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

## CITY OF MASON
**PWS ID# 1600001, CCN# 10461**

*Prepared for:*

**THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY**


*Prepared by:*

**THE UNIVERSITY OF TEXAS BUREAU OF ECONOMIC GEOLOGY**

**AND**

**PARSONS**

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

**AUGUST 2007**

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**AUGUST 2007**

# EXECUTIVE SUMMARY

## INTRODUCTION

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

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

This feasibility report provides an evaluation of water supply alternatives for the City of Mason PWS, a municipal water system located in Mason County. Recent sample results from the City of Mason water system exceeded the MCL for radium of 5 picoCuries per liter (pCi/L) (USEPA 2005a; TCEQ 2004a).

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

**Table ES.1**
**City of Mason PWS**
**Basic System Information**

| | |
|---|---|
| Population served | 2,004 |
| Connections | 1,245 |
| Average daily flow rate | 0.439 million gallons per day (mgd) |
| Water system peak capacity | 3.240 mgd |
| Typical total radium range | 1.8 to 10.1 pCi/L |

## STUDY METHODS

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

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

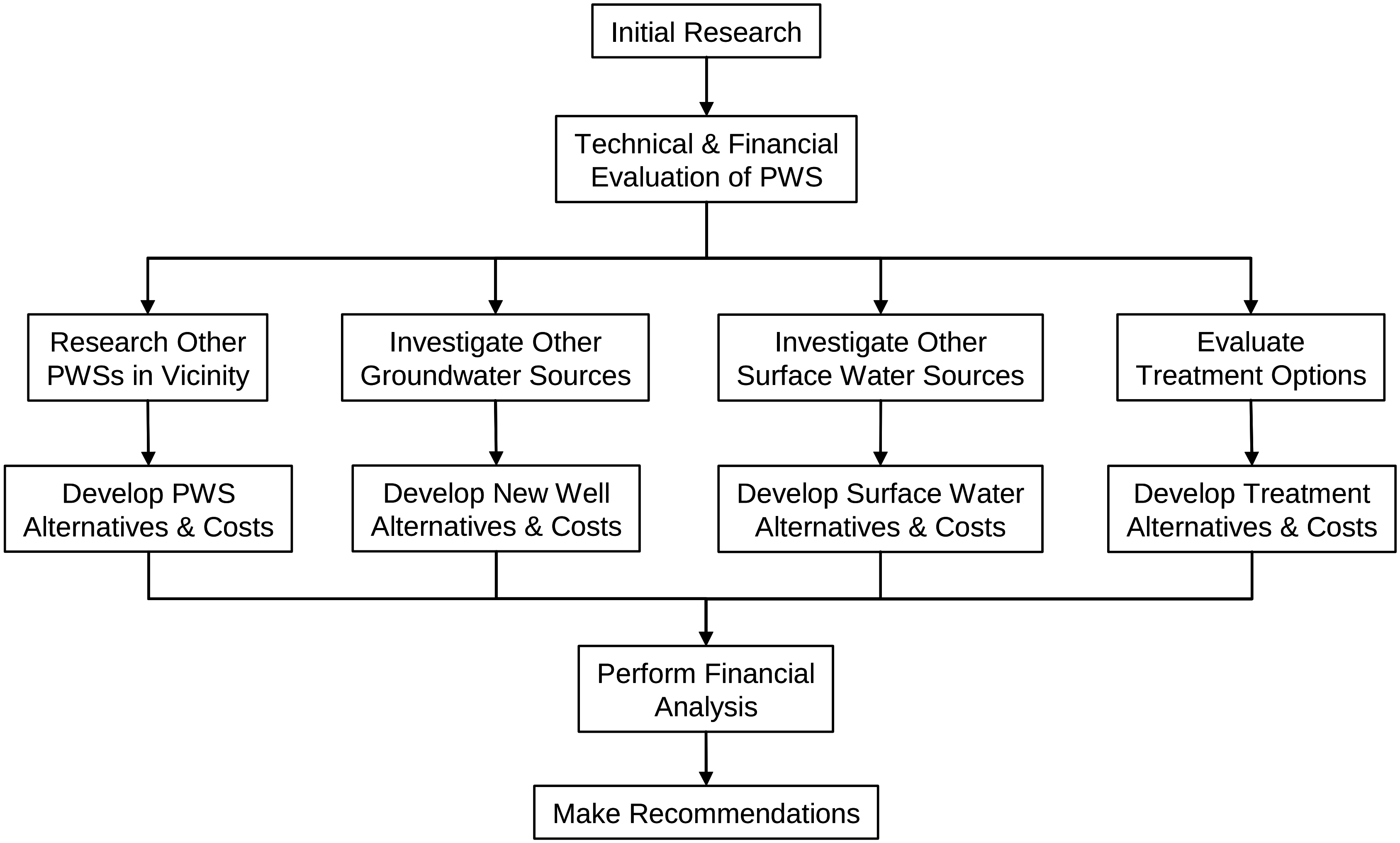
1. Gather data from the TCEQ and Texas Water Development Board databases, from TCEQ files, and from information maintained by the PWS;
2. Conduct financial, managerial, and technical (FMT) evaluations of the PWS;
3. Perform a geologic and hydrogeologic assessment of the study area;
4. Develop treatment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

This basic approach is summarized in Figure ES-1.

## HYDROGEOLOGICAL ANALYSIS

The City of Mason PWS obtains groundwater from eight wells (five primary use wells and three backup wells). Seven of the wells are known to be completed in the Hickory aquifer (one well does not have an aquifer designation). Radionuclides are commonly found in area wells at concentrations greater than the MCLs. Granite and volcanic ash derived from high-silica igneous systems is the source of uranium in sedimentary mineral deposits (Finch 1967). Radium concentrations can vary significantly over relatively short distances; as a result, there could be good quality groundwater nearby. However, the variability of radium concentrations makes it difficult to determine where wells can be located to produce acceptable water. Additionally, systems with more than one well should characterize the water quality of each well. If one of the wells is found to produce compliant water, as much production as possible should be shifted to that well as a method of achieving compliance. It may also be possible to do down-hole testing on non-compliant wells to determine the source of the contaminants. If the

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



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 Mason PWS is a municipal water system overseen by the City Administrator. Overall, the system had an adequate level of FMT capacity. The system had some areas that needed improvement to be able to address future compliance issues; however, the system does have many positive aspects, including knowledgeable and dedicated staff, good internal and external communications, and good source water protection. Areas of concern for the system included lack of process for review of current rates, lack of capital improvement planning, lack of emergency planning, and lack of water loss measurement or management.

There are several PWSs within 35 miles of City of Mason. Many of these nearby systems also have water quality issues, but there are several with good quality water. In general, feasibility alternatives were developed based on obtaining water from the nearest PWSs, either by directly purchasing water, or by expanding the existing well field. There is a minimum of surface water available in the area, and obtaining a new surface water source is considered through an alternative where treated surface water is obtained from the City of Brady and the City of Llano.

A number of centralized treatment alternatives for radium removal have been developed and were considered for this report, for example, the ion exchange (IX) system, WRT Z-88™ adsorption, and potassium permanganate 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 close to the City of Mason is likely to be the best solution if compliant groundwater can be found. Having a new well close to the City of Mason is likely to be one of the lower cost alternatives since the PWS already possesses the technical and managerial expertise needed to implement this option. The cost of new well alternatives quickly increases with pipeline length, making proximity of the alternate source a key concern. A new compliant well or obtaining water from a neighboring compliant PWS has the advantage of providing compliant water to all taps in the system.

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

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

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

## FINANCIAL ANALYSIS

Financial analysis of the City of Mason PWS indicated that current water rates are slightly under funding operations, and a rate increase of approximately 2.8 percent would be necessary to meet operating expenses. This increase would raise the average annual water bill from $249 to $256. The current average water bill represents approximately 0.6 percent of the 2000 median household income (MHI) for Texas, which is $39,927. Table ES.2 provides a summary of the financial impact of implementing selected compliance alternatives, including the rate increase necessary to meet future operating expenses. The alternatives were selected to highlight results for the best alternatives from each different type or category.

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

**Table ES.2**
**Selected Financial Analysis Results**

| Alternative | Funding Option | Average Annual Water Bill | Percent of MHI |
|---|---|---|---|
| Current | NA | $249 | 0.6 |
| To meet current expenses | NA | $256 | 0.6 |
| Nearby well within approximately 1 mile | 100% Grant | $373 | 0.9 |
| | Loan/Bond | $411 | 1.0 |
| Central treatment | 100% Grant | $659 | 1.6 |
| | Loan/Bond | $865 | 2.2 |
| Point-of-use | 100% Grant | $1,767 | 4.4 |
| | Loan/Bond | $1,833 | 4.6 |
| Public dispenser | 100% Grant | $466 | 1.2 |
| | Loan/Bond | $469 | 1.2 |

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1 # ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| °F | Degrees Fahrenheit |
| AA | Activated alumina |
| BAT | Best available technology |
| BEG | Bureau of Economic Geology |
| CA | Chemical analysis |
| CCN | Certificate of Convenience and Necessity |
| CO | Correspondence |
| DWSRF | Drinking Water State Revolving Fund |
| EDR | Electrodialysis reversal |
| FMT | Financial, managerial, and technical |
| GAM | Groundwater Availability Model |
| gpy | Gallons per year |
| gpm | Gallons per minute |
| ISD | Independent School District |
| IX | Ion exchange |
| $m^3$/day | Cubic meters per day |
| MBfR | Membrane biofilm reactor |
| MCL | Maximum contaminant level |
| µg | Microgram |
| mg/L | Milligram per liter |
| mgd | Million gallons per day |
| MHI | Median household income |
| MOR | Monthly operating report |
| NLDC | National land cover dataset |
| NMEFC | New Mexico Environmental Finance Center |
| O&M | Operation and Maintenance |
| pCi/L | picoCuries per liter |
| POE | Point-of-entry |
| POU | Point-of-use |
| psi | Pounds per square inch |
| PVC | Polyvinyl chloride |
| PWS | Public water system |
| RO | Reverse osmosis |
| SDWA | Safe Drinking Water Act |
| SSCT | Small System Compliance Technology |
| 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 |
| WAM | Water Availability Model |
| WCID | Water Control and Improvement District |
| 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. A total of 15 PWSs were evaluated in this project and each is addressed in a separate report. The 15 systems evaluated for this project are listed below:

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

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

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

This feasibility report provides an evaluation of water supply compliance options for the City of Mason Water System, PWS ID# 1600001, Certificate of Convenience and Necessity (CCN) #10461, located in Mason County. Recent sample results from the City of Mason PWS exceeded the MCL for radium of 5 picoCuries per liter (pCi/L) (USEPA 2005a; TCEQ 2004a). The location of the City of Mason PWS, also referred to as the "study area" in this report, is shown on Figure 1.1. Various water supply and planning jurisdictions are shown on Figure 1.2. These water supply and planning jurisdictions are used in the evaluation of alternate water supplies that may be available in the area.

## 1.1 PUBLIC HEALTH AND COMPLIANCE WITH MCL

The goal of this project is to promote compliance for PWSs that supply drinking water exceeding regulatory MCLs. This project only addresses these contaminants and does not address any other violations that may exist for a PWS. As mentioned above, the City of Mason PWS has had recent sample results that exceed the MCL for radium. In general, contaminant(s) in drinking water above the MCL(s) can have both short-term (acute) and long-term or lifetime (chronic) effects. According to the U.S. Environmental Protection Agency (USEPA), long-term ingestion of drinking water with radium-226 and/or radium-228 above the MCL may increase the risk of cancer (USEPA 2005a).

## 1.2 METHODOLOGY

The methodology for this project follows that of the pilot study performed in 2004 and 2005 by TCEQ, BEG, and Parsons. The pilot study evaluated water supply alternatives for PWSs that supply drinking water with nitrate concentrations above USEPA and Texas drinking water standards. Three PWSs were evaluated in the pilot study to develop the methodology (*i.e.*, decision tree approach) for analyzing options for provision of compliant drinking water. This project is performed using the decision tree approach developed in the pilot study.

Other tasks of the feasibility study are as follows:

- Identifying available data sources;
- Gathering and compiling data;
- Conducting financial, managerial, and technical (FMT) evaluations of the selected PWSs;
- Performing a geologic and hydrogeologic assessment of the study area;

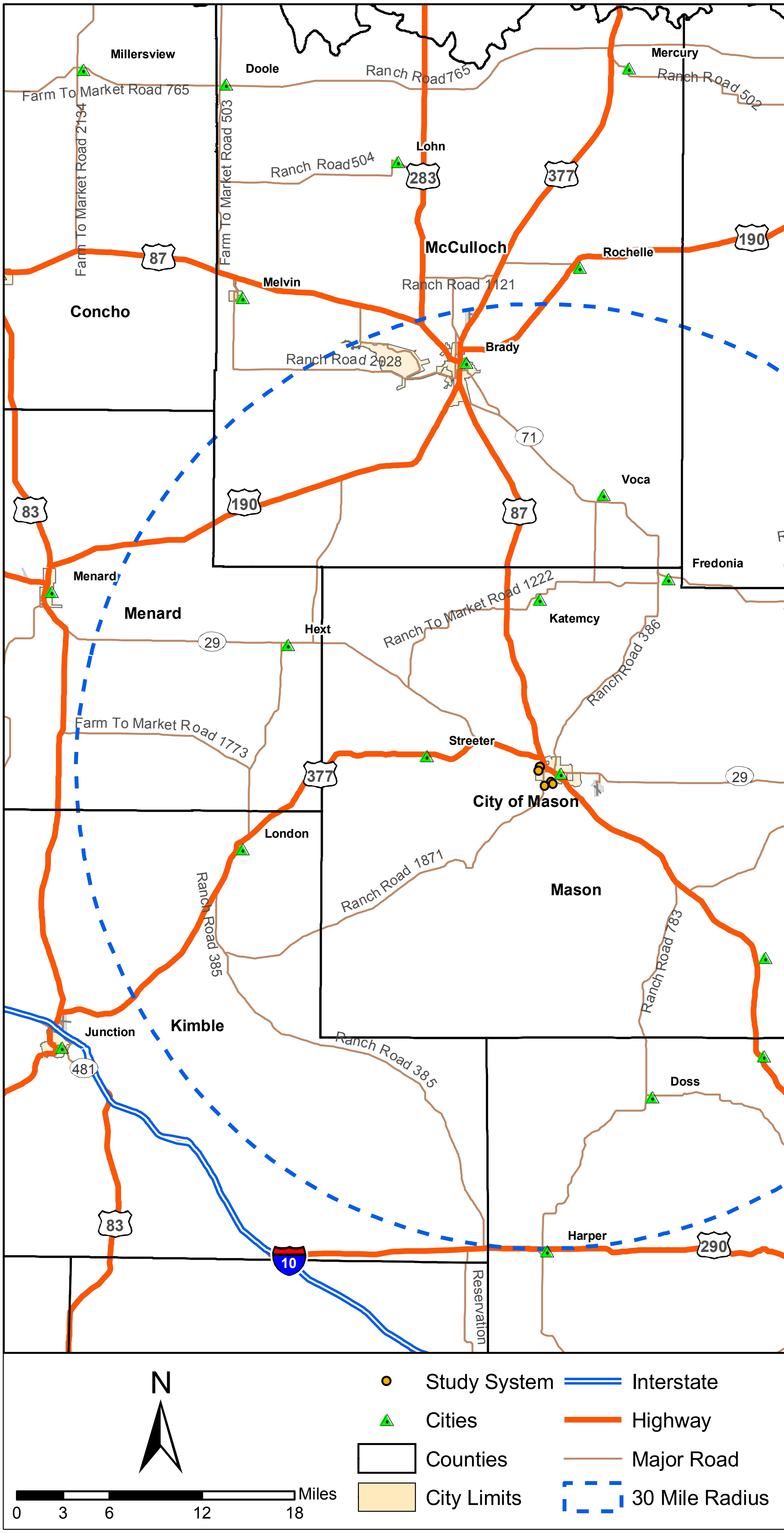


**Figure 1.1**

**City of Mason Location Map**

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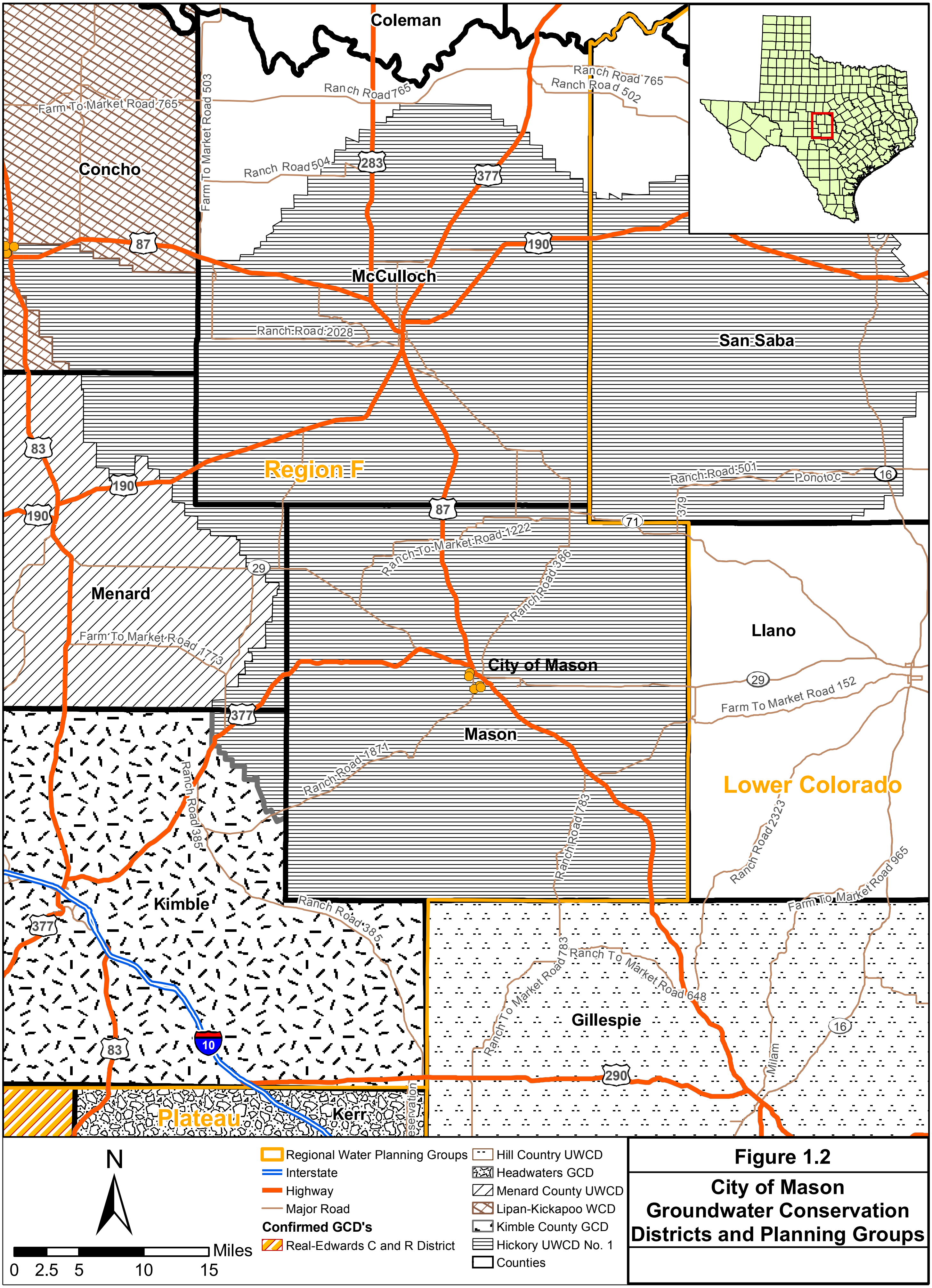


**Figure 1.2**
**City of Mason Groundwater Conservation Districts and Planning Groups**

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- Developing treatment and non-treatment compliance alternatives;
- Assessing potential alternatives with respect to economic and non-economic criteria;
- Preparing a feasibility report; and
- Suggesting refinements to the approach for future studies.

The remainder of Section 1 of this report addresses the regulatory background, and provides a summary of radium abatement options. Section 2 describes the methodology used to develop and assess compliance alternatives. The groundwater sources of radium are addressed in Section 3. Findings for the City of Mason PWS, along with compliance alternatives development and evaluation, can be found in Section 4. References to sources cited in this report are listed in Section 5.

## 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) that include oversight of PWSs and water utilities. These responsibilities include:

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

This project was conducted to assist in achieving these responsibilities.

## 1.4 ABATEMENT OPTIONS

When a PWS exceeds a regulatory MCL, the PWS must take action to correct the violation. Potable drinking water samples collected on November 22, 2004 contained a combined radium-226 and radium-228 concentration of 6 pCi/L. The MCL for the combined total of radium-226 and radium-228 is 5 pCi/L. The following subsections explore alternatives considered as potential option for obtain/providing compliant drinking water.

### 1.4.1 Existing Public Water Supply Systems

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

#### 1.4.1.1 Quantity

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

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

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

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

#### 1.4.1.2 Quality

If a potential supplier PWS obtains its water from the same aquifer (or same portion of the aquifer) as the non-compliant PWS, the quality of water may not be significantly better. However, water quality can vary significantly due to well location, even within the same aquifer. If localized areas with good water quality cannot be identified, the non-compliant PWS will 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 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 Brazoria County, the following standards could be used in a rough screening to identify compliant groundwater:
  - Radium-226 and radium-228 combined concentrations less than 4 pCi/L (below the MCL of 5 pCi/L); and
  - Concentrations of total dissolved solids (TDS) 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 that are of sufficient size and that have been used for industrial or irrigation purposes. Often the TWDB database will include well yields, which may indicate the likelihood of a particular well being 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 the willingness to work with the PWS. Once the

owner agrees to participate with the program, questions should be asked about the wells. Many owners have more than one well, and would probably be the best source of information regarding the latest test dates, who tested the water, flow rates, and other well characteristics.

- After collecting as much information as possible from cooperative owners, the PWS would then narrow down the selection and sample selected wells and analyze 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" 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 will 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, where they are available, water rights could possibly be purchased.

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

#### 1.4.3.2 New Surface Water Sources

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

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

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

### 1.4.4 Identification of Treatment Technologies

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

Additionally, it may be possible to make use of shallow groundwater wells to provide water for blending. The shallow wells, if they fall under the classification of groundwater under the direct influence of surface water (GWUDI), will require additional treatment, typically filtration, beyond standard chlorination for disinfection. It should be noted that GWUDI is generally characterized by much lower turbidity levels compared to surface water sources. As a result, it should be possible to employ treatment methods appropriate for low turbidity waters that are typically simpler and less expensive to operate.

#### 1.4.4.1 Treatment Technologies for Radionuclides

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

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

The following BATs were identified in the final rule for achieving compliance with the MCLs for combined radium-226 and radium-228:

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

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

- RO;
- RO (point-of-use);
- IX;
- IX (point-of-use);
- Electrodialysis/Electrodialysis Reversal (EDR);

- Activated Alumina;
- Enhanced Coagulation/Filtration;
- Lime Softening;
- Greensand Filtration;
- Co-precipitation with Barium Sulfate; and
- Pre-formed Hydrous Manganese Oxide Filtration.

#### 1.4.4.2 Treatment Technologies for GWUDI

In January 2002, the USEPA published the Long Term 1 Enhanced Surface Water Treatment Rule, which is the smaller system counterpart of the Interim Enhanced Surface Water Treatment Rule, and applies to systems that use surface water or GWUDI and serve fewer than 10,000 people. This rule builds upon the requirement of the 1989 Surface Water Treatment Rule, and improves public health protection through control of microbial contaminants, particularly *Cryptosporidium*.

