419	$ 8,990	$ 16,472	$ 18,382	$ 18,382	$ 18,382	$ 18,382	$ 18,382	$ 18,382	$ 18,382	$ 18,382	$ 18,382	$ 18,382	$ 18,382	$ 18,382	$ 18,382	$ 18,382	$ 18,382	$ 18,382
	Residential Tier2 Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier3 Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier4 Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Unmetered Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Residential Operating Revenues Sum				$ 39,329	$ 39,329	$103,427	$189,498	$211,469	$211,469	$211,469	$211,469	$211,469	$211,469	$211,469	$211,469	$211,469	$ 211,469	$ 211,469	$ 211,469	$ 211,469	$ 211,469	$ 211,469	$ 211,469

Location_Name	Melvin
Alt_Desc	Purchase Water from Millersview-Doole

		Current_Year																					
Funding_Alt	Data	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Bond	Sum of Beginning_Cash_Bal	$ 8,372	$ (699)	$ (64,099)	$ (86,070)	$ (21,971)	$ 64,099	$150,169	$236,239	$322,309	$408,380	$494,450	$580,520	$666,590	$752,660	$838,730	$ 924,800	$1,010,871	$1,096,941	$1,183,011	$1,269,081	$1,355,151	$1,441,221
	Sum of Total_Expenditures	$ 38,700	$787,523	$112,460	$112,460	$112,460	$112,460	$112,460	$112,460	$112,460	$112,460	$112,460	$112,460	$112,460	$112,460	$112,460	$ 112,460	$ 112,460	$ 112,460	$ 112,460	$ 112,460	$ 112,460	$ 112,460
	Sum of Total_Receipts	$ 39,329	$733,824	$103,427	$189,498	$211,469	$211,469	$211,469	$211,469	$211,469	$211,469	$211,469	$211,469	$211,469	$211,469	$211,469	$ 211,469	$ 211,469	$ 211,469	$ 211,469	$ 211,469	$ 211,469	$ 211,469
	Sum of Net_Cash_Flow	$ 629	$ (53,699)	$ (9,033)	$ 77,038	$ 99,009	$ 99,009	$ 99,009	$ 99,009	$ 99,009	$ 99,009	$ 99,009	$ 99,009	$ 99,009	$ 99,009	$ 99,009	$ 99,009	$ 99,009	$ 99,009	$ 99,009	$ 99,009	$ 99,009	$ 99,009
	Sum of Ending_Cash_Bal	$ 9,001	$ (54,399)	$ (73,131)	$ (9,033)	$ 77,038	$163,108	$249,178	$335,248	$421,318	$507,388	$593,459	$679,529	$765,599	$851,669	$937,739	$1,023,809	$1,109,879	$1,195,950	$1,282,020	$1,368,090	$1,454,160	$1,540,230
	Sum of Working_Cap	$ 6,450	$ 6,450	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689	$ 9,689
	Sum of Repl_Resv	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250	$ 3,250
	Sum of Total_Reqd_Resv	$ 9,700	$ 9,700	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939	$ 12,939
	Sum of Net_Avail_Bal	$ (699)	$ (64,099)	$ (86,070)	$ (21,971)	$ 64,099	$150,169	$236,239	$322,309	$408,380	$494,450	$580,520	$666,590	$752,660	$838,730	$924,800	$1,010,871	$1,096,941	$1,183,011	$1,269,081	$1,355,151	$1,441,221	$1,527,292
	Sum of Add_Resv_Needed	$ (699)	$ (64,099)	$ (86,070)	$ (21,971)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Sum of Rate_Inc_Needed	0%	163%	83%	12%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0
	Sum of Percent_Rate_Increase	0%	0%	163%	382%	438%	438%	438%	438%	438%	438%	438%	438%	438%	438%	438%	438%	438%	438%	438%	438%	438%	438%

APPENDIX E
GEOCHEMISTRY OF RADIONUCLIDES

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 picoCuries (pCi) while 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 the exposure pathway. Activity is related to contaminant concentration and its half-life. A higher concentration and a shorter half-life lead to an increase in activity. Given the ratio of their half-life (Table 1) it is apparent that radium is approximately one 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 K40.

Uranium and thorium (atomic number 92 and 90, respectively), both radium sources, are common trace elements and have a crustal abundance of 2.6 and 10 mg/kg, respectively. They are abundant in acidic rock. Intrusive rock such as granite will partly sequester uranium and thorium in erosion-resistant accessory minerals (*e.g.,* monazite, thorite) while uranium in volcanic rock is much more labile and can be leached by surface water 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 rock, uranium and thorium aqueous concentrations are controlled mainly by the sorbing potential of the rock (metal oxide, clay, and organic matter).

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 ion UO_2^{+2}. Solubility is higher at low pH (acid), decreases at neutral pHs, and increases at high pH (alkaline). The uranyl ion can easily form aqueous complexes, such as with hydroxyl, fluoride and carbonate and phosphate ligands. Hence in the presence of carbonates, uranium solubility is considerably enhanced in the form of uranyl-carbonate (UO_2CO_3) and other higher order carbonate complexes: uranyl-di-carbonate ($UO_2(CO_3)_2^{-2}$ and uranyl-tri-carbonates $UO_2(CO_3)_3^{-4}$). Adsorption of uranium is inversely related to its solubility and is highest at neutral pHs (DeSoto 1978). Uranium sorbs strongly to metal oxide and clay. Uranium (IV) is the other commonly found redox state. In that state, however, uranium is not very soluble and precipitates as uranite, UO_2, coffinite, $USiO_4.nH_2O$ (if SiO_2 >60 mg/L, Henry, *et al.* 1982), or related minerals. In most aquifers, there is no mineral controlling uranium solubility in oxidizing conditions. However, uranite and coffinite are the controlling minerals if the 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 maybe at higher pH when complexed by carbonate ions (USEPA 1999). Similarly to uranium, thorium sorbs strongly to metal oxides.

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 E.1) decay while 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 while 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}, similarly to other alkaline earth element (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.

USEPA 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

APPENDIX REFERENCES

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APPENDIX F
SAMPLE RESULTS FOR OPERATIONAL AND BACKUP WELLS

CITY OF MELVIN SAMPLING DATA											
Samp. No.	Delay	Source (Well)	Location		Ra 226	Err ±		Ra 228	Err ±	Comb Ra	Comments
Mel-A-01	1 min	G1540003A	NW Corner of Melvin		5.5	0.3		2.1	0.7	6.6	*Currently used DW well.*
Mel-A-15	15 mins	G1540003A	NW Corner of Melvin		6.8	0.4		3.1	0.7	8.8	
Mel-A-30	30 mins	G1540003A	NW Corner of Melvin		8.9	0.4		4.9	0.9	12.5	
Mel-B-01	1 min	G1540003B	40 yards west of EST		6.0	0.3		3.1	0.8	8.0	*Currently unused DW well.*
Mel-B-15	15 mins	G1540003B	40 yards west of EST		5.8	0.3		2.2	0.7	7.0	
Mel-B-30	30 mins	G1540003B	40 yards west of EST		6.3	0.4		2.7	0.7	7.9	

Delay denotes the time period of sample collection after the well was activated. Note that some wells had been running for some time when the first sample was collected.