### 1.4.5 Description of Treatment Technologies

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

In addition to treatment for radium removal, the use of GWUDI not contaminated by radium can be considered as an alternative. However, GWUDI needs to be treated to meet the Long Term 1 Enhanced Surface Water Treatment Rule. Because GWUDI is usually low in turbidity, it may be less expensive than treatment for radium removal. The radium removal and GWUDI treatment technologies applicable to small systems are discussed in this section.

#### 1.4.5.1 Ion Exchange

Process – In solution, salts separate into positively-charged cations and negatively charged anions. Ion exchange is a reversible chemical process in which ions from an insoluble, permanent, solid resin bed are exchanged for ions in the water. The process relies on the fact that certain ions are preferentially adsorbed on the ion exchange resin. Operations begin with a fully charged cation or anion bed having enough positively or negatively charged ions to carry out the cation or anion exchange. Usually a polymeric resin bed is composed of millions of spherical beads about the size of medium sand grains. As water passes the resin bed, the charged ions are released into the water, being substituted or replaced with the contaminants in the water (ion exchange). When the resin becomes exhausted of positively or negatively charged ions, the bed must be regenerated by passing a strong, sodium chloride, solution over the resin, displacing the contaminants ions with sodium ions for cation exchange and chloride ion for anion exchange. Many different types of resins can be used to reduce dissolved contaminant concentrations. The IX treatment train for groundwater typically includes cation or anion resins beds with a regeneration system, chlorine disinfection, and clear well storage. Treatment trains for surface water may also include raw water pumps, debris screens, and filters for pre-treatment. Additional treatment or management of the concentrate and the removed solids 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 sodium form can remove 99 percent of the radium. This is the same type of resin used for hardness removal in IX softeners. The strong acid resin has less capacity for radium adsorption in water with high hardness and it has the following adsorption preference: $Ra^{2+} > Ba^{2+} > Ca^{2+} > Mg^{2+} > Na^{+}$. Hardness breakthrough occurs much earlier than radium in the fresh IX resin. Because of this selectivity, radium and barium are much more difficult to remove from the resin during regeneration than calcium and magnesium. For economical reasons regeneration usually removes most of the hardness ions but leaves some of the radium and barium ions in the resin. Radium and barium can buildup on the resin after repeated cycles to the point where equilibrium is reached and then radium and barium will begin to break through shortly after hardness. In an operating IX system removing radium from water containing 200mg/L hardness, regeneration of the resin produced 2.4 bed volumes (BV) of 16,400mg/L TDS brine for every 100BV of water treated. In this case, the resin was regenerated using 6.5lb NaCl/ft$^3$ of resin. The radium concentration in the regeneration waste was approximately 40 times the influent radium concentration in the groundwater.

Pretreatment – There are pretreatment requirements for pH, organics, turbidity, and other raw water characteristics. Pretreatment may be required to reduce excessive amounts of 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 the raw water characteristics (especially hardness), the contaminant concentration, and the size and number of the IX vessels. Many systems have undersized the IX vessels only to realize higher than necessary operating costs. Preparation of the sodium chloride solution is required. If used, filter replacement and backwashing would be required.

Waste Disposal – Approval from local authorities is usually required for disposal of concentrate from the regeneration cycle (highly concentrated salt solution with radioactivity); occasional solid wastes (in the form of broken resin beads) from the resin backwashes during regeneration; and if used, spent filters and backwash wastewater.

**Advantages**

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

**Disadvantages**

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

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

#### 1.4.5.2 WRT Z-88™ Media

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

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

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

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

**Advantages**

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

**Disadvantages**

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

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

#### 1.4.5.3 Reverse Osmosis

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

Pretreatment – RO requires careful review of raw water characteristics and pretreatment is necessary to prevent membranes from fouling, scaling, or degrading other membranes. Removal or sequestering of suspended and colloidal solids is necessary to prevent fouling, and removal of sparingly soluble constituents such as calcium, magnesium, silica, sulfate, barium, *etc*., may be required to prevent scaling. Pretreatment can include media filters, ion exchange softening, acid and antiscalant feed, activated carbon or bisulfite feed to dechlorinate, and cartridge filters to remove any remaining suspended solids to protect membranes from upsets.

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

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

**Advantages**

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

**Disadvantages**

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

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

#### 1.4.5.4 Electrodialysis/Electrodialysis Reversal

Process – Electrodialysis (ED) is an electrochemical separation process in which ions migrate through ion-selective semi-permeable membranes as a result of their attraction to two electrically charged electrodes. The driving force for ion transfer is direct electric current. ED is different from RO in that it removes only dissolved inorganics but not particulates, organics, and silica. EDR is an improved form of ED in which the polarity of the direct current is changed approximately every 15 minutes. The change of polarity helps reduce the formation of scale and fouling films and, thus, achieves higher water recovery. EDR has been the dominant form of ED systems used for the past 25-30 years. A typical EDR system includes a membrane stack with a number of cell pairs, each consisting of a cation transfer membrane, a demineralized water flow spacer, an anion transfer membrane, and a concentrate flow spacer. Electrode compartments are at opposite ends of the stack. The influent feed water (chemically treated to prevent precipitation) and concentrate reject flow in parallel across the membranes and through the demineralized water and concentrate flow spacers, respectively. The electrodes are continually flushed to reduce fouling or scaling. Careful consideration of flush feed water is required. Typically, the membranes are cation or anion exchange resins cast in sheet form; the spacers are high density polyethylene; and the electrodes are inert metal. EDR stacks are tank-contained and often staged. Membrane selection is based on review of raw water characteristics. A single-stage EDR system usually removes 40-50 percent of the dissolved salts, including radium, and multiple stages may be required to meet the MCL if radium concentration is high. The conventional EDR treatment train typically includes EDR membranes, chlorine disinfection, and clearwell storage.

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

<u>Maintenance</u> – EDR membranes are durable, can tolerate pH from 1-10 and temperatures to 115$^{o}$F for cleaning. The membranes can be removed from the unit and scrubbed. Solids can be washed off by turning the power off and letting water circulate through the stack. Electrode washes flush out byproducts of electrode reaction. The byproducts are hydrogen, formed in the cathode space, and oxygen and chlorine gas, formed in the anode space. If the chlorine is not removed, toxic chlorine gas could form. Depending on the raw water characteristics, the membranes would require regular maintenance or replacement. If used, pretreatment filter replacement and backwashing would be required. The EDR stack must be disassembled, mechanically cleaned, and reassembled at regular intervals.

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

**Advantages**

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

**Disadvantages**

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

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

#### 1.4.5.5 Potassium Permanganate Greensand Filtration

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 to make sure that some $MnO_2$ is still available for radium sorption. The $KMnO_4$-greensand filtration process can accomplish this purpose because it is coated with $MnO_2$ which is regenerated by the continuous feeding of $KMnO_4$. Many operating treatment systems that use continuous feed $KMnO_4$, 30-minute contact times, and manganese greensand, remove radium to concentrations below the MCL. The treatment system equipment includes a $KMnO_4$ feed system, a pressurized reaction tank, and a manganese greensand filter. Backwashing of the greensand filter is usually required, but periodic regeneration is not required.

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

Maintenance – The greensand requires periodic backwashing to remove suspended materials and metal oxides. $KMnO_4$ is usually supplied in powder form, and preparation of $KMnO_4$ solution is required. Occasional monitoring to ensure no overfeeding of

$KMnO_4$ (pink water) is important to avoid problems in the distribution system and household fixtures.

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

**Advantages**

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

**Disadvantages**

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

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

#### 1.4.5.6 Filtration Technologies for GWUDI

Conventional Filtration – Conventional filtration includes chemical coagulation, rapid mixing, and flocculation, followed by floc removal via sedimentation (or flotation). The clarified water is then filtered. Common filter media designs include sand, dual-media, and tri-media. Conventional treatment has demonstrated removal efficiencies greater then 99 percent for viruses and 97 to 99.9 percent for *Giardia lamblia*. Conventional filtration is the most widely used technology for treating surface water supplies for turbidity and microbial contaminants, but may be less applicable to smaller water systems because of its relatively high costs and technical complexity. This technical complexity has led the USEPA to recommend that only those systems with full-time access to a skilled operator use conventional filtration.

Direct Filtration – Direct filtration involves an initial chemical coagulation step, followed by rapid mixing and filtration. Direct filtration methods exclude the use of sedimentation or another clarification step prior to filtration. Filters used are generally dual- or mixed-media filters using pressure or gravity units. In general, direct filtration usually requires low turbidity raw water and is attractive because of its low cost relative to conventional treatment. Direct filtration has demonstrated removal efficiencies of 90 to 99 percent for viruses, 50 percent for *Giardia lamblia* without coagulation, and 95-99 percent for *Giardia lamblia* with coagulation pretreatment. Direct filtration requires advanced operator skill and has high monitoring requirements. For this reason, USEPA suggests that only those systems with full-time access to a skilled operator use direct filtration.

Slow Sand Filtration – Slow sand filters are simple, easily used by small systems, and have been adapted to package plant construction. Slow sand filtration is similar to single media rapid-rate filtration in some respects, but there are crucial differences in the mechanisms employed. The *schmutzdecke*, the top-most, biologically active filter, removes suspended organic materials and microorganisms by biodegradation and other processes rather than relying solely on simple filter straining or physico-chemical sorption. Advantages of slow sand filtration include low maintenance and the fact that its efficiency does not depend on actions of the operator. However, slow sand filters do require time for the *schmutzdecke* to develop after each cleaning. During this "ripening period," however, filter performance steadily improves. Slow sand filtration should not be used without pretreatment or process modifications unless the raw water is low in turbidity, algae, and color. Slow sand filtration has demonstrated removal efficiencies in the 90 to 99.9999 percent range for viruses, and greater than 99.99 percent for *Giardia lamblia*.

Diatomaceous Earth (DE) Filtration – DE filtration, also known as pre-coat or diatomite filtration, can be used to directly treat low turbidity raw water supplies or chemically coagulated, more turbid water sources. DE filters consist of a pre-coat layer of DE, approximately 1/8-inch thick, supported by a septum or filter element. DE filtration is very effective for removing *Giardia* cysts, but filtration studies with plain DE have not indicated a marked capability to remove very small particles, *e.g.*, viruses. Recent studies indicate excellent removal rates of *Cryptosporidium* oocysts for DE grades commonly used by smaller systems.

Membrane Processes – Membrane processes make use of pressure-driven semi-permeable membrane filters. The following membrane processes have been historically used for specific drinking water uses:

- RO treatment in a high pressure mode, in removal of salts from brackish water and seawater;
- Nanofiltration, also referred to as membrane softening or low pressure RO, for removal of calcium and magnesium ions (hardness) and/or control of natural organics and disinfection byproducts;
- Ultrafiltration, characterized by a wide band of molecular weight cutoffs and pore sizes, for removal of specific dissolved organics (*e.g.*, humic substances, for control of disinfection byproducts in finished water) and for removing particulates; and
- Microfiltration, as with ultrafiltration using low operating pressures, for removal of particulates, including pathogenic cysts.

RO and nanofiltration are effective for removal of cysts, bacteria, and viruses. Ultrafiltration and microfiltration are effective for removal of *Giardia* cysts and partial removal of bacteria and viruses; and when used in combination with disinfection, appear to control these microorganisms in water.

Bag Filtration – Bag filtration systems are based on the physical screening process to remove particles. If the pore size of the bag filter is small enough, parasite removal will occur. In a bag filtration unit system, water to be treated passes through a bag-shaped filter where particulates are collected, allowing filtered water to pass to the outside of the bag. Unless the quality of the raw water precludes the need for pretreatment, the USEPA recommends pretreatment of the raw water using sand or multimedia filters, followed by preliminary bag or cartridge filters of 1-micron or larger pore size, and 1- 5-micron filters as final filters to increase particulate removal efficiencies and extend the life of the filter. Bag filters have shown mixed results in the removal of *Cryptosporidium*, ranging from approximately 70 percent to 99.9 percent.

Cartridge Filtration – Cartridge filtration relies on a simple physical screening process to remove particles. Small pore size openings prevent passage of contaminants through the filter. Typical cartridge filters are pressure filters with glass fiber or ceramic membranes or strings wrapped around a filter element, housed in a pressure vessel. The pleating allows for higher surface area for filtration. Cartridge filter units are very compact and do not require much space. Depending on the quality of the raw water, sand or multimedia filter prefiltration may be required, followed by bag or cartridge filters of 10 microns or larger pore size as preliminary filter, and the use of 1-5 micron filter as final filters are recommended to increase particulate removal efficiencies and to extend the life of the filter. Cartridge filters can be used for removal of *Giardia lamblia*, and have been demonstrated to achieve log removals of 3.51 to 3.68 for *Cryptosporidium*.

Since GWUDI is expected to have very low turbidity compared to surface water, the pretreatment requirements or recommendations mentioned in the descriptions above should not be necessary for most cases of treatment by GWUDI. Also, use of cartridge filters is relatively simple and is recommended for small water system use. As a result, cartridge filters are used in the conceptual treatment designs to establish capital and O&M costs.

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

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

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

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

- If POU devices are used as an SDWA compliance strategy, certain consumer behavioral changes will be necessary (*e.g.,* encouraging people to drink water only from certain treated taps) to ensure comprehensive consumer health protection.
- Although not explicitly prohibited in SDWA, USEPA indicates that POU treatment devices should not be used to treat for radon or for most volatile organic contaminants (VOCs) to achieve compliance, because POU devices do not provide 100 percent protection against inhalation or contact exposure to those contaminants at untreated taps (e.g., shower heads).

- Liability – PWSs considering unconventional treatment options (POU, POE, or bottled water) must address liability issues. These could be meeting the drinking water standards, property entry and ensuing liabilities, and damage arising from improper installation or improper function of the POU and POE devices.

### 1.4.7 Water Delivery or Central Drinking Water Dispensers

Current USEPA regulations 40 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 that is 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, the consumer would have to do no more than he/she currently does 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 that the customer would not have to notify the utility when the supply is low.
- Use utility personnel and equipment to handle water containers, without requiring customers to lift or handle bottles with water in them.
- Be sanitary (*e.g*., where an outside connection is made, contaminants from the environment must be eliminated).
- Be vandal-resistant.
- Avoid heating the water due to exterior temperatures and solar radiation.
- Avoid freezing the water.

# SECTION 2
# EVALUATION METHODOLOGY

## 2.1 DECISION TREE

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

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

## 2.2 DATA SOURCES AND DATA COLLECTION

### 2.2.1 Data Search

#### 2.2.1.1 Water Supply Systems

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

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

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

These files were reviewed for the PWS and surrounding systems.

TREE 1 – EXISTING FACILITY ANALYSIS

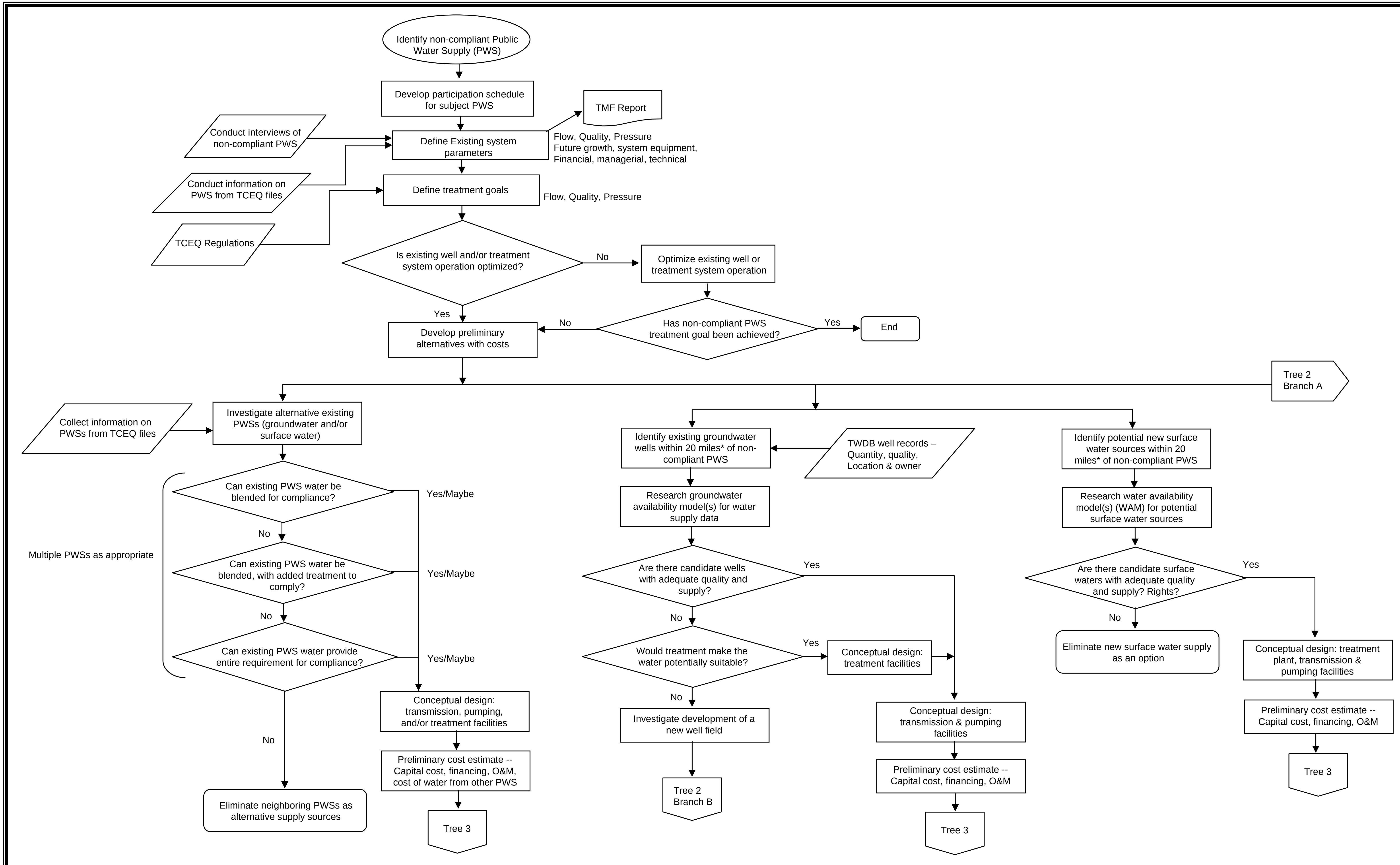
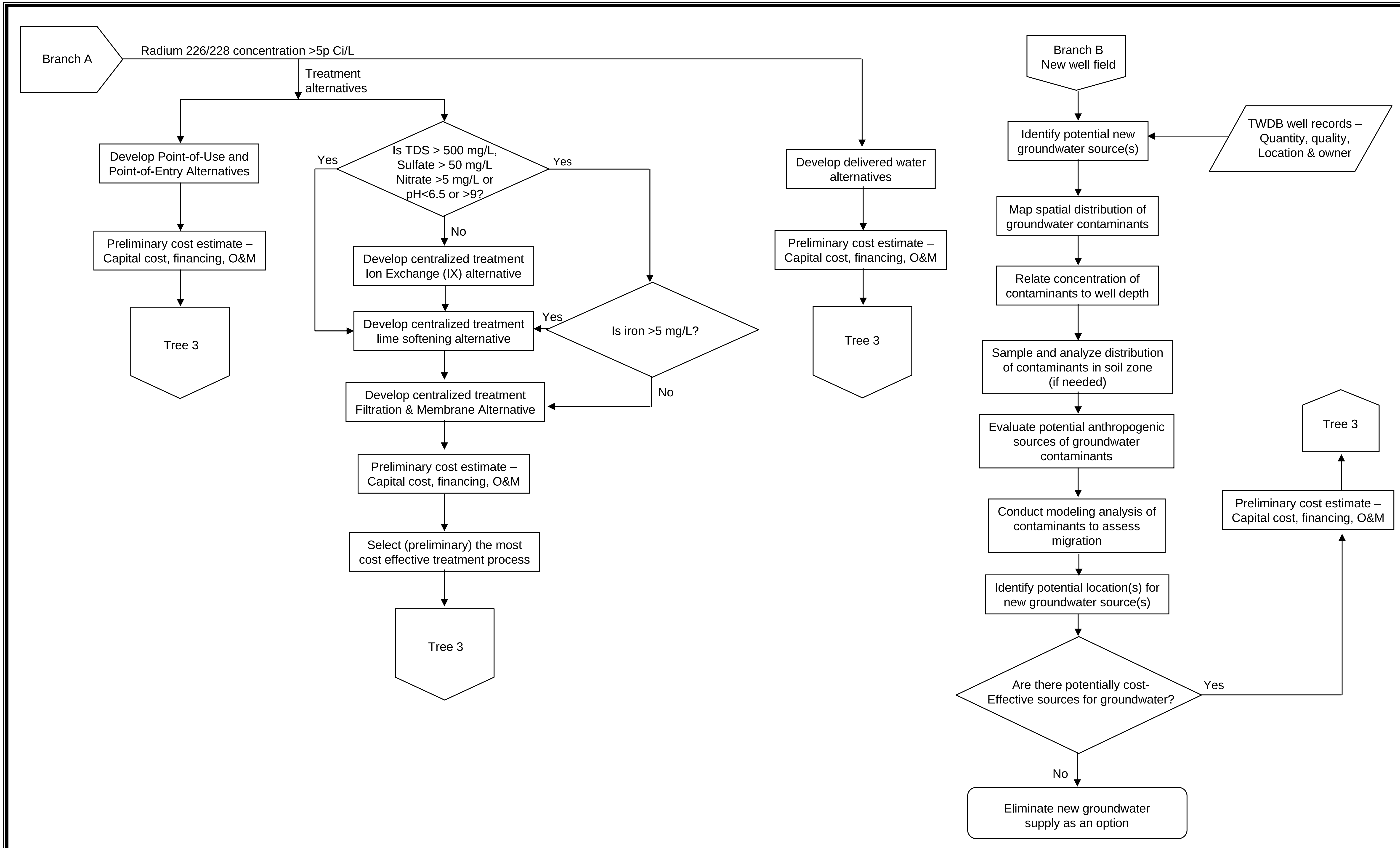


Figure 2.2
TREE 2 – DEVELOP TREATMENT ALTERNATAIVES



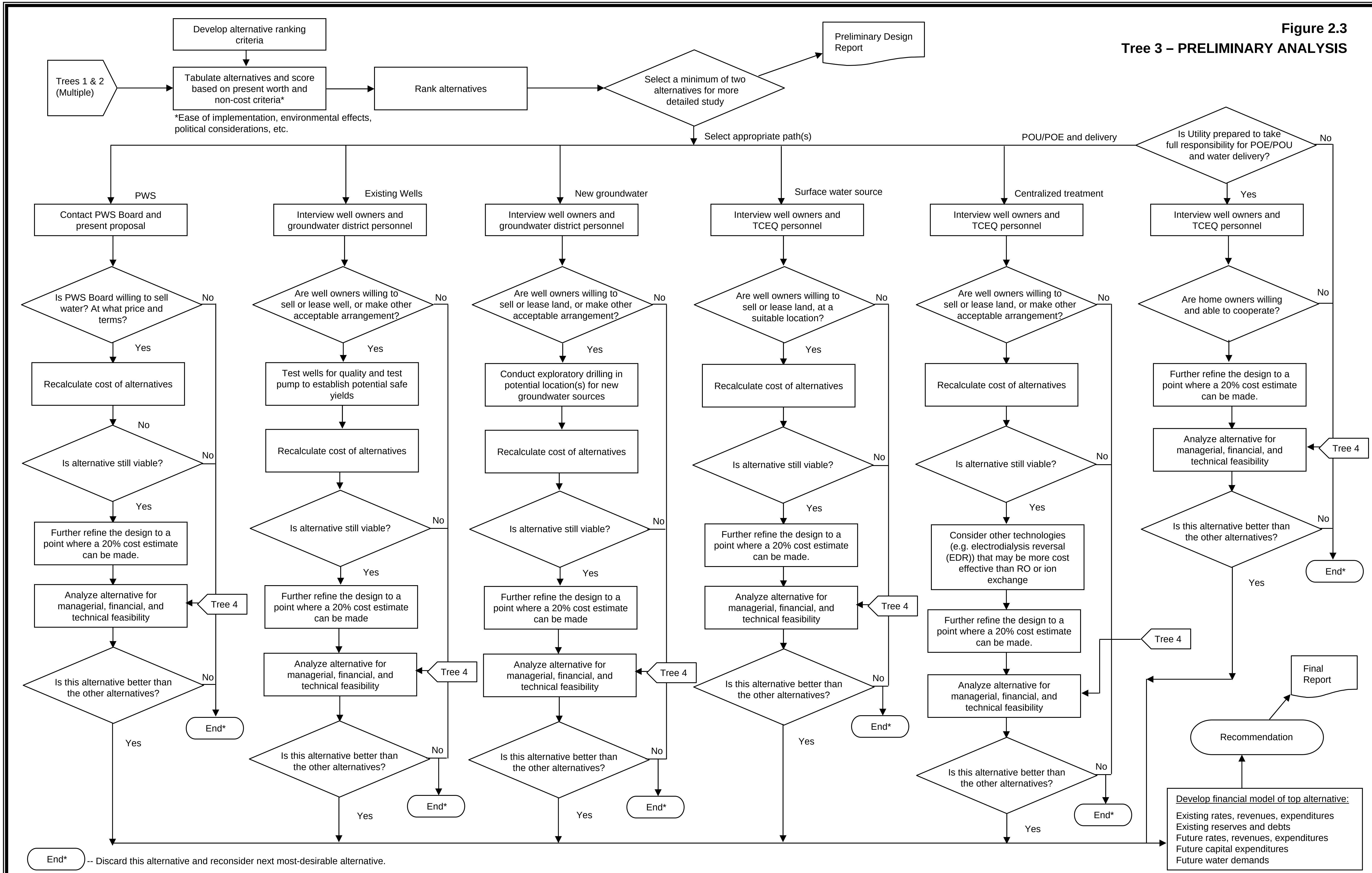
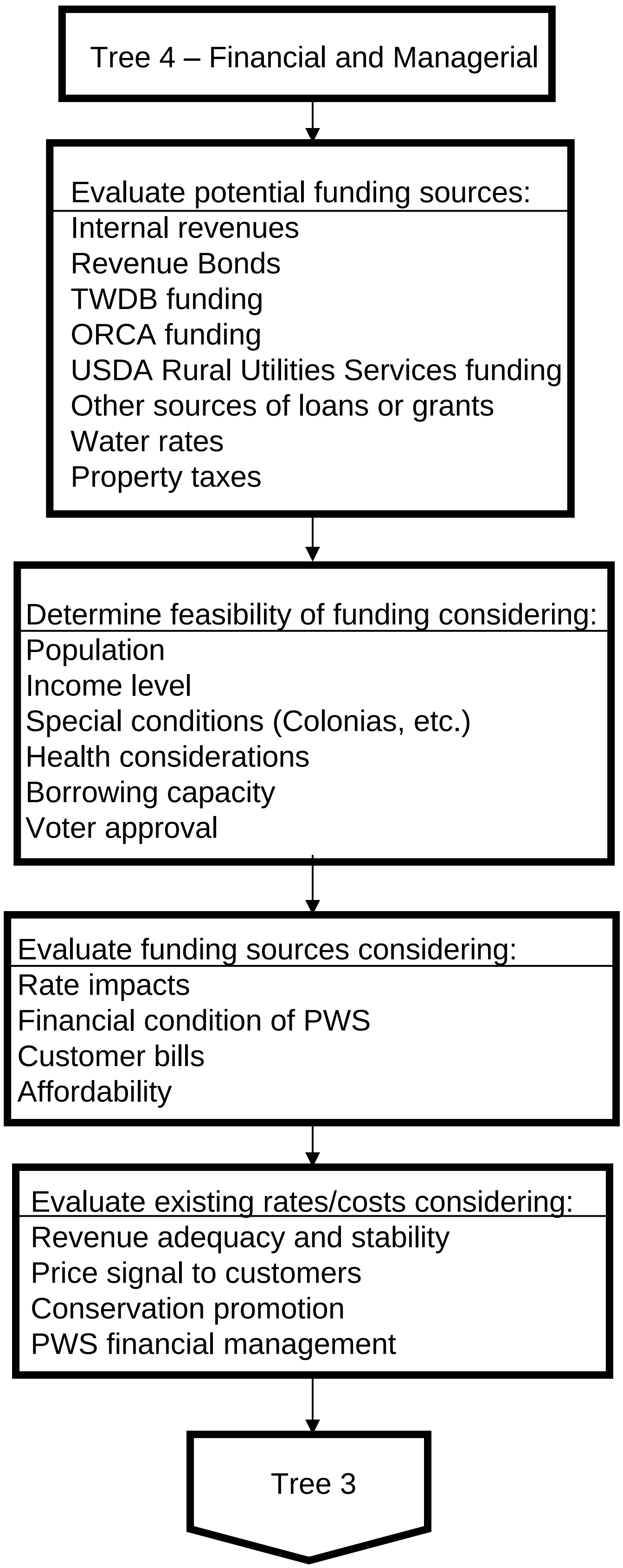


Figure 2.3
Tree 3 – PRELIMINARY ANALYSIS
Develop alternative ranking criteria
Trees 1 & 2 (Multiple)
Tabulate alternatives and score based on present worth and non-cost criteria*
*Ease of implementation, environmental effects, political considerations, etc.
Rank alternatives
Select a minimum of two alternatives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

**Figure 2.4**
**TREE 4 – FINANCIAL AND MANAGERIAL**



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

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

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

#### 2.2.1.2 Existing Wells

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

#### 2.2.1.3 Surface Water Sources

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

#### 2.2.1.4 Groundwater Availability Model

The Hickory aquifer is the primary groundwater source for public water supplies in the Mason system vicinity. This aquifer is classified by the TWDB as minor on the basis of potential water production. Pockets of water-bearing rock layers of the aquifer that appear at the land surface (outcrop) are scattered throughout Mason and Llano counties, while deeper aquifer formations (downdip) are present in throughout Mason County and 11 adjacent counties. The Mason water system, according to TCEQ records, withdraws water from the Hickory sandstone.

No GAM has yet been developed for the Hickory aquifer. The 2002 Texas Water Plan indicates that the groundwater supply from the Hickory aquifer will steadily decline over several decades. The estimated decline in supply is 9 percent, from 50,699 acre-feet per year in 2000 to 46,133 acre-feet per year in 2050.

Sections of Mason County overlay an additional potential groundwater supply, the Ellenburger-San Saba. The outcrop of the Ellenburger-San Saba aquifer, according to the spatial distribution provided by the 2002 Texas Water Plan, covers the south-central Mason County, and its downdip extends throughout west and south sections of the county. No GAM has yet been developed for this aquifer. The 2002 Texas Water Plan estimates that current supply of the Ellenburger-San Saba aquifer will remain near its current value of 22,580 acre-feet per year over the next 50 years.

#### 2.2.1.5 Water Availability Model

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

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

The vicinity of the Mason system has a minimum availability of surface water for new uses as indicated by the TCEQ's availability maps for the Colorado River Basin. In the site vicinity, and over the entire Mason 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 municipal water supply.

#### 2.2.1.6 Financial Data

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

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

#### 2.2.1.7 Demographic Data

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

### 2.2.2 PWS Interviews

#### 2.2.2.1 PWS Capacity Assessment Process

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

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

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

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

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

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

Assessment of the FMT capacity of the PWS was based on an approach developed by the New Mexico Environmental Finance Center (NMEFC), which is consistent with the TCEQ FMT assessment process. This methodology was developed from work the

NMEFC did while assisting USEPA Region 6 in developing and piloting groundwater comprehensive performance evaluations. The NMEFC developed a standard list of questions that could be asked of water system personnel. The list was then tailored slightly to have two sets of questions – one for managerial and financial personnel and one for operations personnel (the questions are included in Appendix A). Each person who has a role in the FMT capacity of the system is asked the applicable standard set of questions individually. The interviewees are not given the questions in advance and are not told the answers others have provided. Also, most of the questions are open ended type questions so they are not asked in a fashion to indicate what would be the "right" or "wrong" answer. The interviews last 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 are made. A technical information form was created to capture this information. This form is contained in Appendix A. This information was considered supplemental to the interviews because it could serve as a check on information provided in the interviews. For example, if an interviewee stated he or she had an excellent preventative maintenance schedule and the visit to the facility indicated a significant amount of deterioration (more than would be expected for the age of the facility) then the preventative maintenance program could be further investigated or the assessor could decide that the preventative maintenance program was inadequate.

Following interviews and the 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 is asked the question, "Do you have a budget?" he or she may say, "yes" and the capacity assessor is 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 is to determine which items that were noted as a potential deficiency truly have a negative effect on the system's operations. If a system has what appears to be a deficiency, but this deficiency is not creating a problem in terms of the operations or management of the system, it is not critical and may not need to be addressed as a high priority. As an example, the assessment may reveal that there appear to be insufficient staff members to operate the facility. However, it may also be revealed that the system is able to work around this problem by receiving assistance from a neighboring system so no severe problems result 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 their storage tank. In this case, the system needs to address the reserve account issue so that proper maintenance can be completed.

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

#### 2.2.2.2 Interview Process

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

## 2.3 ALTERNATIVE DEVELOPMENT AND ANALYSIS

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

### 2.3.1 Existing PWS

The neighboring PWSs were identified, and the extents of their systems were investigated. PWSs farther than 35 miles from the non-compliant PWS were not considered because the length of pipelines required would make the alternative cost prohibitive. The quality of water provided was also investigated. For neighboring PWSs with compliant water, options for water purchase and/or expansion of existing well fields were considered. The neighboring PWSs 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 they use and the quantity of water they might have available for sale. They were contacted to identify key locations in their systems where a connection might be made to obtain water, and to explore on a preliminary basis their willingness to partner or sell water. Then, the major system components that would be required to provide compliant water were identified. The major system components included treatment units, wells, storage tanks, pump stations, and pipelines.

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

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

### 2.3.2 New Groundwater Source

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

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

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

### 2.3.3 New Surface Water Source

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

### 2.3.4 Treatment

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

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

## 2.4 COST OF SERVICE AND FUNDING ANALYSIS

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

### 2.4.1 Financial Feasibility

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

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

- Current Ratio = current assets divided by current liabilities provides insight into the ability to meet short-term payments. For a healthy utility, the value should be greater than 1.0.
- Debt to Net Worth Ratio = total debt divided by net worth shows to what degree the 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 shows the degree to which revenues cover ongoing expenses. The value is greater than 1.0 if the utility is covering its expenses.

### 2.4.2 Median Household Income

The 2000 Census was used as the basis for MHI. In addition to consideration of affordability, MHI may also be an important factor for sources of funds for capital programs needed to resolve water quality issues. Many grant and loan programs are available to lower income rural areas, based on comparisons of local income to statewide incomes. In the 2000 Census, MHI for the State of Texas was $39,927, compared to the U.S. level of $41,994. For service areas with a sparse population base, county data may be the most reliable and, for many rural areas, corresponds to census tract data.

### 2.4.3 Annual Average Water Bill

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

### 2.4.4 Financial Plan Development

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

- Accounts and consumption data
- Water tariff structure
- Beginning available cash balance
- Sources of receipts:
  - Customer billings
  - Membership fees
  - Capital funding receipts from:
    - Grants
    - Proceeds from borrowing
- Operating expenditures:
  - Water purchases
  - Utilities
  - Administrative costs
  - Salaries
- Capital expenditures
- Debt service:
  - Existing principal and interest payments
  - Future principal and interest necessary to fund viable operations
- Net cash flow

- Restricted or desired cash balances:
    - Working capital reserve (based on 1-4 months of operating expenses)
    - Replacement reserve to provide funding for planned and unplanned repairs and replacements

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

### 2.4.5 Financial Plan Results

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

#### 2.4.5.1 Funding Options

Results, summarized in Table 4.4, show the following according to alternative and funding source:

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

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

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

- If local MHI = 50-60 percent of state MHI, 0 percent interest and 15 percent forgiveness of principal.
- If local MHI less than 50 percent of state MHI, 0 percent interest and 35 percent forgiveness of principal.

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

#### 2.4.5.2 General Assumptions Embodied in Financial Plan Results

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

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

#### 2.4.5.3 Interpretation of Financial Plan Results

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

#### 2.4.5.4 Potential Funding Sources

A number of potential funding sources exist for rural utilities. Both state and federal agencies offer grant and loan programs to assist rural communities in meeting their infrastructure needs. Within Texas, the following state agencies offer financial assistance if needed:

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

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

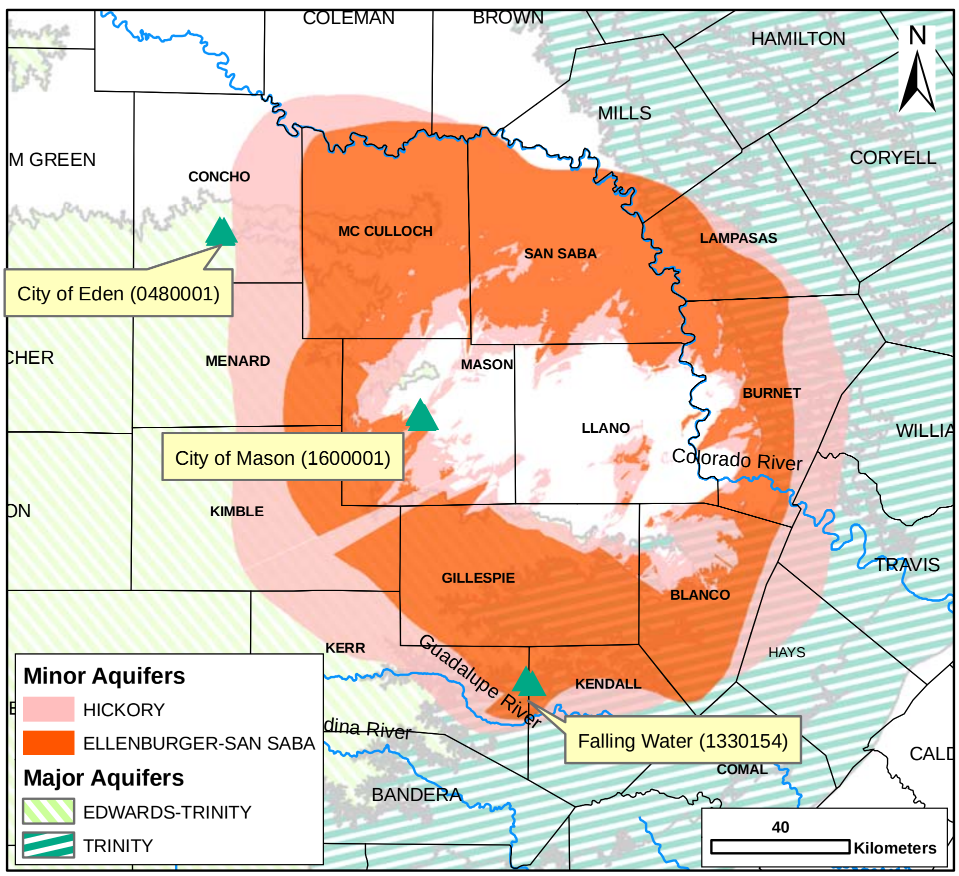
- United States Department of Agriculture, Rural Utilities Service, and
- United States Housing and Urban Development.

# SECTION 3
# UNDERSTANDING SOURCES OF CONTAMINANTS

## 3.1 RADIONUCLIDES IN CENTRAL TEXAS AQUIFERS

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

**Figure 3.1 PWS Wells and Aquifers in the Study Area**



## 3.2 HYDROGEOLOGY

### 3.2.1 Hickory Aquifer

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

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

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

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

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

### 3.2.2 Edwards-Trinity (Plateau) Aquifer

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

### 3.2.3 Trinity Aquifer

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

### 3.2.4 Ellenburger-San Saba Aquifer

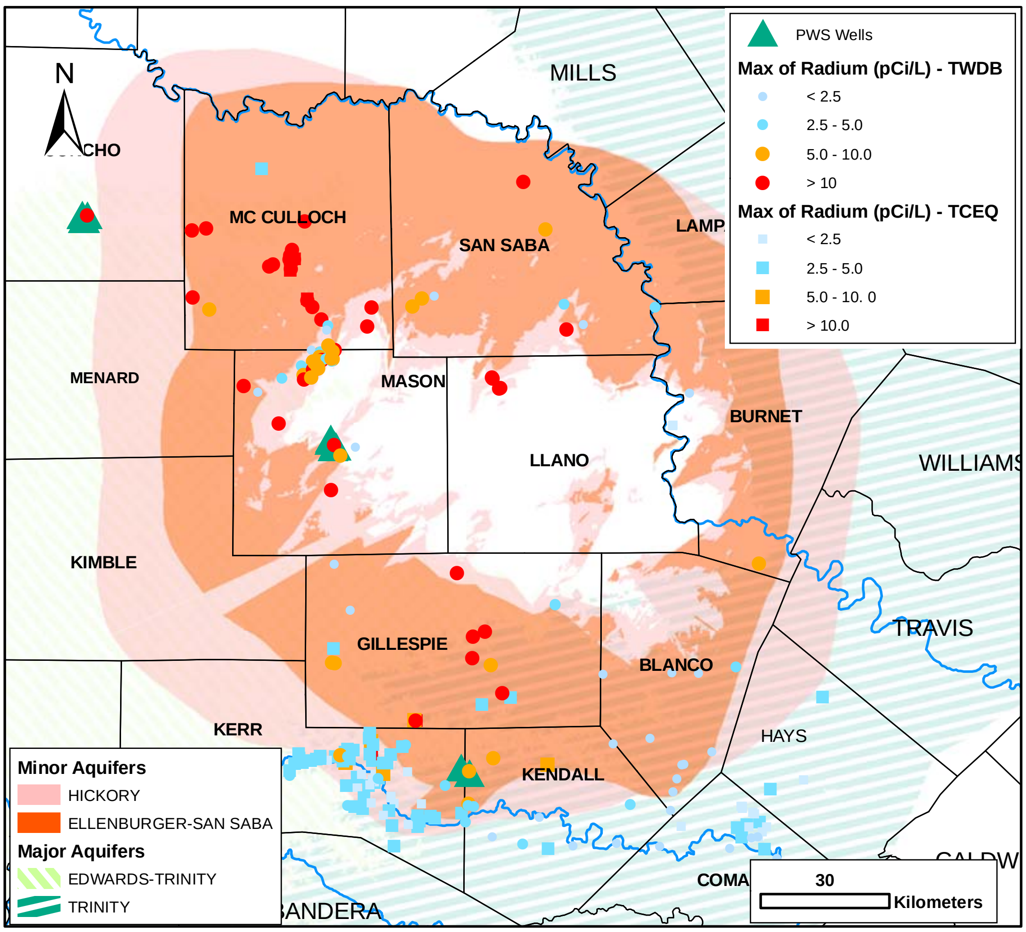
The Ellenburger-San Saba aquifer is a minor aquifer that occurs in parts of 15 counties in the Llano Uplift (Ashworth and Hopkins 1992). Outcrops of the geologic units surround older rocks in the core of the Llano uplift; the downdip portion extends to ~3,000 feet. The aquifer has been compartmentalized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

## 3.3 GENERAL RADIONUCLIDE TRENDS

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

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

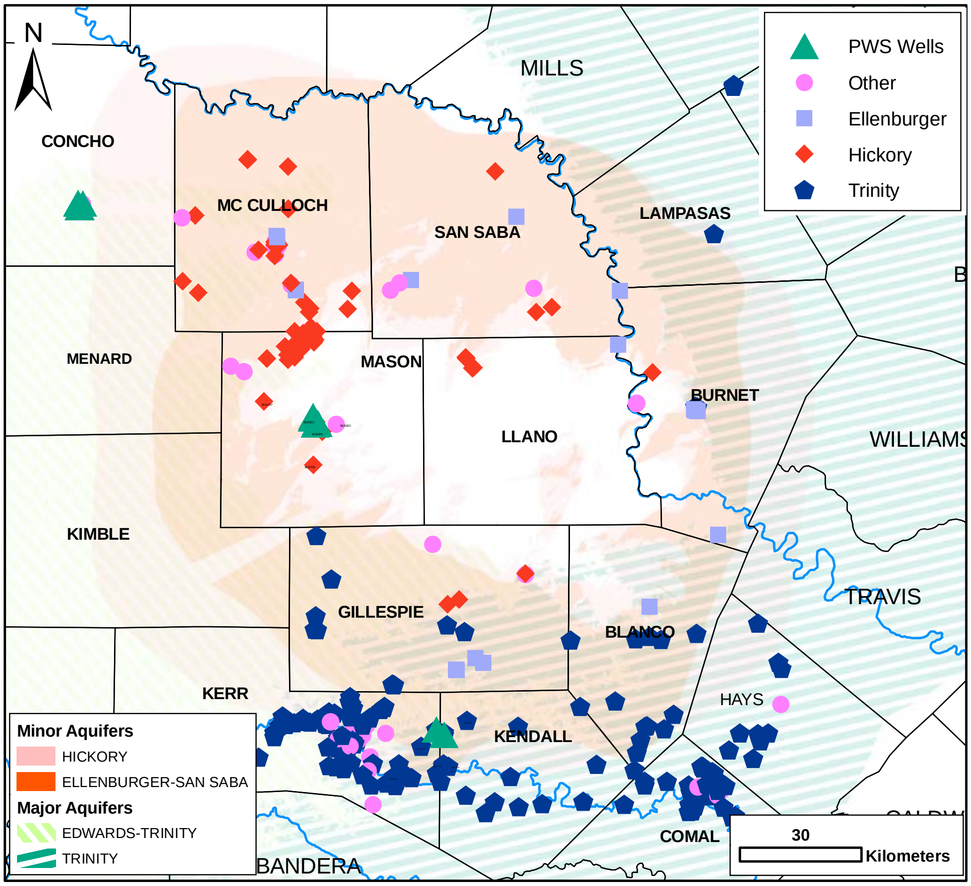
**Figure 3.2 Radium Concentrations in the Study Area (TWDB and TCEQ Databases)**




Samples are from the TWDB (Storet code 09503 and 81366) and TCEQ databases (Contaminant ID 4020 and 4030) for each sample. Radium-226 and radium-228 were combined, and the maximum combined value for each well is shown. Measurements that can be related to a specific well from a single entry point were used from the TCEQ database only. A total of 139 wells from the TCEQ database (sample dates between 1999 and 2005) and 129 wells from the TWDB database (sample dates between 1977 and

1994) were used in the analysis. Samples were limited to an area delimited by the following coordinates: bottom left corner -100.15E, 29.85N**,** and upper right corner -98.04E, 31.59N. Coordinates are in decimal degrees, and the datum is North American Datum 1983 (NAD 1983). Figure 3.3 shows wells with radium samples categorized by aquifer.

**Figure 3.3 Wells with Radium Samples Categorized by Aquifer**



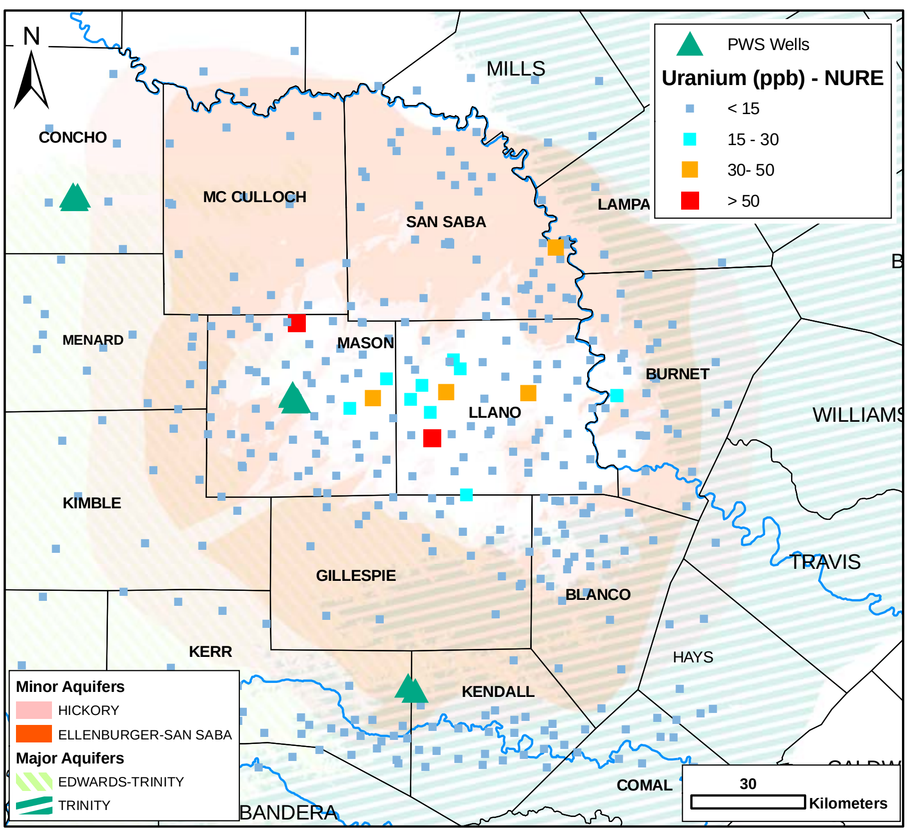

The above map (Figure 3.3) shows 129 wells from the TWDB database: 55 in the Hickory, 47 in the Trinity, nine in the Ellenburger, and 18 in other formations; 139 wells from the TCEQ PWS database: eight in the Hickory, eight in the Ellenburger, 101 in the Trinity and 22 in other formations. The two maps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

**Table 3.1 Wells with Radium Measurements**

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

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

**Figure 3.4 Uranium Concentrations (NURE Database)**



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

## 3.4 CORRELATION WITH DEPTH

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

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

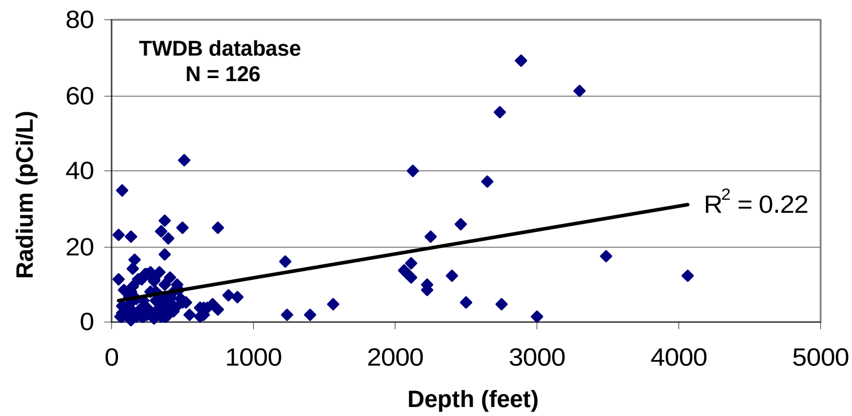
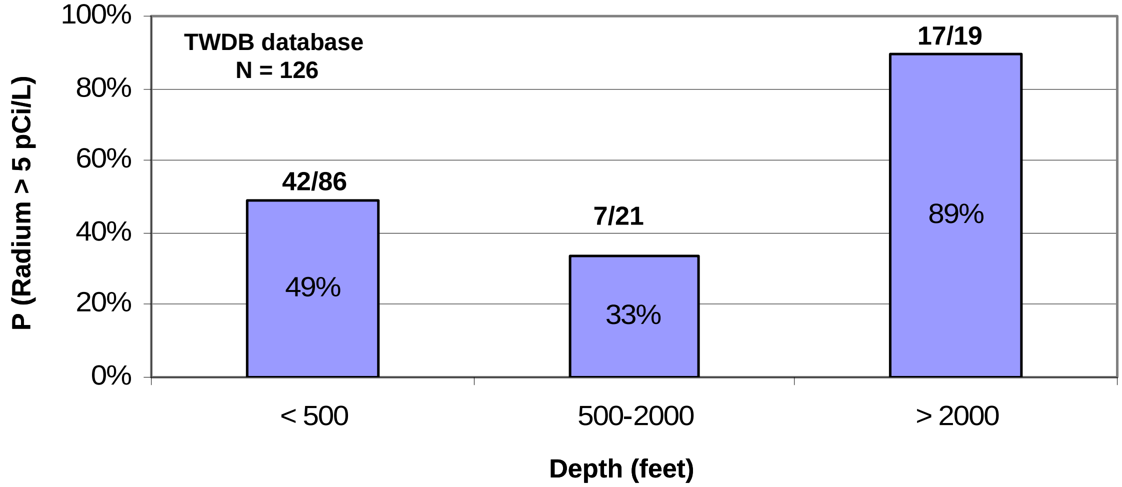
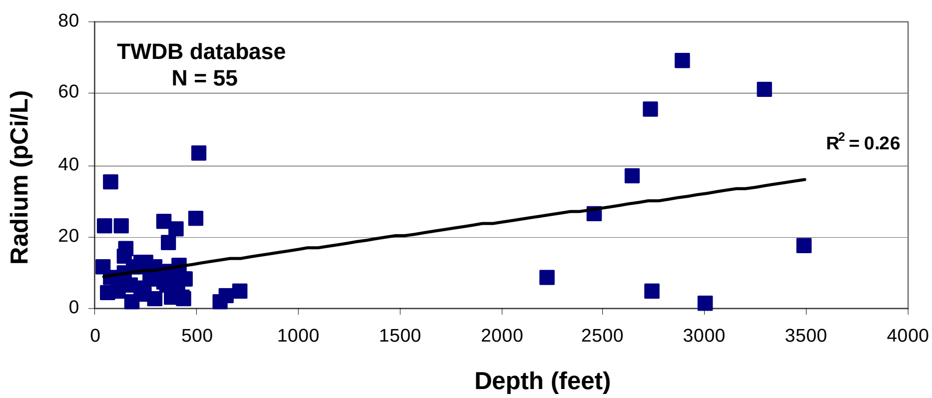


**Figure 3.6 Probability of Radium Concentration Exceeding 5 pCi/L vs. Well Depth**




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

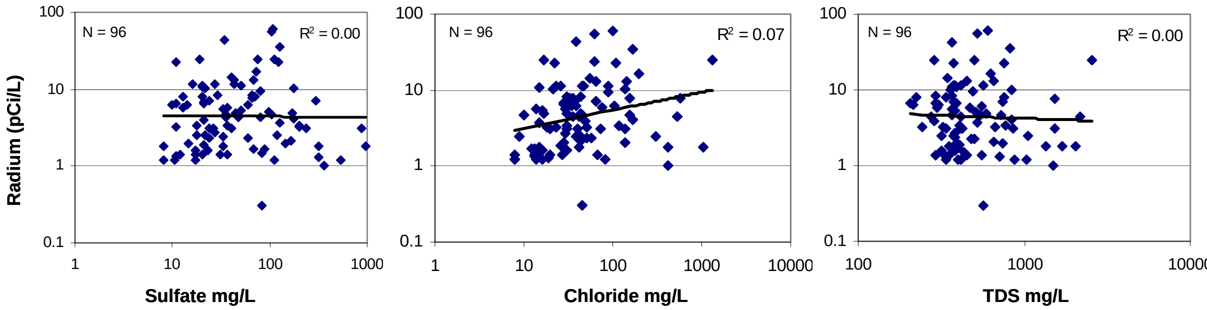
**Figure 3.7 Radium Concentrations vs. Well Depth in the Hickory Aquifer**




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

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

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



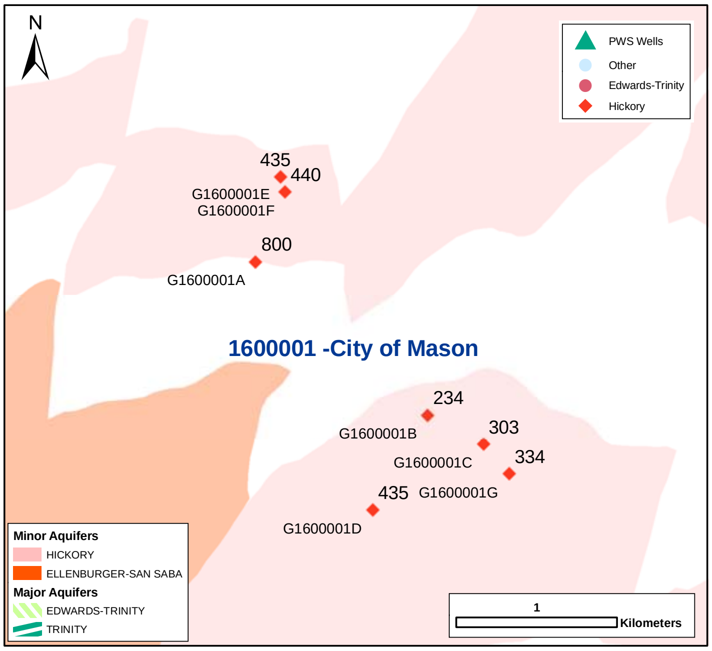

Data are from the TWDB database, and N represents number of wells in the analysis (96). The most recent radium sample for each well is shown. Sulfate, chloride, and TDS samples are from the same dates radium was sampled (if more than one sample existed for one day the average for the day was calculated).

## 3.5 DETAILED ASSESSMENTS

### 3.5.1 City of Mason (PWS 1600001)

City of Mason PWS has eight wells, seven of which are within the Hickory aquifer (well G1600001H does not have an aquifer designation), and well depths range from 234 to 800 feet. There are two entry points to the water supply system. Three wells (G1600001A, G1600001E, and G1600001F) are connected to entry point 1, and five wells (G1600001B, G1600001C, G1600001D, G1600001H, and G1600001G) are connected to entry point 2. Figure 3.9 shows well locations, aquifers, well depths, and screen depths. Geologic information is not available for PWS wells. Wells on the map are symbolized by aquifer and labeled by well depth (ft). All wells are open-hole wells that have openings between 52 and 780 feet.

**Figure 3.9 City of Mason PWS Well Information**




| Water Source | Well Depth (feet) | Screen depth (feet) | Aquifer |
|---|---|---|---|
| G1600001A | 800 | 293 - 781 | Hickory |
| G1600001B | 234 | 22 - 254 | Hickory |
| G1600001C | 303 | NA | Hickory |
| G1600001D | 435 | 60 - 284 | Hickory |
| G1600001E | 435 | 83 - 437 | Hickory |
| G1600001F | 440 | 52 - 440 | Hickory |
| G1600001G | 334 | 58 - 355 | Hickory |
| G1600001 H | 355 | NA | NA |

0

** Map does not show well G1600001H because it has no coordinates in the database.*

Table 3.2 summarizes radium concentrations sampled at the City of Mason PWS from TCEQ and TWDB databases.

**Table 3.2 Radium Concentrations in the City of Mason PWS Wells**

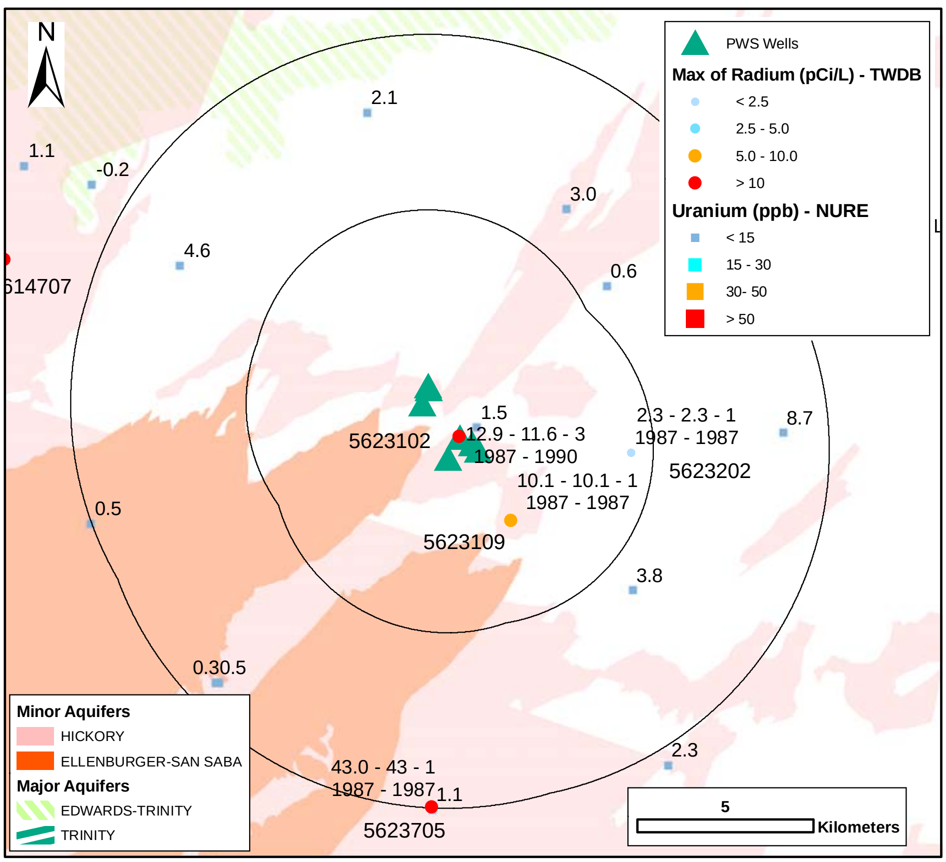
| Entry point / Well Number | Date | Radium-226 (pCi/L) | Radium-228 (pCi/L) | Radium Combined (pCi/L) | Source |
|---|---|---|---|---|---|
| G1600001B (W.N. 5623102 ) | 7/20/1987 | 1.6 | 10 | 11.6 | TWDB |
| G1600001B (W.N. 5623102) | 8/3/1988 | 2.1 | 10 | 12.1 | TWDB |
| G1600001B (W.N 5623102) | 6/20/1990 | 3.1 | 9.8 | 12.9 | TWDB |
| Sample Type D (Distribution) | 4/2/1998 | 2.4 | 4.9 | 7.3 | TCEQ |
| Sample Type D (Distribution) | 3/15/2000 | 2.1 | 4.1 | 6.2 | TCEQ |
| E.P. 1 | 5/6/2002 | 1.9 | 5 | 6.9 | TCEQ |
| E.P. 2 | 5/8/2002 | 1.9 | 7.7 | 9.6 | TCEQ |
| E.P. 1 | 11/5/2003 | 1.8 | 3.7 | 5.5 | TCEQ |
| E.P. 2 | 11/5/2003 | 1.6 | 5.5 | 7.1 | TCEQ |
| E.P. 1 | 11/22/2004 | 2.2 | 4.1 | 6.3 | TCEQ |
| E.P. 2 | 11/22/2004 | 1.7 | 5.5 | 7.2 | TCEQ |

** E.P. = Entry point W.N. = Well number in the TWDB database*

Eight radium samples are from the TCEQ database (1998–2004), and three samples from the TWDB database (1987–1990). All samples have high radium concentrations, which include samples from entry points 1 and 2 and from individual wells. Thus, it is difficult to point to a specific well as the source of elevated radium and suggests that more than one well has elevated radium concentrations. Samples from the TWDB database show that well G1600001B has high radium levels. This well is one of the shallower wells (depth 234 feet). Three uranium samples are in the TCEQ database, but all are less than half the MCL for uranium (30 µg/L). Figure 3.10 shows radium and uranium concentrations from TWDB and NURE databases within 5- and 10-km buffers of PWS wells (no radium samples are in the TCEQ database within the 10-km buffer).

Groundwater radium concentrations can have a high degree of spatial variability. Because of this, an investigation of the existing wells was conducted to determine whether all or only some of the wells produce non-compliant water. This investigation is described further in Section 4.1.1. If one or more wells were found to produce compliant water, as much production as possible could be shifted to the compliant wells. Also, if one or more wells were found to produce compliant water, the wells may be compared in terms of depth and well logs to identify differences that could be responsible for the elevated concentration of radium in the other well(s). Then if blending of water from the existing wells does not produce a sufficient quantity of compliant water, it may be possible to install a new well similar to the existing compliant well(s) that also would provide compliant water.

**Figure 3.10 Radium Concentrations (TWDB) and Uranium Concentrations (NURE) in 5- and 10-km Buffers of the City of Mason PWS Wells**



Data are from TWDB and NURE databases. Wells are symbolized by maximum concentration, and labels show maximum, minimum, and number of samples, as well as first and last sample year. Samples from the NURE database were taken between 1976 and 1980. Three wells from the TWDB have high radium concentrations, and one well has low concentrations. Uranium samples from the NURE dataset are all below 10 µg/L. Table 3.3 details radium concentrations, aquifer, well depth, and screen depth of wells within the 10-km buffer of PWS wells.

**Table 3.3 Water Source (Wells) in the 10-km Buffer from City of Mason PWS Wells**

| Well Number | Max.-Min.-Num. of Radium Samples (pCi/L) | Well Depth (feet) | Screen Depth (feet) | Aquifer |
|---|---|---|---|---|
| 5623102 (G1600001B) | 12.9 - 11.6 - 3 | 234 (TWDB = 254) | 22 - 254 | Hickory |
| 5623202 | 2.3 - 2.3 - 1 | 123 | NA | Packsaddle Schist |
| 5623109 | 10.1 - 10.1 - 1 | 375 | 10 - 375 | Hickory |
| 5623705 | 43.0 - 43.0 - 1 | 513 | 53 - 503 | Hickory |

*Source: TWDB databases*

Four wells in the TWDB database have radium samples. Three of the four wells have radium concentrations exceeding the MCL (5 pCi/L). Well 5623102 is one of the wells of the City of Mason PWS (Well G1600001B), which also has elevated concentrations of radium (>10 pCi/L). The only well with concentrations below the MCL is Well 5623202, and it is not within the Hickory aquifer but is in the Packsaddle Schist Formation.

# SECTION 4
# ANALYSIS OF THE CITY OF MASON PWS

## 4.1 DESCRIPTION OF EXISTING SYSTEM

### 4.1.1 Existing System

The City of Mason PWS is shown in Figure 4.1. The water sources for this community water system are five primary use wells and three backup wells. Seven of the wells are completed in the Hickory aquifer (Code 371HCKR); one well does not have an aquifer designation. The wells vary between 234 and 800 feet in depth. The PWS has two entry points to the distribution system: the stand-pipe type water tower and at the two ground storage tanks. A map of the City's distribution system is shown in Appendix E.

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

Basic system information is as follows:

- Population served: 2,004
- Connections: 1,245
- Average daily flow: 0.439 mgd
- Total production capacity: 3.240 mgd
- Typical total radium range: 1.8 pCi/L to 10.1 pCi/L
- Typical nitrate range: 1.12 to 2.15 mg/L
- Typical TDS range: 288 to 328 mg/L

Local shallow irrigation wells are believed to contain little to no radium. The reliability of these wells during prolonged drought is unknown.

As described in Section 3.5.1, groundwater concentrations of radium have high spatial variability. To address this issue, a groundwater sampling effort was conducted in October 2005 on seven of the eight water supply wells for the City of Mason. An eighth well was also sampled, which is a local shallow irrigation well. Parsons, with the

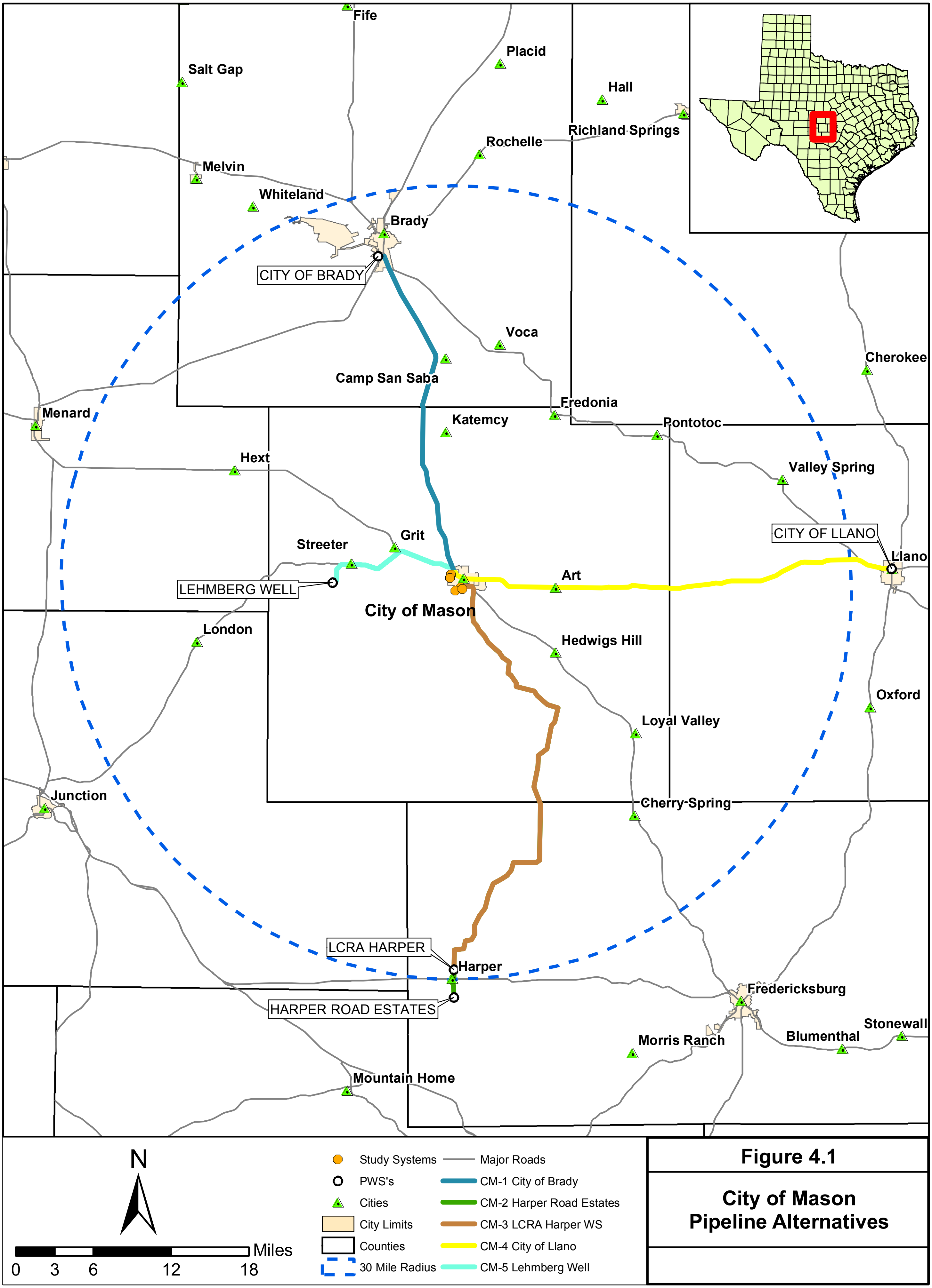



**Figure 4.1**

**City of Mason Pipeline Alternatives**

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assistance of the City of Mason, collected one to three water samples from each of the wells and sent the samples to a TCEQ contract lab for radium analysis. The detailed results of these analyses are presented in Appendix G. These results indicate that radium concentrations in Wells A, D, E and F are below the MCL for radium of 5.0 pCi/L. Based on these results, it may be possible for the City of Mason to shift water production to these four wells to achieve compliance at a minimal cost.

### 4.1.2 Capacity Assessment for the City of Mason

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

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

#### 4.1.2.1 General Structure

The City of Mason is a municipal water system. The City is governed by a Mayor and a City Council who provide managerial and financial oversight of the system. The Water/Wastewater/Streets Supervisor manages and operates the system on a daily basis. He has four assistants, two of whom are certified operators, who assist in the operations and maintenance of the system. The Supervisor reports directly to the City Administrator.

The water system has approximately 1,245 connections, and serves a population of about 2,004 people. The system is fully metered and is supplied by groundwater.

The City of Mason is located in a remote area and is the only public water system in the county. The closest other public water system is over 20 miles away.

#### 4.1.2.2 General Assessment of Capacity

There has been a significant amount of turnover of the City administration during the past few months; however, the operations staff has remained constant and reliable. The new City administration is interested in learning about the water system and is moving in the right direction. At this time, they have an adequate level of capacity, but there is room for improvement.

#### 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. As an example, the City of Mason has a new administrator and mayor who are highly motivated and willing to learn new activities and approaches. They are currently working on goals, job descriptions, and team building. This commitment can be relied upon in addressing the deficiencies. The factors that were particularly important for the City of Mason are listed below.

- **Knowledgeable and Dedicated Staff** – The Supervisor has been with the City for 26 years and in his current position since 2002. He is familiar with the needs of the water system and is working hard to address the problems. He is certified and is on standby 24 hours a day.

  The operators are encouraged to attend training and obtain the credits needed to maintain their certification. This is critical since at this time, the City administration is relying on the expertise of the operators to apprise them of water system operation and regulatory issues. In addition, the staff receives safety training, which is critical to their jobs, especially considering the hazards related to O&M of the gas chlorination system.

- **Communication**

  Internal – There is good communication between the new City Administrator and the Supervisor. They meet on a weekly basis. In addition, the Supervisor meets with his staff on a daily basis to issue work orders and determine priorities for the day.

  External – The City of Mason addresses various water system issues in its monthly newsletter. In addition, they are distributing quarterly public notices as required by TCEQ, to inform their customers about the exceedance of the radium MCL.

- **Source Water Protection** – The wells are located in residential areas on private land that the City accesses through easements. All of the wells are enclosed by 6-foot fences with barbed wire and have locked gates. The wells are located within a confined aquifer, which provides a natural barrier to surface contamination. The City is part of the Hickory Underground Water District, which provides aquifer education to City residents and neighboring communities.

#### 4.1.2.4 Capacity Deficiencies

The following capacity deficiencies were noted in conducting the assessment.

- **No Process for Review of Current Rates –** It was unclear when the last rate review occurred. However it appears that the base rate was raised sometime in 2004 from $4 to $12. It is important to have some type of clearly defined rate review process that includes evaluating the following: operating expenses, debt requirements, costs of future maintenance and repair projects, and proposed capital improvements projects. While comparing current rates with rates in surrounding communities might be a useful tool in gaining public support for a rate increase, it is important to develop a rate structure that reflects the actual cost of providing water.

- **Lack of Long-term Capital Improvements Planning –** The system does not practice long-term capital improvements planning. The lack of planning negatively impacts the system's ability to look long term and develop a budget and associated rate structure that will provide for the system's long-term needs.

- **No Reserve Account –** The City has a reserve account for emergencies; however, it is not earmarked for water. Because the City's policy is to pay for everything up front and they are not willing to incur any debt, a reserve account is especially critical to fund long-term projects and emergencies.

- **Water Loss –** The system does not have a program to measure or manage water system losses. They do not perform leak tests or water audits of any type. The City's water loss has been estimated at about 21 percent; however, they believe the water loss is greater. Although they are unsure of the source of the leaks, they are considering replacing 10 percent of the water meters every year. A reduction in water loss would significantly reduce the amount of water that must be pumped and/or treated.

#### 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.

- **Plans for New Well –** The City is considering selling some property to fund a new well. However, they have not made any arrangements to investigate the water quality in the area they have selected. Additional planning (*i.e.*, drilling a test well) could assist in determining if there is an issue with radium, or any other regulated drinking water contaminants. Obtaining this information prior to drilling a production well could potentially save the City a substantial amount of time and money.

- **Understanding of Drinking Water Regulations –** Although they are working on it, the new City Administration is not familiar with the requirements of the Safe Drinking Water Act. They rely on the water operators to keep them apprised of existing and new regulations. Training for City Administrators would enable them to improve budgeting and planning activities.

- **Preventive Maintenance Program –** There is no preventive maintenance program. The operators make repairs on a reactive rather than proactive basis. However, they do maintain a small inventory of spare parts and flush the lines once a month. In addition, there is no scheduled valve-exercising program. Without regular schedules of valve exercising, there can be no sure way to identify those valves that need replacement prior to failure in an emergency.

- **Written Procedures –** There are no written procedures for operational staff. At this time, the staff knows what tasks they need to do and are able to operate the system without written procedures. The Supervisor provides on-the-job training. However, if staff leaves or if additional staff is hired, the lack of written 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, the PWSs surrounding the City of Mason were reviewed with regard to their reported drinking water quality and production capacity. PWSs that appeared to have water supplies with water quality issues were ruled out from consideration as alternative sources, while those without identified water quality issues were investigated further. If it was determined that these PWSs had excess supply capacity and might be willing to sell the excess, or might be a suitable location for a new groundwater well, the system was taken forward for further consideration.

Table 4.1 is a list of the existing PWSs within approximately 35 miles of the City of Mason. This distance was selected as the radius for the evaluation owing to the relatively small number of PWSs in the proximity of the City of Mason and because 35 miles was considered to be the upper limit of economic feasibility for the construction of a new water line.

**Table 4.1 PWSs within 35 Miles of Mason**

| System Name | Distance from Mason | Capacity | Comments/Other Issues |
|---|---|---|---|
| London Water System | 20.5 miles | <1 mgd | Small system with WQ issues: TDS, sulfate, gross alpha exceedances |
| Live Oak Hills Subdivision | 21.4 miles | <1 mgd | Small system with WQ issues: radium (total Rd, Rd 226, Rd 228), gross alpha exceedances |
| Doss Consolidated School District | 21.7 miles | <1 mgd | Small system with WQ issues: arsenic, iron exceedances |
| Deer Country Water System | 26.9 miles | <1 mgd | Small system with WQ issues: nitrate, gross alpha exceedances |
| Brady Lake Water System | 27.4 miles | <1 mgd | Small system with WQ issues: iron, radium (Rd 228, Rd 226), gross alpha exceedances |
| City of Brady | 27.5 miles | 4.1 mgd | >1 mgd system with WQ issues: iron, radium (total Rd, Rd 226, Rd 228), gross alpha exceedances |
| LCRA Harper Water System | 29.9 miles | <1 mgd | Small system without identified WQ issues |
| TPWD Enchanted Rock S N A | 30.4 miles | <1 mgd | Small system with marginal fluoride exceedances |
| Lakeland Services | 30.7 miles | <1 mgd | Small system with marginal exceedances of dissolved solids |
| Harper Road Estates | 31.9 miles | <1 mgd | Small system without identified WQ issues |
| El Gallo Mexican Restaurant | 32.4 miles | <1 mgd | Small system without identified WQ issues |

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

**Table 4.2 PWSs within 35 Miles of Mason**

| System Name | Pop | Conn | Total Production (mgd) | Ave Daily Usage (mgd) | Approx. Dist. from Mason |
|---|---|---|---|---|---|
| City of Brady | 5,433 | 2,854 | 5.695 | 1.430 | 27 miles |
| LCRA Harper Water System | 360 | 120 | 0.216 | 0.042 | 30 miles |
| City of Llano | 3,350 | 1,764 | 3.210 | 0.630 | 34 miles |

#### 4.2.1.1 City of Brady

The City of Brady is located approximately 28 miles to the north by northwest of the City of Mason. The City has five active and one inactive deep groundwater wells. The wells are approximately 2060 – 2249 feet deep with production capacity of 350 – 650 gpm. The groundwater has elevated levels of radium. The City has a water allocation of 1000 acre-ft/yr 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 maximum use of 3.5 mgd during drought conditions; normal maximum 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 then measured, the mix will be adjusted to minimize the use of the surface water.

After the water treatment plant is completed in October 2005, there may be excess production capacity within the system. They currently provide drinking water to the communities of Melvin, Live Oak Hills, and Lakeland Services. 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 TWDB to cover the costs of the upgrades.

#### 4.2.1.2 LCRA Harper Water System

The Lower Colorado River Authority (LCRA) Harper Water System is located in Harper, which is approximately 30 miles to the south of the City of Mason. The PWS is operated by the LCRA and is supplied by a single 715-foot groundwater well, completed in the Hensell Sand aquifer which is a member of the Travis Peak Formation (Code 218HNSL). The well has a total production of 0.216 mgd and water is hypochlorinated before distribution. The system has 150,000 gallons of storage capacity. The LCRA Harper Water System serves a population of 360, has 120 metered connections, and has an approximate average daily usage of 0.042 mgd.

There is not sufficient excess capacity at the LCRA Harper Water System to supplement the City of Mason's existing supply; however, based on the available water quality data, the location may be a suitable point for a new groundwater well.

#### 4.2.1.3 City of Llano

The City of Llano is a publicly owned water system located at the junction of State Highways 16 and 29, approximately 34 miles east of the City of Mason. This PWS uses a surface water treatment plant (SWTP) that has its intake on the South Llano River. The SWTP is a 3.210 mgd system that has two treatment trains, each comprising coagulation, two-stage mechanical flocculation, clarification, and dual-media filtration steps. Disinfection is achieved pre- and post-treatment using chloramines. The City of Llano PWS has 2.2 million gallons of total storage capacity, serves a population of 3,350, and has 1,668 metered connections.

#### 4.2.1.4 Lehmberg Irrigation Well

Mr. L. Lehmberg is the private owner of several irrigation wells west and south of the City. He has informed the City that he is willing to sell them water. This would require the construction of a storage tank, pump station and 12 miles of pipe that would follow U.S. Highway 377. The pipeline would terminate at the existing storage tanks owned by the City of Mason. Mr. Lehmberg does not currently supply groundwater to off-site users.

### 4.2.2 Potential for New Groundwater Sources

#### 4.2.2.1 Installing New Compliant Wells

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

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

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

#### 4.2.2.2 Results of Groundwater Availability Modeling

The Hickory aquifer is the primary groundwater source for public water supplies in the Mason system vicinity. This aquifer is classified by the TWDB as minor on the basis of potential water production. Pockets of water-bearing rock layers of the aquifer that appear at the land surface (outcrop) are scattered throughout Mason and Llano counties, while deeper aquifer formations (downdip) are present in Mason County and 11 adjacent counties. The Mason water system, according to TCEQ records, withdraws water from the Hickory sandstone.

No GAM has yet been developed for the Hickory aquifer. The 2002 Texas Water Plan indicates that the groundwater supply from the Hickory aquifer will steadily decline over several decades. The estimated decline in supply is 9 percent, from 50,699 acre-feet per year in 2000 to 46,133 acre-feet per year in 2050.

Sections of Mason County overlay an additional potential groundwater supply, the Ellenburger-San Saba aquifer. The outcrop of the Ellenburger-San Saba aquifer, according to the spatial distribution provided by the 2002 Texas Water Plan, covers the south-central Mason County, and its downdip extends throughout west and south sections of the county. No GAM has yet been developed for this aquifer. The 2002 Texas Water Plan estimates that current supply of the Ellenburger-San Saba aquifer will remain near its current value of 22,580 acre-feet per year over the next 50 years.

### 4.2.3 Potential for New Surface Water Sources

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

Mason is located in the upper reach of the Colorado River Basin where current surface water availability is expected to steadily decrease as a result of 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 Mason system has a minimum availability of surface water for new uses as indicated by the TCEQ's availability maps for the Colorado River Basin. In the site vicinity, and over the entire Mason County, unappropriated flows for new uses are available at most 25 percent of the time. This supply is inadequate as the TCEQ requires a 100 percent supply availability for a municipal water supply.

### 4.2.4 Options for Detailed Consideration

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

1. Purchase water from the City of Brady and install storage tanks, pump stations, and pipeline (Alternative CM-1).

2. Drill a new well near LCRA Harper and install storage tanks, pump stations, and pipeline (Alternative CM-2).

3. Purchase water from the City of Llano and install storage tanks, pump stations, and pipeline (Alternative CM-3).

4. Purchase water from Larry Lehmberg and install a storage tank, pump station, and pipeline (Alternative CM-4).

In addition to the location-specific alternatives above, three hypothetical alternatives are considered in which new wells would be installed 10-, 5-, and 1-miles from the City of Mason PWS. Under each of these alternatives, it is assumed that a source of compliant water can be located and then a new well would be completed and a pipeline would be constructed to transfer the compliant water to the City of Mason. These alternatives are CM-11, CM-12, and CM-13.

## 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 Mason. IX, WRT Z-88™ adsorption, and $KMnO_4$-greensand filtration are potential applicable processes. The central IX treatment alternative is Alternative CM-5, the central Z-88 treatment process alternative is Alternative CM-6, and the central $KMnO_4$-greensand treatment alternative is Alternative CM-7.

### 4.3.2 Point-of-Use Systems

Point-of-use treatment using RO technology is valid for radium removal. The POU treatment alternative is CM-9.

### 4.3.3 Point-of-Entry Systems

Point-of-entry treatment using RO technology is valid for radium removal. The POE treatment alternative is CM-10.

## 4.4 BOTTLED WATER

Provision of 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. The alternatives addressing bottled water are CM-14, CM-15, and CM-16.

## 4.5 ALTERNATIVE DEVELOPMENT AND ANALYSIS

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

### 4.5.1 Alternative CM-1: City of Brady

This alternative involves the purchase of treated surface water from the City of Brady, which will be used to supply the City of Mason. While Brady does not currently have sufficient excess capacity to sell additional water outside their community, the City has indicated that it may have excess production capacity within the system following completion of their surface water treatment plant in October 2005. It is possible that this excess might be sufficient to supply the City of Mason with treated water for blending, assuming that an agreement could be negotiated.

This alternative would require construction of three 5,000-gallon storage tanks at a point adjacent to the City of Brady's water system, and a pipeline from the tanks to the existing intake point for the City of Mason's PWS. Three pump stations would also be required to overcome pipe friction and the elevation differences between Brady and Mason. The required pipeline would be constructed of 10-inch PVC pipe and would follow Highway 87 from Brady to Mason. Using this route, the length of pipe required would be approximately 27 miles. The pipeline would terminate at the existing storage tanks owned by the City of Mason.

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

The estimated capital cost for this alternative includes the cost to construct the pipeline and pump stations. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost that the City of Mason currently pays to operate their well field, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump stations. The estimated capital cost for this alternative is $10.27 million, and the alternative's estimated annual O&M cost is $366,400. If the purchased water was used for blending rather than for the full water supply, the annual O&M cost for this alternative could be reduced because of reduced pumping costs and reduced water purchase costs. However, additional costs would be incurred for equipment to ensure proper blending, and additional monitoring to ensure the finished water is compliant.

Reliability of supply 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 City of Mason's perspective, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood, and the City currently operates pipelines and a pump station. If the decision was made to perform blending then the operational complexity would increase.

This alternative does not provide an opportunity for a shared solution.

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

### 4.5.2 Alternative CM-2: LCRA Harper

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

This alternative would require the completion of two new wells and five storage tanks at LCRA Harper, and the construction of a pipeline from the wells to the existing intake point for the City of Mason PWS. Five pump stations would also be required to overcome pipe friction and the elevation differences between LCRA Harper and Mason. The required pipeline would be constructed of 10-inch PVC pipe and would follow the Doss-Harper road to Doss, then Ranch Road 783, and then State Highway 87 to the City of Mason. Using this route, the pipeline required would be approximately 38.6 miles in length. The pipeline would terminate at the existing storage tanks owned by the City of Mason.

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

The estimated capital cost for this alternative includes the cost to complete the new wells, and construct the pipeline and pump stations. The estimated O&M cost for this alternative includes the maintenance cost for the pipeline, and power and O&M labor and materials for the pump stations. The estimated capital cost for this alternative is $15.26 million, and the alternative's estimated annual O&M cost is $215,400. If the purchased water was used for blending rather than for the full water supply, the annual O&M cost for this alternative could be reduced because of reduced pumping costs and reduced water purchase costs. However, additional costs would be incurred for equipment to ensure proper blending, and additional monitoring to ensure the finished water is compliant.

Reliability of supply of adequate amounts of compliant water under this alternative should be good. From the City of Mason's perspective, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood, and the City currently operates pipelines and a pump station.

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

### 4.5.3 Alternative CM-3: City of Llano

This alternative involves the purchase of treated surface water from the City of Llano, which will be used to supply the City of Mason. The availability of excess capacity is currently unknown.

This alternative would require construction of two 5,000-gallon storage tanks at a point adjacent to the City of Llano's water system, and a pipeline from the tanks to the existing intake point for the City of Mason's PWS. Two pump stations would also be required to overcome pipe friction and the elevation differences between Llano and Mason. The required pipeline would be constructed of 10-inch PVC pipe and would follow Highway 29 from Llano to Mason. Using this route, the length of pipe required would be approximately 35 miles. The pipeline would terminate at the existing storage tanks owned by the City of Mason.

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

The estimated capital cost for this alternative includes the cost to construct the pipeline and pump stations. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost that the City of Mason currently pays to operate their well field, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump stations. The estimated capital cost for this alternative is $12.8 million, and the alternative's estimated annual O&M cost is $313,800. If the purchased water was used for blending rather than for the full water supply, the annual O&M cost for this alternative could be reduced because of reduced pumping costs and reduced water purchase costs. However, additional costs would be incurred for equipment to ensure proper blending, and additional monitoring to ensure the finished water is compliant.

Reliability of supply of adequate amounts of compliant water under this alternative should be good. The City of Llano already supplies groundwater on a fairly large scale, and has adequate O&M resources. From the City of Mason's perspective, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood, and the City currently operates pipelines and a pump station. If the decision was made to perform blending then the operational complexity would increase.

This alternative does not provide an opportunity for a shared solution.

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

### 4.5.4 Alternative CM-4: Lehmberg Irrigation Well

This alternative involves the purchase of groundwater from Larry Lehmberg. Mr. Lehmberg has informed the City that he is willing to sell them water. He owns several wells west and south of the City. The wells are currently used for irrigation and will need to be tested for all the MCL parameters.

This alternative would require construction of one 5,000-gallon storage tank at a point adjacent to the selected well, and a pipeline from the tank to the existing intake point for the City of Mason's PWS. A pump station would also be required to overcome pipe friction and the elevation differences between the well and Mason. The required pipeline would be constructed of 10-inch PVC pipe and would follow U.S. Highway 377. Using this route, the length of pipe required would be approximately 12 miles. The pipeline would terminate at the existing storage tanks owned by the City of Mason.

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

The estimated capital cost for this alternative includes the cost to construct the pipeline and pump station. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost that the City of Mason currently pays to operate their 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 $4.3 million, and the alternative's estimated annual O&M cost is $237,500. 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.

Reliability of supply of adequate amounts of compliant water under this alternative should be fair. Mr. Lehmberg does not currently supply groundwater to off-site users. From the City of Mason's perspective, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood, and the City currently operates pipelines and a pump station. If the decision was made to perform blending then the operational complexity would increase.

This alternative does not provide an opportunity for a shared solution.

The feasibility of this alternative is dependent on an agreement being reached with the Mr. Lehmberg to purchase water.

### 4.5.5 Alternative CM-5: Central Ion Exchange Treatment

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

The two IX treatment plants, located at the Mason well fields, each features a 2,400-square foot building with a paved driveway, a skid holding the pre-constructed IX equipment, a 20-ton brine tank with regeneration equipment, four transfer pumps, a 50,000-gallon tank for storing the treated water, a 40,000-gallon tank for storing spent backwash water, and a 40,000-gallon tank for storing regenerant waste. Spent backwash water would be discharged to the sewer at a controlled rate; regenerant waste would be trucked off site for disposal. The treated water would be chlorinated and stored in the new treated water tank prior to being pumped into the distribution system. The entire facility is fenced.

The estimated capital cost for this alternative is $2.54 million, and the estimated annual O&M cost is $172,200.

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

#### 4.5.6 Alternative CM-6: WRT Z-88™ Media

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

This alternative consists of constructing two Z-88 treatment systems at the existing Mason well fields. WRT owns the Z-88 equipment and the City would pay for construction for the treatment units and auxiliary facilities. Each plant is composed of a tall (25-30-feet) 600 square foot building with a paved driveway; the pre-fabricated Z-88 adsorption system owned by WRT; and piping system. The entire facility would be fenced. The treated water would be chlorinated prior to distribution. It is assumed the well pumps would have adequate pressure to pump the water through the Z-88 system to the ground storage tanks without requiring new pumps.

The estimated capital cost for this alternative is $444,700 and the annual O&M cost is estimated to be $211,800.

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

#### 4.5.7 Alternative CM-7: Potassium Permanganate Greensand Filtration

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

The two greensand plants, located at the Mason well fields, each features an 800 square foot building with a paved driveway; a skid with the pre constructed filters and a $KMnO_4$ solution tank; a 55,000-gallon spent backwash tank; and piping systems. The spent backwash water would be discharged to the sewer at a controlled rate. The entire facility is fenced.

The estimated capital cost for this alternative is $1.60 million and the annual O&M is estimated to be $122,500.

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

### 4.5.8 Alternative CM-8: Filtration Technologies for GWUDI

A shallow limestone aquifer lies near and beneath portions of Comanche Creek, which is likely to be GWUDI. The reliability of this aquifer for use as a year-around water source is unknown. Nevertheless, this water is not likely to contain unacceptable concentrations of radium. The aquifer is currently used for irrigation.

Under this alternative, the City of Mason would continue to pump water from its existing wells; however, GWUDI from the shallow wells that have no radium problems would be treated using a filtration system prior to blending with water from the deep wells that exhibit some radium contamination. The concentration of radium is unknown in the shallow wells along Comanche Creek. Existing shallow wells will need to be tested for radium. Records indicate the shallow wells (less than 150 feet deep) produce less than 40 gpm. Therefore, several wells would be needed. A more thorough investigation is needed to determine if the shallow wells are cost effective to use as a supplemental water source.

This alternative consists of installing a cartridge filtration unit at two central locations. Each unit would include a building with a paved driveway, two pre-filters and two final filters, a tank for storing the treated water, and two transfer pumps. The treated water would be chlorinated and stored in the new treated-water tank prior to being blended with water from the deep wells. The existing underground storage tank would continue to be used to accumulate the blended water. The entire facility would be fenced.

The estimated capital cost for this alternative is $287,700, and the estimated annual O&M cost is $41,200.

The reliability of adequate amounts of compliant water under this alternative is fair. While filtration is a common and well-understood treatment technology, the City of Mason has experienced reduced production from its shallow wells during drought conditions and this alternative relies upon a minimum production from those wells to maintain a compliant water supply. It is possible a location might be found to install a new shallow well to supplement this supply, although that would increase the cost of the alternative and would still not guarantee a reliable supply during drought conditions. O&M efforts required for the central filtration unit would include changing filter cartridges, verifying the effectiveness of treatment and blending, and maintaining the equipment. City of Mason personnel would require training to operate the new equipment.

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

### 4.5.9 Alternative CM-9: Point-of-Use Treatment

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

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

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing and installing the POU treatment systems. The estimated O&M cost for this alternative includes purchasing and replacing filters and media or membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $821,700, and the estimated annual O&M cost for this alternative is $778,100. For the cost estimate, it is assumed that one POU treatment unit would be required for each of the 1,245 existing connections. 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 Mason personnel are inexperienced in this type of work. From the perspective of the City of Mason, 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.

### 4.5.10 Alternative CM-10: Point-of-Entry Treatment

This alternative consists of the continued operation of the City of Mason well fields, plus treatment of water as it enters residences to remove radium. 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 would be responsible for purchasing and maintaining the treatment units, including media or membrane and filter replacement, periodic sampling, and necessary repairs. It may also be desirable to modify piping so water for non-consumptive uses can be withdrawn upstream of the treatment unit. The POE treatment units would be installed outside the residences, so entry would not be necessary for O&M. Some cooperation from customers would be necessary for installation and maintenance of the treatment systems.

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

This alternative does not present options for a 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 $14.4 million, and the estimated annual O&M cost for this alternative is $1.74 million. For the cost estimate, it is assumed that one POE treatment unit would be required for each of the 1,245 existing connections to the PWS.

The reliability of adequate amounts of compliant water under this alternative is fair, but better than POU systems since it relies less on the active cooperation of customers for system installation, use, and maintenance, and compliant water is supplied to all taps within a house. Additionally, O&M efforts required for the POE systems would be significant, and the City personnel are inexperienced in this type of work. From the perspective of the City, 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.

### 4.5.11 Alternative CM-11: New Wells at 10 Miles

This alternative consists of installing two new wells within 10 miles of the City of Mason that would produce compliant water in place of the water produced by the Mason well field. 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 two new 600-foot wells, a new pump station with storage tank near the new wells, and a pipeline from the new wells/tank to the existing intake point for the City of Mason PWS. The pump station and storage tank would be necessary to overcome pipe friction and changes in land elevation. For this alternative, the pipeline is assumed to be approximately 10 miles long, and would be a 10-inch PVC line that discharges to the existing storage tank at the City of Mason. 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 wells and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes O&M for the pipeline and pump station, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing City of Mason wells. The estimated capital cost for this alternative is $3.90 million, and the estimated annual O&M cost for this alternative is $13,600.

The reliability of adequate amounts of compliant water under this alternative should be good, since water wells, pump stations and pipelines are commonly employed. From the perspective of the City of Mason, this alternative would be similar to operate as the existing system. The City of Mason 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 likely the alternate groundwater source would not be found on land controlled by the City of Mason, so landowner cooperation would likely be required.

### 4.5.12 Alternative CM-12: New Wells at 5 Miles

This alternative consists of installing two new wells within 5 miles of the City of Mason that would produce compliant water in place of the water produced by the Mason well field. 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 two new 600-foot wells, a new pump station with storage tank near the new wells, and a pipeline from the new wells/tank to the existing intake point for the City of Mason PWS. The pump station and storage tank would be necessary to overcome pipe friction and changes in land elevation. For this alternative, the pipeline is assumed to be approximately 5 miles long, and would be a 10-inch PVC line that discharges to the existing storage tank at the City of Mason. 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 wells and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes O&M for the pipeline and pump station, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing City of Mason wells. The estimated capital cost for this alternative is $2.10 million, and the estimated annual O&M cost for this alternative is $2,600 less than current costs.

The reliability of adequate amounts of compliant water under this alternative should be good, since water wells, pump stations and pipelines are commonly employed. From the perspective of the City of Mason, this alternative would be similar to operate as the existing system. The City of Mason 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 likely the alternate groundwater source would not be found on land controlled by the City of Mason, so landowner cooperation would likely be required.

### 4.5.13 Alternative CM-13: New Wells at 1 Mile

This alternative consists of installing two new wells within 1 mile of the City of Mason that would produce compliant water in place of the water produced by the Mason well field. 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 two new 600-foot wells and a pipeline from the new wells/tank to the existing intake point for the City of Mason PWS. For this alternative, the pipeline is assumed to be approximately 1 mile long, and would be a 10 inch PVC line that discharges to the existing storage tank at the City of Mason.

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 wells and constructing the pipeline. The estimated O&M cost for this alternative includes O&M for the pipeline, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing City of Mason wells. The estimated capital cost for this alternative is $469,300, and the estimated annual O&M cost for this alternative is $32,800 less than current costs.

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 Mason, this alternative would be similar to operate as the existing system. The City of Mason 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 likely the alternate groundwater source would not be found on land controlled by the City of Mason, so landowner cooperation would likely be required.

### 4.5.14 Alternative CM-14: Public Dispenser for Treated Drinking Water

This alternative consists of the continued operation of the Mason well fields, 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 Mason 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 the customers in order to be effective.

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing and installing the treatment system to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes purchasing and replacing filters and media or membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $46,400 and the estimated annual O&M cost for this alternative is $66,600.

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 Mason has not provided this type of service in the past. From the perspective of the City of Mason, 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.

### 4.5.15 Alternative CM-15: 100 Percent Bottled Water Delivery

This alternative consists of the continued operation of the Mason well fields, 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 Mason 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 Mason's customers.

This alternative does not present options for a regional solution.

The estimated initial capital cost is for setting up the program. The estimated O&M cost for this alternative includes program administration and purchase of the bottled water. The estimated capital cost for this alternative is $23,900, and the estimated annual O&M cost for this alternative is $1.19 million. 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 Mason.

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

#### 4.5.16 Alternative CM-16: Public Dispenser for Trucked Drinking Water

This alternative consists of continued operation of the Mason well field, plus dispensing compliant water for drinking and cooking at a publicly accessible location. The compliant water would be purchased from the City of 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 Mason 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 $150,900, and the estimated annual O&M cost for this alternative is $70,600.

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 Mason has not provided this type of service in the past. From the perspective of the City of Mason, 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 Mason.

1 **Table 4.3 Summary of Compliance Alternatives for the City of Mason**

| Alt No. | Alternative Description | Major Components | Capital Cost[1] | Annual O&M Cost | Total Annualized Cost[2] | Reliability | System Impact | Remarks |
|---|---|---|---|---|---|---|---|---|
| CM-1 | Purchase treated water from City of Brady | Pump stations and 27-mile pipeline | $10,274,000 | $366,400 | $1,262,100 | Good | N | Agreement must be successfully negotiated with the City of Brady. Blending may be possible. |
| CM-2 | New well at LCRA Harper | New GW wells, pump stations, and 38.6-mile pipeline | $15,257,700 | $215,400 | $1,545,700 | Good | N | May be difficult to find well with good water quality. |
| CM-3 | Purchase treated water from City of Llano | Pump stations and 35-mile pipeline | $12,841,300 | $313,800 | $1,433,400 | Good | N | Agreement must be successfully negotiated with the City of Llano. Blending may be possible. |
| CM-4 | Purchase treated water from Larry Lehmberg | Pump station and 12-mile pipeline | $4,338,100 | $237,500 | $615,700 | Good | N | Agreement must be successfully negotiated with the Mr. Lehmberg. Blending may be possible. |
| CM-5 | Continue operation of Mason well fields with central IX treatment | Central IX treatment plant | $2,541,000 | $172,200 | $393,800 | Good | T | No nearby system to possibly share treatment plant cost. |
| CM-6 | Continue operation of Mason well fields with central WRT Z-88 treatment | Central WRT Z-88 treatment plant | $444,700 | $211,800 | $250,600 | Good | T | No nearby system to possibly share treatment plant cost. |
| CM-7 | Continue operation of Mason well fields with central $KMnO_4$ treatment | Central $KMnO_4$ treatment plant | $1,597,600 | $122,500 | $261,800 | Good | T | No nearby system to possibly share treatment plant cost. |
| CM-8 | Continue operation of Mason well fields and treat GWUDI for blending | Central cartridge filtration units, pump stations, piping and storage for blending | $287,700 | $41,200 | $66,200 | Fair | T | Dependent on reliability of existing shallow wells. |
| CM-9 | Continue operation of Mason well fields, and POU treatment | POU treatment units | $821,700 | $778,100 | $849,800 | Fair | T, M | Only one compliant tap in home. Cooperation of residents required for installation, maintenance, and testing. |
| CM-10 | Continue operation of Mason well fields, and POE treatment | POE treatment units | $14,379,800 | $1,743,000 | $2,996,700 | 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 |
|---|---|---|---|---|---|---|---|---|
| CM-11 | Install new compliant well within 10 miles | New wells, storage tank, pump station, and 10-mile pipeline | $3,898,900 | $13,600 | $353,500 | Good | N | May be difficult to find well with good water quality. |
| CM-12 | Install new compliant well within 5 miles | New wells, storage tank, pump station, and 5-mile pipeline | $2,102,200 | $(2,600) | $180,700 | Good | N | May be difficult to find well with good water quality. |
| CM-13 | Install new compliant well within 1 mile | New wells and 1-mile pipeline | $469,300 | $(32,800) | $8,100 | Good | N | May be difficult to find well with good water quality. |
| CM-14 | Continue operation of Mason well fields, but furnish public dispenser for treated drinking water | Water treatment and dispenser unit | $46,400 | $66,600 | $70,600 | Fair/interim measure | T | INTERIM SOLUTION: Does not provide compliant water to all taps, and requires a lot of effort by customers. |
| CM-15 | Continue operation of Mason well fields, but furnish bottled drinking water for all customers | Set up bottled water system | $23,900 | $1,194,000 | $1,196,100 | Fair/interim measure | T, M | INTERIM SOLUTION: Does not provide compliant water to all taps, and requires customers to order and use. Management of program may be significant. |
| CM-16 | Continue operation of Mason well fields, but furnish public dispenser for trucked drinking water | Construct storage tank and dispenser Purchase potable water truck | $150,900 | $70,600 | $83,800 | Fair/interim measure | T, M | INTERIM SOLUTION: Does not provide compliant water to all taps, and requires a lot of effort by customers. |

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

## 4.6 COST OF SERVICE AND FUNDING ANALYSIS

To evaluate the financial impact of implementing the compliance alternatives, a 30-year financial planning model was developed. This model can be found in Appendix D. The financial model is based on estimated cash flows, with and without implementation of the compliance alternatives. Data for such models are derived from established budgets, audited financial reports, published water tariffs, and consumption data.

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

#### 4.6.1.1 City of Mason

Copies of the most recent annual budget and balance sheets were made available by the City of Mason. The water system budget is included in a separate Utility Fund which is designated as an "Enterprise Fund" within the City's budget. Operating revenues and expenditures are treated individually for each utility, which includes electric, sewer, refuse collection in addition to water. Water revenues and expenditures represent approximately 12 percent of the Utility Fund budget. The Utility Fund operates with a substantial annual surplus, and utility funds are transferred to the General Fund on an annual basis. Annual water revenues slightly exceed annual water-related expenditures. The City has no outstanding water or sewer system bond indebtedness or notes payable.

#### 4.6.1.2 Current Financial Condition

##### 4.6.1.2.1 Cash Flow Needs

In 2004 the City substantially increased its basic residential water rate from $4 to $12 for the first 1,000 gallons of water. The City's residential customers are currently being charged a base rate of $12 per month for the first 1,000 gallons; $1.00 per 1,000 gallons for the next 9,000 gallons; and $1.10 per 1,000 gallons for more than 10,000 gallons per month. Water usage rates for the City's commercial customers are $15 for the first 1,000 gallons; $1.00 per 1,000 gallons for the next 9,000 gallons; and $1.10 per 1,000 gallons in excess of 10,000 gallons per month. Based on the total monthly water consumption data provided by the City, the average annual water bill for the City's residential customers is estimated at $249, or less than 1 percent of the median annual household income, as given in the 2000 Census. However, because of the school and an unknown number of commercial connections are included in the total consumption data, the average residential customer's annual bill is most likely to be lower than this estimate.

#### 4.6.1.2.2 Ratio Analysis

Current Ratio = 1.0+

The Current Ratio for the City's water system could not be determined since current assets and liabilities are consolidated in the Utility Fund balance sheet. However, the Current Ratio exceeds 1.0 for the current assets and liabilities of the Utility Fund. 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 Mason's water system is able to meet its current obligations, with customer meter deposits representing the major short-term liability.

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 has no outstanding bond indebtedness or long-term notes payable, the water system's Debt-to-Net-Worth Ratio is very favorable, indicating a financially healthy enterprise.

Operating Ratio = 1.03

Estimated annual water-related operating revenues of $303,000 slightly exceed estimated annual operating expenditures of approximately $295,000, resulting in an Operating Ratio of 1.03. A value exceeding 1.0 indicates the utility is covering its expenses.

### 4.6.1.3 Financial Plan Results

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

For State Revolving Fund funding options, customer MHI compared to the state average determines the availability of subsidized loans. The 2000 U.S. Census for MHI data for the City of Mason indicates the City had an annual MHI of $26,344, or equivalent to 66 percent of the statewide average of $39,927. Thus, the City of Mason would qualify for an interest rate of 0 percent since the City's MHI is below 70 percent of the state MHI. Repayment over 20 years is standard for SRF loans.

Results of the financial impact analysis are provided in Table 4.4 and Figure 4.2. Figure 4.2 provides a bar chart that in terms of the yearly billing to an average customer shows the following:

- Current yearly billing, and
- Projected yearly billing including rate increases to maintain financial viability and also for implementing the various compliance alternatives.

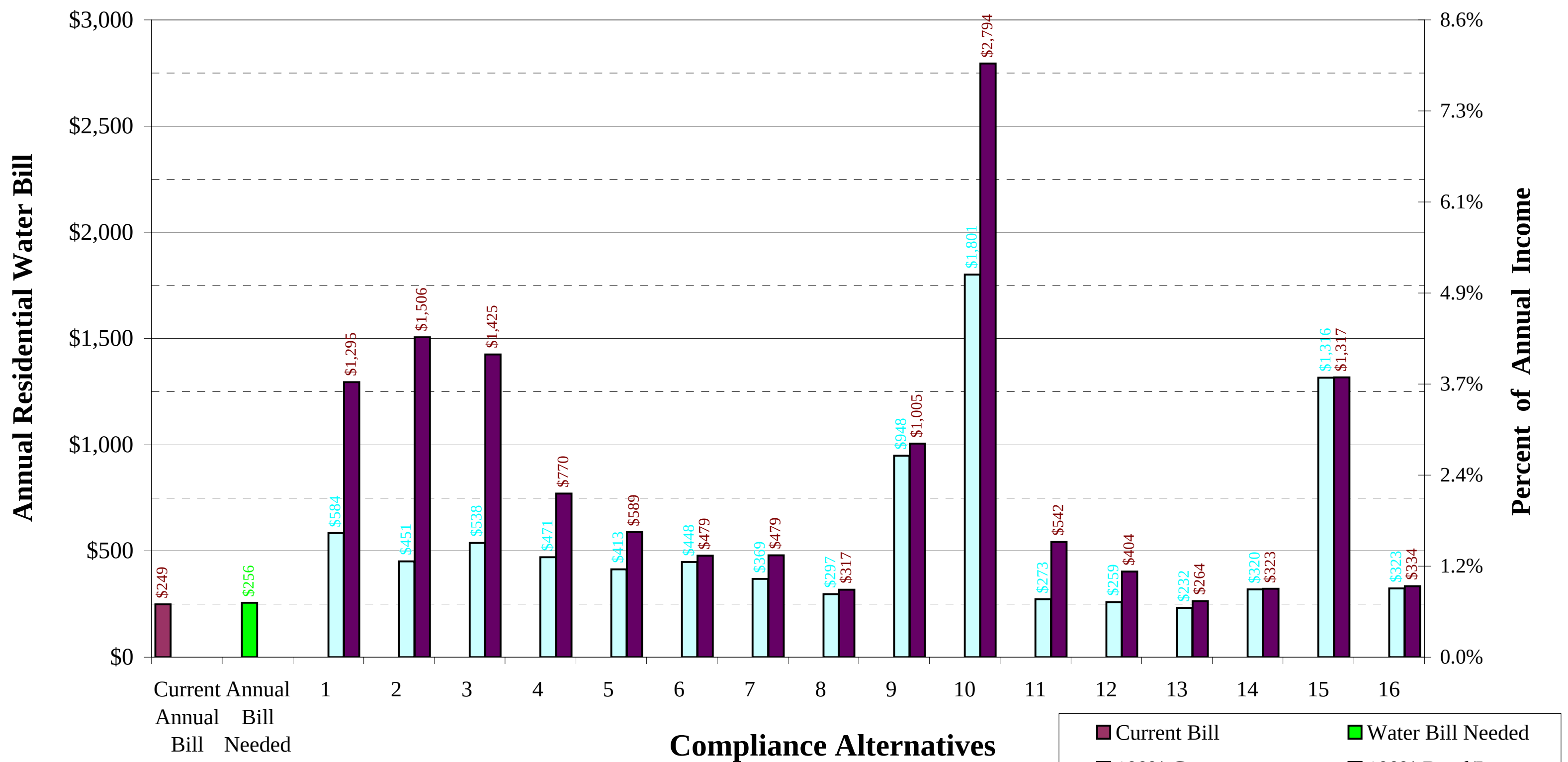
The two bars shown for each compliance alternative represent the rate increases necessary assuming 100 percent grant funding and 100 percent loan/bond funding. Most funding options would fall between 100 percent grant and 100 percent loan/bond funding, with the exception of 100 percent revenue financing. If existing reserves are insufficient to fund a compliance alternative, rates would need to be raised before implementing the compliance alternative to 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 for the City of Mason

| | Funding Source # | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| | | All Revenue | 100% Grant | 75% Grant | 50% Grant | SRF | Loan/Bond |
| **ALTERNATIVES** | | | | | | | |
| Mason-1 | % of HH Income | 37% | 4% | 6% | 7% | 8% | 10% |
| | Rate Increase % | 3869% | 343% | 486% | 629% | 708% | 914% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |
| Mason-2 | % of HH Income | 54% | 3% | 5% | 7% | 8% | 11% |
| | Rate Increase % | 5577% | 218% | 430% | 642% | 760% | 1066% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |
| Mason-3 | % of HH Income | 46% | 4% | 5% | 7% | 8% | 11% |
| | Rate Increase % | 4759% | 300% | 478% | 657% | 756% | 1013% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |
| Mason-4 | % of HH Income | 17% | 3% | 4% | 4% | 5% | 5% |
| | Rate Increase % | 1707% | 236% | 297% | 357% | 391% | 478% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |
| Mason-5 | % of HH Income | 11% | 3% | 3% | 3% | 4% | 4% |
| | Rate Increase % | 1041% | 182% | 218% | 253% | 273% | 324% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |
| Mason-6 | % of HH Income | 4% | 3% | 3% | 3% | 3% | 3% |
| | Rate Increase % | 313% | 215% | 221% | 227% | 231% | 240% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |
| Mason-7 | % of HH Income | 7% | 2% | 2% | 3% | 3% | 3% |
| | Rate Increase % | 686% | 141% | 163% | 186% | 198% | 230% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |
| Mason-8 | % of HH Income | 3% | 2% | 2% | 2% | 2% | 2% |
| | Rate Increase % | 186% | 84% | 88% | 92% | 95% | 100% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |

| | Funding Source # | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| | | **All Revenue** | **100% Grant** | **75% Grant** | **50% Grant** | **SRF** | **Loan/Bond** |
| **ALTERNATIVES** | | | | | | | |
| Mason-9 | % of HH Income | 7% | 7% | 8% | 8% | 8% | 8% |
| | Rate Increase % | 685% | 685% | 696% | 707% | 714% | 730% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |
| Mason-10 | % of HH Income | 57% | 15% | 17% | 19% | 20% | 23% |
| | Rate Increase % | 5898% | 1484% | 1684% | 1884% | 1995% | 2284% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |
| Mason-11 | % of HH Income | 15% | 2% | 2% | 3% | 3% | 4% |
| | Rate Increase % | 1458% | 73% | 127% | 181% | 211% | 290% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |
| Mason-12 | % of HH Income | 9% | 2% | 2% | 2% | 2% | 3% |
| | Rate Increase % | 813% | 66% | 95% | 125% | 141% | 183% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |
| Mason-13 | % of HH Income | 3% | 1% | 2% | 2% | 2% | 2% |
| | Rate Increase % | 220% | 54% | 60% | 67% | 70% | 80% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |
| Mason-14 | % of HH Income | 2% | 2% | 2% | 2% | 2% | 2% |
| | Rate Increase % | 111% | 95% | 95% | 96% | 96% | 97% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |
| Mason-15 | % of HH Income | 11% | 11% | 11% | 11% | 11% | 11% |
| | Rate Increase % | 1029% | 1029% | 1030% | 1030% | 1030% | 1031% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |
| Mason-16 | % of HH Income | 2% | 2% | 2% | 2% | 2% | 2% |
| | Rate Increase % | 150% | 98% | 100% | 102% | 103% | 107% |
| | Year | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |

# Figure 4-2 Alternative Cost Summary




Current Rates:

| | |
|---|---|
| Monthly: | $20.75 |
| Median Household Income | $26,344 |
| Average Monthly Residential Usage | 9,725 gallons |

# SECTION 5
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# APPENDIX A
# PWS INTERVIEW FORM

# CAPACITY DEVELOPMENT ASSESSMENT FORM

*Prepared By*____________________________________ *Date*____________________________

## Section 1. Public Water System Information

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

3. County [ ]

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

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

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

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

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

11. Source Type [ ]

12. Total PWS Annual Water Used [ ]

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

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

# A. Basic Information

1. Name of Water System:

2. Name of Person Interviewed:

3. Position:

4. Number of years at job:

5. Number of years experience with drinking water systems:

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

7. Certified Water Operator (Yes or No):

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

   7b. How long have you been certified?

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

# B. Organization and Structure

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

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

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

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

   3b. May we see a copy?

## C. Personnel

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

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

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

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

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

# D. Communication

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

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

3. How are your work priorities set?

4. How are work tasks delegated to staff?

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

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

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

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

9. Describe communication between utility and customers.

# E. Planning and Funding

1. Describe the rate structure for the utility.

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

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

3. How often are the rates reviewed?

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

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

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

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

8. How is the budget approved or adopted?

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

    9a. How are budget shortfalls handled?

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

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

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

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

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

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

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

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

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

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

## F. Policies, Procedures, and Programs

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

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

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

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

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

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

7. Approximately how many complaints are there per month?

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

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

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

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

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

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

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

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

## G. Operations and Maintenance

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

   a. Process Control

   b. Purchases of supplies or small equipment

   c. Compliance sampling/reporting

   d. Staff scheduling

2. Describe your utility's preventative maintenance program.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

## H. SDWA Compliance

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

2. How were the violations handled?

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

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

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

# I. Emergency Planning

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

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

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

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

# Attachment A

## A. Technical Capacity Assessment Questions

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

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

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

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

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

   YES ☐ NO ☐

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

   _____NM Small System _____Class 2

   _____NM Small System Advanced _____Class 3

   _____Class 1 _____Class 4

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

   YES ☐ NO ☐ No Deficiencies ☐

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

   Source ☐ Storage ☐

   Treatment ☐ Distribution ☐

   Other _____

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

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

   Radionuclides YES ☐ NO ☐ Doesn't Apply ☐

   Arsenic YES ☐ NO ☐ Doesn't Apply ☐

   Stage 1 Disinfectants and Disinfection By-Product (DBP)

   YES ☐ NO ☐ Doesn't Apply ☐

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

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

   YES ☐ NO ☐

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

YES ☐ NO ☐

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

Drought _____ Limited Supply _____

System Failure _____ Other _____

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

YES ☐ NO ☐ Don't Know ☐

If YES, please complete the following table.

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

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

YES ☐ NO ☐

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

Source ☐ Storage ☐

Treatment ☐ Distribution ☐

Other ☐ _____

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

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

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

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

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

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

YES ☐ NO ☐

14. Does the system have a flushing program?

YES ☐ NO ☐

If YES, please describe.

15. Are there any pressure problems within the system?

YES ☐ NO ☐

If YES, please describe.

16. Does the system disinfect the finished water?

YES ☐ NO ☐

If yes, which disinfectant product is used? ______

| Interviewer Comments on Technical Capacity: |
|---|
| |

## B. Managerial Capacity Assessment Questions

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

YES ☐ NO ☐

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

YES ☐ NO ☐

18. Does the system have written operating procedures?

YES ☐ NO ☐

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

YES ☐ NO ☐

20. Does the system have:

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

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

Water quality violations
YES ☐ NO ☐

Public notification
YES ☐ NO ☐

Sampling exemptions
YES ☐ NO ☐

22. Please describe how the above records are maintained:

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

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

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

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

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

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

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

If yes, from which agency and how much?

Describe the project?

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

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

YES ☐ NO ☐

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

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

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

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

Interviewer Comments on Managerial Capacity:

## C. Financial Capacity Assessment

30. Does the system have a budget?

YES ☐ NO ☐

If YES, what type of budget?

Operating Budget ☐

Capital Budget ☐

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

YES ☐ NO ☐

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

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

YES ☐ NO ☐

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

34. Are rates reviewed annually?

YES ☐ NO ☐

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

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

Operation & Maintenance ☐

Infrastructure Repair & replacement ☐

Staffing ☐

Emergency/Reserve fund ☐

Debt payment ☐

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

YES ☐ NO ☐

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

YES ☐ NO ☐

If yes, is this policy implemented?

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

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

[Convert to % of active connections

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

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

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

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

YES ☐ NO ☐

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

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

YES ☐ NO ☐

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

YES ☐ NO ☐

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

YES ☐ NO ☐

If yes, please describe.

41. Has the system ever had a financial audit?

YES ☐ NO ☐

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

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

| Interviewer Comments on Financial Assessment: |
|---|
| |

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

# APPENDIX B
# COST BASIS

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

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

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

Unit costs for pipeline components are based on recent bids on Texas Department of Highways projects. The amounts of boring and encasement and open cut and encasement were estimated by counting the road, highway, railroad, stream, and river crossings for a conceptual routing of the pipeline. The number of air release valves is estimated by examining the land surface profile along the conceptual pipeline route. It is assumed gate valves and flush valves would be installed on average every 5,000 feet along the pipeline. Pipeline cost estimates are based on use of C-900 PVC pipe. Other pipe materials could be considered for more detailed development of attractive alternatives.

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

Electrical power cost is estimated to be $0.095 per kWH, as supplied by the City of Mason. The annual cost for power to a pump station is calculated based on the pumping head and volume, and includes 11,800 kWH for pump building heating, cooling, and lighting, as recommended in USEPA publication, *Standardized Costs for Water Supply Distribution Systems* (1992).

In addition to the cost of electricity, pump stations have other maintenance costs. These costs cover: materials for minor repairs to keep the pumps operating; purchase of a maintenance vehicle, fuel costs, and vehicle maintenance costs; utilities; office supplies, small tools and equipment; and miscellaneous materials such as safety, clothing, chemicals, and paint. The non-power O&M costs are estimated based on the USEPA publication, *Standardized Costs for Water Supply Distribution Systems* (1992), which provides cost curves for O&M components. Costs from the 1992 report are adjusted to 2005 dollars based on the ENR construction cost index.

Pipeline maintenance costs include routine cleaning and flushing, as well as minor repairs to lines. The unit rate for pipeline maintenance is calculated based on the USEPA technical report, *Innovative and Alternate Technology Assessment Manual MCD 53* (1978). Costs from the 1978 report are adjusted to 2005 dollars based on the ENR construction cost index.

Storage tank maintenance costs include cleaning and renewal of interior lining and exterior coating. Unit costs for storage tank O&M are based on USEPA publication *Standardized Costs for Water Supply Distribution Systems* (1992). Costs from the 1992 report are adjusted to 2005 dollars based on the ENR construction cost index.

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

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

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

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

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

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

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

**Table B.1**
**Summary of General Data**
**City of Mason**
**PWS #1600001**
**General PWS Information**

**Service Population** 2,004 **Number of Connections** 1245
**Total PWS Daily Water Usage** 0.439 (mgd) **Source** 2005 Report

**Unit Cost Data**
**Central Texas**

| **General Items** | **Unit** | **Unit Cost** |
|---|---|---|
| Treated water purchase cost | *See alternative* | |
| Water purchase cost (trucked) | $/1,000 gals | $ 1.60 |
| | | |
| Contingency | 20% | n/a |
| Engineering & Constr. Management | 25% | n/a |
| Procurement/admin (POU/POE) | 20% | n/a |
| | | |
| **Pipeline Unit Costs** | **Unit** | **Unit Cost** |
| PVC water line, Class 200, 10" | LF | $ 44 |
| Bore and encasement, 12" | LF | $ 70 |
| Open cut and encasement, 10" | LF | $ 35 |
| Gate valve and box, 10" | EA | $ 970 |
| 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, 10" | EA | $ 4,000 |
| Gate valve, 10" | EA | $ 1,400 |
| Check valve, 10" | EA | $ 2,075 |
| Electrical/Instrumentation | EA | $ 10,000 |
| Site work | EA | $ 2,000 |
| Building pad | EA | $ 4,000 |
| Pump Building | EA | $ 10,000 |
| Fence | EA | $ 5,870 |
| Tools | EA | $ 1,000 |
| | | |
| **Well Installation Unit Costs** | **Unit** | **Unit Cost** |
| Well installation | *See alternative* | |
| Water quality testing | EA | $ 1,500 |
| Well pump | EA | $ 7,500 |
| Well electrical/instrumentation | EA | $ 5,000 |
| Well cover and base | EA | $ 3,000 |
| Piping | EA | $ 2,500 |
| Storage Tank - 5,000 gals | EA | $ 7,025 |
| | | |
| Electrical Power | $/kWH | $ 0.095 |
| Building Power | kWH | 11,800 |
| Labor | $/hr | $ 30 |
| Materials | EA | $ 1,200 |
| Transmission main O&M | $/mile | $ 200 |
| Tank O&M | EA | $ 1,000 |
| | | |
| **POU/POE Unit Costs** | | |
| POU treatment unit purchase | EA | $ 250 |
| POU treatment unit installation | EA | $ 150 |
| POE treatment unit purchase | EA | $ 3,000 |
| POE - pad and shed, per unit | EA | $ 2,000 |
| POE - piping connection, per unit | EA | $ 1,000 |
| POE - electrical hook-up, per unit | EA | $ 1,000 |
| | | |
| POU treatment O&M, per unit | $/year | $ 225 |
| POE treatment O&M, per unit | $/year | $ 1,000 |
| Contaminant analysis | $/year | $ 100 |
| POU/POE labor support | $/hr | $ 30 |
| | | |
| **Dispenser/Bottled Water Unit Costs** | | |
| Treatment unit purchase | EA | $ 3,000 |
| Treatment unit installation | EA | $ 5,000 |
| Treatment unit O&M | EA | $ 500 |
| Administrative labor | hr | $ 40 |
| Bottled water cost (inc. delivery) | gallon | $ 1.60 |
| Water use, per capita per day | gpcd | 1.0 |
| Bottled water program materials | EA | $ 5,000 |
| Storage Tank - 5,000 gals | EA | $ 7,025 |
| Site improvements | EA | $ 4,000 |
| Potable water truck | EA | $ 60,000 |
| Water analysis, per sample | EA | $ 100 |
| Potable water truck O&M costs | $/mile | $ 1.00 |

| **Central Treatment Unit Costs** | **Unit** | **Unit Cost** |
|---|---|---|
| Site preparation | acre | $ 4,000 |
| Slab | CY | $ 1,000 |
| Building | SF | $ 60 |
| Building electrical | SF | $ 8.00 |
| Building plumbing | SF | $ 8.00 |
| Heating and ventilation | SF | $ 7.00 |
| Fence | LF | $ 15 |
| Paving | SF | $ 2.00 |
| Electrical, IX | JOB | $ 50,000 |
| Electrical, WRT Z-88 | JOB | $ 50,000 |
| Electrical, KMnO4 | JOB | $ 50,000 |
| Electrical GWUDI filtration | JOB | $ 20,000 |
| Piping, IX | JOB | $ 20,000 |
| Piping, WRT Z-88 | JOB | $ 20,000 |
| Piping, KMnO4 | JOB | $ 20,000 |
| Piping, GWUDI filtration | JOB | $ 10,000 |
| IX package (a) | UNIT | $ 519,000 |
| IX package (b) | UNIT | $ 460,000 |
| WRT Z-88 package | UNIT | $ - |
| KMnO4 package (a) | UNIT | $ 383,000 |
| KMnO4 package (b) | UNIT | $ 323,000 |
| Transfer pumps (20 hp) | EA | $ 5,000 |
| Sewer connection fee | EA | $ 15,000 |
| Backwash tank | GAL | $ 2.00 |
| Tank, 20,000 GAL | GAL | $ 1.00 |
| Tank, 10,000 GAL | GAL | $ 1.50 |
| Mixer on tank | EA | $ 15,000 |
| Salt feeder | EA | $ 20,000 |
| Excavation | CYD | $ 3.00 |
| Chlorination point | EA | $ 2,000 |
| Compacted fill | CYD | $ 7.00 |
| Lining | SF | $ 0.50 |
| Vegetation | SY | $ 1.00 |
| Access road | LF | $ 30 |
| GWUDI Filter units | EA | $ 7,200 |
| Turbidity meters | EA | $ 1,800 |
| Blending controls | EA | $ 10,000 |
| | | |
| Building Power | kwh | $ 0.095 |
| Equipment power | kwh | $ 0.095 |
| Labor | hr | $ 40 |
| IX (a) Materials | year | $ 10,000 |
| IX (b) Materials | year | $ 8,000 |
| WRT Z-88 treated water | kgal | $ 1.00 |
| KMnO4 (a) Materials | year | $ 7,000 |
| KMnO4 (b) Materials | year | $ 6,000 |
| Backwash discharge to sewer | MGAL | $ 5,000 |
| Chemicals, IX (a) | year | $ 10,000 |
| Chemicals, IX (b) | year | $ 8,000 |
| Chemicals, KMnO4 (a) | year | $ 5,000 |
| Chemicals, KMnO4 (b) | year | $ 4,000 |
| Analyses | test | $ 200 |
| Spent media disposal | CY | $ 20 |
| GWUDI cartridges, calibration | EA | $ 17,000 |
| GWUDI calibration chem | EA | $ 400 |
| Turbidity test | EA | $ 50 |
| Truck rental | day | $ 700 |
| Haul reject water | miles | $ 1.00 |
| Disposal fee | kgal | $ 5.00 |

# APPENDIX C
# COMPLIANCE ALTERNATIVE CONCEPTUAL COST ESTIMATES

This appendix presents the conceptual cost estimates developed for the compliance alternatives. The conceptual cost estimates are given in Tables D.1 through D.16. 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 Mason*
**Alternative Name** *Purchase Water from City of Brady*
**Alternative Number** *CM-1*

| | | |
|---|---|---|
| **Distance from Alternative to PWS (along pipe)** | 27.0 | miles |
| **Total PWS annual water usage** | 160.235 | MG |
| **Treated water purchase cost** | $ 1.65 | per 1,000 gals |
| **Number of Pump Stations Needed** | 3 | |

### Capital Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Pipeline Construction* | | | | |
| Number of Crossings, bore | 35 | n/a | n/a | n/a |
| Number of Crossings, open cut | 26 | n/a | n/a | n/a |
| PVC water line, Class 200, 10" | 142,482 | LF | $ 44.00 | $ 6,269,208 |
| Bore and encasement, 12" | 7,000 | LF | $ 70.00 | $ 490,000 |
| Open cut and encasement, 10" | 1,300 | LF | $ 35.00 | $ 45,500 |
| Gate valve and box, 10" | 28 | EA | $ 970.00 | $ 27,642 |
| Air valve | 27 | EA | $ 1,000.00 | $ 27,000 |
| Flush valve | 28 | EA | $ 750.00 | $ 21,372 |
| Metal detectable tape | 142,482 | LF | $ 0.15 | $ 21,372 |
| **Subtotal** | | | | **$ 6,902,094** |
| *Pump Station(s) Installation* | | | | |
| Pump | 3 | EA | $ 7,500 | $ 22,500 |
| Pump Station Piping, 10" | 3 | EA | $ 4,000 | $ 12,000 |
| Gate valve, 10" | 12 | EA | $ 1,400 | $ 16,800 |
| Check valve, 10" | 6 | EA | $ 2,075 | $ 12,450 |
| Electrical/Instrumentation | 3 | EA | $ 10,000 | $ 30,000 |
| Site work | 3 | EA | $ 2,000 | $ 6,000 |
| Building pad | 3 | EA | $ 4,000 | $ 12,000 |
| Pump Building | 3 | EA | $ 10,000 | $ 30,000 |
| Fence | 3 | EA | $ 5,870 | $ 17,610 |
| Tools | 3 | EA | $ 1,000 | $ 3,000 |
| Storage Tank - 5,000 gals | 3 | EA | $ 7,025 | $ 21,075 |
| **Subtotal** | | | | **$ 183,435** |
| **Subtotal of Component Costs** | | | | **$ 7,085,529** |
| Contingency | 20% | | | $ 1,417,106 |
| Design & Constr Management | 25% | | | $ 1,771,382 |
| **TOTAL CAPITAL COSTS** | | | | **$ 10,274,017** |

### Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Pipeline O&M* | | | | |
| Pipeline O&M | 27.0 | mile | $ 200 | $ 5,397 |
| **Subtotal** | | | | **$ 5,397** |
| *Water Purchase Cost* | | | | |
| From Source | 160,235 | 1,000 gal | $ 1.65 | $ 264,388 |
| **Subtotal** | | | | **$ 264,388** |
| *Pump Station(s) O&M* | | | | |
| Building Power | 35,400 | kWH | $ 0.095 | $ 3,363 |
| Pump Power | 1,089,600 | kWH | $ 0.095 | $ 103,512 |
| Materials | 3 | EA | $ 1,200 | $ 3,600 |
| Labor | 1,095 | Hrs | $ 30 | $ 32,850 |
| Tank O&M | 3 | EA | $ 1,000 | $ 3,000 |
| **Subtotal** | | | | **$ 146,325** |
| *O&M Credit for Existing Well Closure* | | | | |
| Pump power | 37,279 | kWH | $ 0.095 | $ (3,542) |
| Well O&M matl | 7 | EA | $ 1,200 | $ (8,400) |
| Well O&M labor | 1,260 | Hrs | $ 30 | $ (37,800) |
| **Subtotal** | | | | **$ (49,742)** |
| **TOTAL ANNUAL O&M COSTS** | | | | **$ 366,368** |

## Table C.2

**PWS Name** *City of Mason*
**Alternative Name** *New Well at LCRA Harper*
**Alternative Number** *CM-2*

| | | |
|---|---|---|
| **Distance from PWS to new well location** | 38.65 | miles |
| **Estimated well depth** | 700 | feet |
| **Number of wells required** | 2 | |
| **Well installation cost (location specific)** | $25 | per foot |
| **Number of pump stations needed** | 5 | |

### Capital Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Pipeline Construction* | | | | |
| Number of Crossings, bore | 66 | n/a | n/a | n/a |
| Number of Crossings, open cut | 34 | n/a | n/a | n/a |
| PVC water line, Class 200, 10" | 204,068 | LF | $ 44 | $ 8,978,992 |
| Bore and encasement, 12" | 13,200 | LF | $ 70 | $ 924,000 |
| Open cut and encasement, 10" | 1,700 | LF | $ 35 | $ 59,500 |
| Gate valve and box, 10" | 41 | EA | $ 970 | $ 39,589 |
| Air valve | 39 | EA | $ 1,000 | $ 39,000 |
| Flush valve | 41 | EA | $ 750 | $ 30,610 |
| Metal detectable tape | 204,068 | LF | $ 0.15 | $ 30,610 |
| **Subtotal** | | | | **$ 10,102,302** |
| *Pump Station(s) Installation* | | | | |
| Pump | 10 | EA | $ 7,500 | $ 75,000 |
| Pump Station Piping, 10" | 5 | EA | $ 4,000 | $ 20,000 |
| Gate valve, 10" | 20 | EA | $ 1,400 | $ 28,000 |
| Check valve, 10" | 10 | EA | $ 2,075 | $ 20,750 |
| Electrical/Instrumentation | 5 | EA | $ 10,000 | $ 50,000 |
| Site work | 5 | EA | $ 2,000 | $ 10,000 |
| Building pad | 5 | EA | $ 4,000 | $ 20,000 |
| Pump Building | 5 | EA | $ 10,000 | $ 50,000 |
| Fence | 5 | EA | $ 5,870 | $ 29,350 |
| Tools | 5 | EA | $ 1,000 | $ 5,000 |
| Storage Tank - 5,000 gals | 5 | EA | $ 7,025 | $ 35,125 |
| **Subtotal** | | | | **$ 343,225** |
| *Well Installation* | | | | |
| Well installation | 1,400 | LF | $ 25 | $ 35,000 |
| Water quality testing | 4 | EA | $ 1,500 | $ 6,000 |
| Well pump | 2 | EA | $ 7,500 | $ 15,000 |
| Well electrical/instrumentation | 2 | EA | $ 5,000 | $ 10,000 |
| Well cover and base | 2 | EA | $ 3,000 | $ 6,000 |
| Piping | 2 | EA | $ 2,500 | $ 5,000 |
| **Subtotal** | | | | **$ 77,000** |
| **Subtotal of Component Costs** | | | | **$ 10,522,527** |
| Contingency | 20% | | | $ 2,104,505 |
| Design & Constr Management | 25% | | | $ 2,630,632 |
| **TOTAL CAPITAL COSTS** | | | | **$ 15,257,664** |

### Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Pipeline O&M* | | | | |
| Pipeline O&M | 38.6 | mile | $ 200 | $ 7,730 |
| **Subtotal** | | | | **$ 7,730** |
| *Pump Station(s) O&M* | | | | |
| Building Power | 59,000 | kWH | $ 0.095 | $ 5,605 |
| Pump Power | 1,776,350 | kWH | $ 0.095 | $ 168,753 |
| Materials | 5 | EA | $ 1,200 | $ 6,000 |
| Labor | 1,825 | Hrs | $ 30 | $ 54,750 |
| Tank O&M | 5 | EA | $ 1,000 | $ 5,000 |
| **Subtotal** | | | | **$ 240,108** |
| *Well O&M* | | | | |
| Pump power | 43,448 | kWH | $ 0.095 | $ 4,128 |
| Well O&M matl | 2 | EA | $ 1,200 | $ 2,400 |
| Well O&M labor | 360 | Hrs | $ 30 | $ 10,800 |
| **Subtotal** | | | | **$ 17,328** |
| *O&M Credit for Existing Well Closure* | | | | |
| Pump power | 37,279 | kWH | $ 0.095 | $ (3,542) |
| Well O&M matl | 7 | EA | $ 1,200 | $ (8,400) |
| Well O&M labor | 1,260 | Hrs | $ 30 | $ (37,800) |
| **Subtotal** | | | | **$ (49,742)** |
| **TOTAL ANNUAL O&M COSTS** | | | | **$ 215,424** |

# Table C.3

**PWS Name** *City of Mason*
**Alternative Name** *Purchase Water from City of Llano*
**Alternative Number** *CM-3*

| | | |
|---|---|---|
| **Distance from Alternative to PWS (along pipe)** | 35.1 | miles |
| **Total PWS annual water usage** | 160.235 | MG |
| **Treated water purchase cost** | $ 1.65 | per 1,000 gals |
| **Number of Pump Stations Needed** | 2 | |

## Capital Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Pipeline Construction* | | | | |
| Number of Crossings, bore | 25 | n/a | n/a | n/a |
| Number of Crossings, open cut | 63 | n/a | n/a | n/a |
| PVC water line, Class 200, 10" | 185,160 | LF | $ 44.00 | $ 8,147,040 |
| Bore and encasement, 12" | 5,000 | LF | $ 70.00 | $ 350,000 |
| Open cut and encasement, 10" | 3,150 | LF | $ 35.00 | $ 110,250 |
| Gate valve and box, 10" | 37 | EA | $ 970.00 | $ 35,921 |
| Air valve | 35 | EA | $ 1,000.00 | $ 35,000 |
| Flush valve | 37 | EA | $ 750.00 | $ 27,774 |
| Metal detectable tape | 185,160 | LF | $ 0.15 | $ 27,774 |
| **Subtotal** | | | | **$ 8,733,759** |
| | | | | |
| *Pump Station(s) Installation* | | | | |
| Pump | 2 | EA | $ 7,500 | $ 15,000 |
| Pump Station Piping, 10" | 2 | EA | $ 4,000 | $ 8,000 |
| Gate valve, 10" | 8 | EA | $ 1,400 | $ 11,200 |
| Check valve, 10" | 4 | EA | $ 2,075 | $ 8,300 |
| Electrical/Instrumentation | 2 | EA | $ 10,000 | $ 20,000 |
| Site work | 2 | EA | $ 2,000 | $ 4,000 |
| Building pad | 2 | EA | $ 4,000 | $ 8,000 |
| Pump Building | 2 | EA | $ 10,000 | $ 20,000 |
| Fence | 2 | EA | $ 5,870 | $ 11,740 |
| Tools | 2 | EA | $ 1,000 | $ 2,000 |
| Storage Tank - 5,000 gals | 2 | EA | $ 7,025 | $ 14,050 |
| **Subtotal** | | | | **$ 122,290** |
| | | | | |
| **Subtotal of Component Costs** | | | | **$ 8,856,049** |
| | | | | |
| Contingency | 20% | | | $ 1,771,210 |
| Design & Constr Management | 25% | | | $ 2,214,012 |
| | | | | |
| **TOTAL CAPITAL COSTS** | | | | **$ 12,841,271** |

## Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Pipeline O&M* | | | | |
| Pipeline O&M | 35.1 | mile | $ 200 | $ 7,014 |
| **Subtotal** | | | | **$ 7,014** |
| | | | | |
| *Water Purchase Cost* | | | | |
| From Source | 160,235 | 1,000 gal | $ 1.65 | $ 264,388 |
| **Subtotal** | | | | **$ 264,388** |
| | | | | |
| *Pump Station(s) O&M* | | | | |
| Building Power | 23,600 | kWH | $ 0.095 | $ 2,242 |
| Pump Power | 669,500 | kWH | $ 0.095 | $ 63,603 |
| Materials | 2 | EA | $ 1,200 | $ 2,400 |
| Labor | 730 | Hrs | $ 30 | $ 21,900 |
| Tank O&M | 2 | EA | $ 1,000 | $ 2,000 |
| **Subtotal** | | | | **$ 92,145** |
| | | | | |
| *O&M Credit for Existing Well Closure* | | | | |
| Pump power | 37,279 | kWH | $ 0.095 | $ (3,542) |
| Well O&M matl | 7 | EA | $ 1,200 | $ (8,400) |
| Well O&M labor | 1,260 | Hrs | $ 30 | $ (37,800) |
| **Subtotal** | | | | **$ (49,742)** |
| | | | | |
| **TOTAL ANNUAL O&M COSTS** | | | | **$ 313,804** |

## Table C.4

**PWS Name** *City of Mason*
**Alternative Name** *Purchase Water from Lehmburg Well*
**Alternative Number** *CM-4*

| | | |
|---|---|---|
| **Distance from Alternative to PWS (along pipe)** | 12.0 | miles |
| **Total PWS annual water usage** | 160.235 | MG |
| **Treated water purchase cost** | $ 1.65 | 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 | 5 | n/a | n/a | n/a |
| Number of Crossings, open cut | 17 | n/a | n/a | n/a |
| PVC water line, Class 200, 10" | 63,355 | LF | $ 44.00 | $2,787,620 |
| Bore and encasement, 12" | 1,000 | LF | $ 70.00 | $ 70,000 |
| Open cut and encasement, 10" | 850 | LF | $ 35.00 | $ 29,750 |
| Gate valve and box, 10" | 13 | EA | $ 970.00 | $ 12,291 |
| Air valve | 12 | EA | $ 1,000.00 | $ 12,000 |
| Flush valve | 13 | EA | $ 750.00 | $ 9,503 |
| Metal detectable tape | 63,355 | LF | $ 0.15 | $ 9,503 |
| **Subtotal** | | | | **$2,930,667** |
| *Pump Station(s) Installation* | | | | |
| Pump | 1 | EA | $ 7,500 | $ 7,500 |
| Pump Station Piping, 10" | 1 | EA | $ 4,000 | $ 4,000 |
| Gate valve, 10" | 4 | EA | $ 1,400 | $ 5,600 |
| Check valve, 10" | 2 | EA | $ 2,075 | $ 4,150 |
| Electrical/Instrumentation | 1 | EA | $ 10,000 | $ 10,000 |
| Site work | 1 | EA | $ 2,000 | $ 2,000 |
| Building pad | 1 | EA | $ 4,000 | $ 4,000 |
| Pump Building | 1 | EA | $ 10,000 | $ 10,000 |
| Fence | 1 | EA | $ 5,870 | $ 5,870 |
| Tools | 1 | EA | $ 1,000 | $ 1,000 |
| Storage Tank - 5,000 gals | 1 | EA | $ 7,025 | $ 7,025 |
| **Subtotal** | | | | **$ 61,145** |
| **Subtotal of Component Costs** | | | | **$2,991,812** |
| Contingency | 20% | | | $ 598,362 |
| Design & Constr Management | 25% | | | $ 747,953 |
| **TOTAL CAPITAL COSTS** | | | | **$4,338,128** |

### Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Pipeline O&M* | | | | |
| Pipeline O&M | 12.0 | mile | $ 200 | $ 2,400 |
| **Subtotal** | | | | **$ 2,400** |
| *Water Purchase Cost* | | | | |
| From Source | 160,235 | 1,000 gal | $ 1.65 | $ 264,388 |
| **Subtotal** | | | | **$ 264,388** |
| *Pump Station(s) O&M* | | | | |
| Building Power | 11,800 | kWH | $ 0.095 | $ 1,121 |
| Pump Power | 64,900 | kWH | $ 0.095 | $ 6,166 |
| Materials | 1 | EA | $ 1,200 | $ 1,200 |
| Labor | 365 | Hrs | $ 30 | $ 10,950 |
| Tank O&M | 1 | EA | $ 1,000 | $ 1,000 |
| **Subtotal** | | | | **$ 20,437** |
| *O&M Credit for Existing Well Closure* | | | | |
| Pump power | 37,279 | kWH | $ 0.095 | $ (3,542) |
| Well O&M matl | 7 | EA | $ 1,200 | $ (8,400) |
| Well O&M labor | 1,260 | Hrs | $ 30 | $ (37,800) |
| **Subtotal** | | | | **$ (49,742)** |
| **TOTAL ANNUAL O&M COSTS** | | | | **$ 237,483** |

## Table C.5

**PWS Name** *City of Mason*
**Alternative Name** *Central Treatment - IX*
**Alternative Number** *CM-5*

### Capital Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Central-IX** | | | | |
| Site preparation | 2.00 | acre | $ 4,000 | $ 8,000 |
| Slab | 90 | CY | $ 1,000 | $ 90,000 |
| Building | 2,400 | SF | $ 60 | $ 144,000 |
| Building electrical | 2,400 | SF | $ 8.00 | $ 19,200 |
| Building plumbing | 2,400 | SF | $ 8.00 | $ 19,200 |
| Heating and ventilation | 2,400 | SF | $ 7.00 | $ 16,800 |
| Fence | 1,800 | LF | $ 15 | $ 27,000 |
| Paving | 9,600 | SF | $ 2.00 | $ 19,200 |
| Electrical | 2 | JOB | $ 50,000 | $ 100,000 |
| Piping | 2 | JOB | $ 20,000 | $ 40,000 |
| IX package(s) including: | | | | |
| Regeneration system | | | | |
| Brine tank | | | | |
| IX resins & vessels | | | | |
| Unit a | 1 | UNIT | $ 519,000 | $ 519,000 |
| Unit b | 1 | UNIT | $ 460,000 | $ 460,000 |
| Transfer pumps (10 hp) | 4 | EA | $ 5,000 | $ 20,000 |
| Clean water tank | 100,000 | GAL | $ 1.00 | $ 100,000 |
| Regenerant tank | 40,000 | GAL | $ 1.50 | $ 60,000 |
| Backwash tank | 40,000 | GAL | $ 2.00 | $ 80,000 |
| Sewer connection fee | 2 | E | $ 15,000 | $ 30,000 |
| **Subtotal** | | | | **$ 1,752,400** |
| Contingency | 20% | | | 350,480 |
| Design & CM | 25% | | | 438,100 |
| **Total** | | | | **$ 2,540,980** |

### Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **O&M** | | | | |
| Building Power | 36,000 | kwh/yr | $ 0.095 | $ 3,420 |
| Equipment power | 30,000 | kwh/yr | $ 0.095 | $ 2,850 |
| Labor | 2,000 | hrs/yr | $ 40 | $ 80,000 |
| Materials (a) | 1 | year | $ 10,000 | $ 10,000 |
| Chemicals (a) | 1 | year | $ 10,000 | $ 10,000 |
| Materials (b) | 1 | year | $ 8,000 | $ 8,000 |
| Chemicals (b) | 1 | year | $ 8,000 | $ 8,000 |
| Analyses | 48 | test | $ 200 | $ 9,600 |
| Backwash discharge to sewer | 3.204 | MG/yr | $ 5,000 | $ 16,020 |
| Haul regenerant waste and brine | | | | |
| Truck rental | 32 | days | $ 700 | $ 22,433 |
| Mileage charge | 1,923 | miles | $ 1.00 | $ 1,923 |
| **Subtotal** | | | | **$ 172,246** |
| **Total** | | | | **$ 172,246** |

# Table C.6

**PWS Name** *City of Mason*
**Alternative Name** *Central Treatment - WRT Z-88*
**Alternative Number** *CM-6*

## Capital Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Central-WRT Z-88** | | | | |
| Site preparation | 1.00 | acre | $ 4,000 | $ 4,000 |
| Slab | 40 | CY | $ 1,000 | $ 40,000 |
| Building | 1,200 | SF | $ 60 | $ 72,000 |
| Building electrical | 1,200 | SF | $ 8.00 | $ 9,600 |
| Building plumbing | 1,200 | SF | $ 8.00 | $ 9,600 |
| Heating and ventilation | 1,200 | SF | $ 7.00 | $ 8,400 |
| Fence | 900 | LF | $ 15 | $ 13,500 |
| Paving | 4,800 | SF | $ 2.00 | $ 9,600 |
| Electrical | 2 | JOB | $ 50,000 | $ 100,000 |
| Piping | 2 | JOB | $ 20,000 | $ 40,000 |
| WRT Z-88 package including: | | | | |
| Z-88 vessels | | | | |
| Adsorption media | 2 | UNIT | $ - | $ - |
| **Subtotal** | | | | **$ 306,700** |
| Contingency | 20% | | | 61,340 |
| Design & CM | 25% | | | 76,675 |
| **Total** | | | | **$ 444,715** |

## Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **O&M** | | | | |
| Building Power | 18,000 | kwh/yr | $ 0.095 | $ 1,710 |
| Equipment power | 2500 | kwh/yr | $ 0.095 | $ 238 |
| Labor | 1,000 | hrs/yr | $ 40 | $ 40,000 |
| Analyses | 48 | test | $ 200 | $ 9,600 |
| WRT treated water | 160,235 | kgal/yr | $ 1.00 | $ 160,235 |
| **Subtotal** | | | | **$ 211,783** |
| **Total** | | | | **$ 211,783** |

# Table C.7

**PWS Name** *City of Mason*
**Alternative Name** *Central Treatment - KMnO4*
**Alternative Number** *CM-7*

## Capital Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Central-$KMnO_4$-Greensand** | | | | |
| Site preparation | 1.00 | acre | $ 4,000 | $ 4,000 |
| Slab | 30 | CY | $ 1,000 | $ 30,000 |
| Building | 800 | SF | $ 60 | $ 48,000 |
| Building electrical | 800 | SF | $ 8.00 | $ 6,400 |
| Building plumbing | 800 | SF | $ 8.00 | $ 6,400 |
| Heating and ventilation | 800 | SF | $ 7.00 | $ 5,600 |
| Fence | 600 | LF | $ 15 | $ 9,000 |
| Paving | 3,200 | SF | $ 2.00 | $ 6,400 |
| Electrical | 2 | JOB | $ 50,000 | $ 100,000 |
| Piping | 2 | JOB | $ 20,000 | $ 40,000 |
| $KMnO_4$-Greensand package including: | | | | |
| Greensand filters | | | | |
| Solution tank | | | | |
| Unit a | 1 | UNIT | $ 383,000 | $ 383,000 |
| Unit b | 1 | UNIT | $ 323,000 | $ 323,000 |
| Backwash Tank | 55,000 | GAL | $ 2.00 | $ 110,000 |
| Sewer Connection Fee | 2 | EA | $ 15,000 | $ 30,000 |
| **Subtotal** | | | | **$ 1,101,800** |
| Contingency | 20% | | | $ 220,360 |
| Design & CM | 25% | | | $ 275,450 |
| **Total** | | | | **$ 1,597,610** |

## Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **O&M** | | | | |
| Building Power | 12,000 | kwh/yr | $ 0.095 | $ 1,140 |
| Equipment power | 12000 | kwh/yr | $ 0.095 | $ 1,140 |
| Labor | 2,000 | hrs/yr | $ 40 | $ 80,000 |
| Materials (a) | 1 | year | $ 7,000 | $ 7,000 |
| Chemicals (a) | 1 | year | $ 5,000 | $ 5,000 |
| Materials (b) | 1 | year | $ 6,000 | $ 6,000 |
| Chemicals (b) | 1 | year | $ 4,000 | $ 4,000 |
| Analyses | 48 | test | $ 200 | $ 9,600 |
| Backwash discharge to sewer | 1.725 | MG/yr | $ 5,000 | $ 8,624 |
| **Subtotal** | | | | **$ 122,504** |
| **Total** | | | | **$ 122,504** |

# Table C.8

**PWS Name** ***City of Mason***
**Alternative Name** ***Central Treatment - GWUDI Filtration***
**Alternative Number** ***CM-8***

## Capital Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **GWUDI Treatment** | | | | |
| Site preparation | 0.50 | acre | $ 4,000 | $ 2,000 |
| Slab | 20 | CY | $ 1,000 | $ 20,000 |
| 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 | 500 | LF | $ 15 | $ 7,500 |
| Paving | 1,600 | SF | $ 2 | $ 3,200 |
| Electrical | 1 | JOB | $ 50,000 | $ 50,000 |
| Piping | 1 | JOB | $ 20,000 | $ 20,000 |
| Filter system including: | | | | |
| Filter units | 4 | EA | $ 30 | $ 120 |
| Turbidity meters | 2 | EA | $ 1,800 | $ 3,600 |
| Tank for blending | 20,000 | GAL | $ 2.00 | $ 40,000 |
| Blending Pumps | 2 | EA | $ 7,500 | $ 15,000 |
| Blending control system | 1 | EA | $ 1,800 | $ 1,800 |
| Chlorination Point | 1 | EA | $ 2,000 | $ 2,000 |
| **Subtotal** | | | | **$ 198,420** |
| Contingency | 20% | | | 39,684 |
| Design & CM | 25% | | | 49,605 |
| **Total** | | | | **$ 287,709** |

## Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **O&M** | | | | |
| Building Power | 5,000 | kwh/yr | $ 0.095 | $ 475 |
| Equipment power | 22000 | kwh/yr | $ 0.095 | $ 2,090 |
| Labor | 500 | hrs/yr | 40 | $ 20,000 |
| Materials | 1 | year | 17000 | $ 17,000 |
| Chemicals | 1 | year | 400 | $ 400 |
| Analyses | 24 | test | 50 | $ 1,200 |
| **Subtotal** | | | | **$ 41,165** |
| **Total** | | | | **$ 41,165** |

# Table C.9

**PWS Name** ***City of Mason***
**Alternative Name** ***Point-of-Use Treatment***
**Alternative Number** ***CM-9***

**Number of Connections for POU Unit Installation** 1,245

## Capital Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *POU-Treatment - Purchase/Installation* | | | | |
| POU treatment unit purchase | 1,245 | EA | $ 250 | $ 311,250 |
| POU treatment unit installation | 1,245 | EA | $ 150 | $ 186,750 |
| **Subtotal** | | | | **$ 498,000** |
| **Subtotal of Component Costs** | | | | **$ 498,000** |
| Contingency | 20% | | | $ 99,600 |
| Design & Constr Management | 25% | | | $ 124,500 |
| Procurement & Administration | 20% | | | $ 99,600 |
| **TOTAL CAPITAL COSTS** | | | | **$ 821,700** |

## Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *O&M* | | | | |
| POU materials, per unit | 1,245 | EA | $ 225 | $ 280,125 |
| Contaminant analysis, 1/yr per unit | 1,245 | EA | $ 100 | $ 124,500 |
| Program labor, 10 hrs/unit | 12,450 | hrs | $ 30 | $ 373,500 |
| **Subtotal** | | | | **$ 778,125** |
| **TOTAL ANNUAL O&M COSTS** | | | | **$ 778,125** |

## Table C.10

**PWS Name** *City of Mason*
**Alternative Name** *Point-of-Entry Treatment*
**Alternative Number** *CM-10*

**Number of Connections for POE Unit Installation** 1,245

### Capital Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *POE-Treatment - Purchase/Installation* | | | | |
| POE treatment unit purchase | 1,245 | EA | $ 3,000 | $ 3,735,000 |
| Pad and shed, per unit | 1,245 | EA | $ 2,000 | $ 2,490,000 |
| Piping connection, per unit | 1,245 | EA | $ 1,000 | $ 1,245,000 |
| Electrical hook-up, per unit | 1,245 | EA | $ 1,000 | $ 1,245,000 |
| **Subtotal** | | | | **$ 8,715,000** |
| **Subtotal of Component Costs** | | | | **$ 8,715,000** |
| Contingency | 20% | | | $ 1,743,000 |
| Design & Constr Management | 25% | | | $ 2,178,750 |
| Procurement & Administration | 20% | | | $ 1,743,000 |
| **TOTAL CAPITAL COSTS** | | | | **$ 14,379,750** |

### Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *O&M* | | | | |
| POE materials, per unit | 1,245 | EA | $ 1,000 | $ 1,245,000 |
| Contaminant analysis, 1/yr per unit | 1,245 | EA | $ 100 | $ 124,500 |
| Program labor, 10 hrs/unit | 12,450 | hrs | $ 30 | $ 373,500 |
| **Subtotal** | | | | **$ 1,743,000** |
| **TOTAL ANNUAL O&M COSTS** | | | | **$ 1,743,000** |

## Table C.11

**PWS Name** *City of Mason*
**Alternative Name** *New Well at 10 Miles*
**Alternative Number** *CM-11*

| | | |
|---|---|---|
| **Distance from PWS to new well location** | 10.0 | miles |
| **Estimated well depth** | 600 | feet |
| **Number of wells required** | 2 | |
| **Well installation cost (location specific)** | $25 | per foot |
| **Number of pump stations needed** | 1 | |

### Capital Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Pipeline Construction* | | | | |
| Number of Crossings, bore | 12 | n/a | n/a | n/a |
| Number of Crossings, open cut | 12 | n/a | n/a | n/a |
| PVC water line, Class 200, 10" | 52,800 | LF | $ 44 | $ 2,323,200 |
| Bore and encasement, 12" | 2,400 | LF | $ 70 | $ 168,000 |
| Open cut and encasement, 10" | 600 | LF | $ 35 | $ 21,000 |
| Gate valve and box, 10" | 11 | EA | $ 970 | $ 10,243 |
| 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** | | | | **$ 2,548,283** |
| *Pump Station(s) Installation* | | | | |
| Pump | 2 | EA | $ 7,500 | $ 15,000 |
| Pump Station Piping, 10" | 1 | EA | $ 4,000 | $ 4,000 |
| Gate valve, 10" | 4 | EA | $ 1,400 | $ 5,600 |
| Check valve, 10" | 2 | EA | $ 2,075 | $ 4,150 |
| Electrical/Instrumentation | 1 | EA | $ 10,000 | $ 10,000 |
| Site work | 1 | EA | $ 2,000 | $ 2,000 |
| Building pad | 1 | EA | $ 4,000 | $ 4,000 |
| Pump Building | 1 | EA | $ 10,000 | $ 10,000 |
| Fence | 1 | EA | $ 5,870 | $ 5,870 |
| Tools | 1 | EA | $ 1,000 | $ 1,000 |
| Storage Tank - 5,000 gals | 1 | EA | $ 7,025 | $ 7,025 |
| **Subtotal** | | | | **$ 68,645** |
| *Well Installation* | | | | |
| Well installation | 1,200 | LF | $ 25 | $ 30,000 |
| Water quality testing | 4 | EA | $ 1,500 | $ 6,000 |
| Well pump | 2 | EA | $ 7,500 | $ 15,000 |
| Well electrical/instrumentation | 2 | EA | $ 5,000 | $ 10,000 |
| Well cover and base | 2 | EA | $ 3,000 | $ 6,000 |
| Piping | 2 | EA | $ 2,500 | $ 5,000 |
| **Subtotal** | | | | **$ 72,000** |
| **Subtotal of Component Costs** | | | | **$ 2,688,928** |
| Contingency | 20% | | | $ 537,786 |
| Design & Constr Management | 25% | | | $ 672,232 |
| **TOTAL CAPITAL COSTS** | | | | **$ 3,898,946** |

### Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Pipeline O&M* | | | | |
| Pipeline O&M | 10.0 | mile | $ 200 | $ 2,000 |
| **Subtotal** | | | | **$ 2,000** |
| *Pump Station(s) O&M* | | | | |
| Building Power | 11,800 | kWH | $ 0.095 | $ 1,121 |
| Pump Power | 319,458 | kWH | $ 0.095 | $ 30,349 |
| Materials | 1 | EA | $ 1,200 | $ 1,200 |
| Labor | 365 | Hrs | $ 30 | $ 10,950 |
| Tank O&M | 1 | EA | $ 1,000 | $ 1,000 |
| **Subtotal** | | | | **$ 44,620** |
| *Well O&M* | | | | |
| Pump power | 37,279 | kWH | $ 0.095 | $ 3,542 |
| Well O&M matl | 2 | EA | $ 1,200 | $ 2,400 |
| Well O&M labor | 360 | Hrs | $ 30 | $ 10,800 |
| **Subtotal** | | | | **$ 16,742** |
| *O&M Credit for Existing Well Closure* | | | | |
| Pump power | 37,279 | kWH | $ 0.095 | $ (3,542) |
| Well O&M matl | 7 | EA | $ 1,200 | $ (8,400) |
| Well O&M labor | 1,260 | Hrs | $ 30 | $(37,800) |
| **Subtotal** | | | | **$(49,742)** |
| **TOTAL ANNUAL O&M COSTS** | | | | **$ 13,620** |

## Table C.12

**PWS Name** *City of Mason*
**Alternative Name** *New Well at 5 Miles*
**Alternative Number** *CM-12*

| | | |
|---|---|---|
| **Distance from PWS to new well location** | 5.0 | miles |
| **Estimated well depth** | 600 | feet |
| **Number of wells required** | 2 | |
| **Well installation cost (location specific)** | $25 | per foot |
| **Number of pump stations needed** | 1 | |

### Capital Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Pipeline Construction* | | | | |
| Number of Crossings, bore | 6 | n/a | n/a | n/a |
| Number of Crossings, open cut | 6 | n/a | n/a | n/a |
| PVC water line, Class 200, 10" | 26,400 | LF | $ 44 | $ 1,161,600 |
| Bore and encasement, 12" | 1,800 | LF | $ 70 | $ 126,000 |
| Open cut and encasement, 10" | 100 | LF | $ 35 | $ 3,500 |
| Gate valve and box, 10" | 5 | EA | $ 970 | $ 5,122 |
| 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** | | | | **$ 1,309,142** |
| *Pump Station(s) Installation* | | | | |
| Pump | 2 | EA | $ 7,500 | $ 15,000 |
| Pump Station Piping, 10" | 1 | EA | $ 4,000 | $ 4,000 |
| Gate valve, 10" | 4 | EA | $ 1,400 | $ 5,600 |
| Check valve, 10" | 2 | EA | $ 2,075 | $ 4,150 |
| Electrical/Instrumentation | 1 | EA | $ 10,000 | $ 10,000 |
| Site work | 1 | EA | $ 2,000 | $ 2,000 |
| Building pad | 1 | EA | $ 4,000 | $ 4,000 |
| Pump Building | 1 | EA | $ 10,000 | $ 10,000 |
| Fence | 1 | EA | $ 5,870 | $ 5,870 |
| Tools | 1 | EA | $ 1,000 | $ 1,000 |
| Storage Tank - 5,000 gals | 1 | EA | $ 7,025 | $ 7,025 |
| **Subtotal** | | | | **$ 68,645** |
| *Well Installation* | | | | |
| Well installation | 1,200 | LF | $ 25 | $ 30,000 |
| Water quality testing | 4 | EA | $ 1,500 | $ 6,000 |
| Well pump | 2 | EA | $ 7,500 | $ 15,000 |
| Well electrical/instrumentation | 2 | EA | $ 5,000 | $ 10,000 |
| Well cover and base | 2 | EA | $ 3,000 | $ 6,000 |
| Piping | 2 | EA | $ 2,500 | $ 5,000 |
| **Subtotal** | | | | **$ 72,000** |
| **Subtotal of Component Costs** | | | | **$ 1,449,787** |
| Contingency | 20% | | | $ 289,957 |
| Design & Constr Management | 25% | | | $ 362,447 |
| **TOTAL CAPITAL COSTS** | | | | **$ 2,102,191** |

### Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Pipeline O&M* | | | | |
| Pipeline O&M | 5.0 | mile | $ 200 | $ 1,000 |
| **Subtotal** | | | | **$ 1,000** |
| *Pump Station(s) O&M* | | | | |
| Building Power | 11,800 | kWH | $ 0.095 | $ 1,121 |
| Pump Power | 159,729 | kWH | $ 0.095 | $ 15,174 |
| Materials | 1 | EA | $ 1,200 | $ 1,200 |
| Labor | 365 | Hrs | $ 30 | $ 10,950 |
| Tank O&M | 1 | EA | $ 1,000 | $ 1,000 |
| **Subtotal** | | | | **$ 29,445** |
| *Well O&M* | | | | |
| Pump power | 37,279 | kWH | $ 0.095 | $ 3,542 |
| Well O&M matl | 2 | EA | $ 1,200 | $ 2,400 |
| Well O&M labor | 360 | Hrs | $ 30 | $ 10,800 |
| **Subtotal** | | | | **$ 16,742** |
| *O&M Credit for Existing Well Closure* | | | | |
| Pump power | 37,279 | kWH | $ 0.095 | $ (3,542) |
| Well O&M matl | 7 | EA | $ 1,200 | $ (8,400) |
| Well O&M labor | 1,260 | Hrs | $ 30 | $(37,800) |
| **Subtotal** | | | | **$(49,742)** |
| **TOTAL ANNUAL O&M COSTS** | | | | **$ (2,555)** |

## Table C.13

**PWS Name** *City of Mason*
**Alternative Name** *New Well at 1 Mile*
**Alternative Number** *CM-13*

| | | |
|---|---|---|
| **Distance from PWS to new well location** | 1.0 | miles |
| **Estimated well depth** | 600 | feet |
| **Number of wells required** | 2 | |
| **Well installation cost (location specific)** | $25 | per foot |
| **Number of pump stations needed** | 0 | |

### Capital Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Pipeline Construction* | | | | |
| Number of Crossings, bore | 1 | n/a | n/a | n/a |
| Number of Crossings, open cut | 1 | n/a | n/a | n/a |
| PVC water line, Class 200, 10" | 5,280 | LF | $ 44 | $ 232,320 |
| Bore and encasement, 12" | 200 | LF | $ 70 | $ 14,000 |
| Open cut and encasement, 10" | 50 | LF | $ 35 | $ 1,750 |
| Gate valve and box, 10" | 1 | EA | $ 970 | $ 1,024 |
| Air valve | 1.00 | EA | $ 1,000 | $ 1,000 |
| Flush valve | 1 | EA | $ 750 | $ 792 |
| Metal detectable tape | 5,280 | LF | $ 0.15 | $ 792 |
| **Subtotal** | | | | **$ 251,678** |
| *Pump Station(s) Installation* | | | | |
| Pump | - | EA | $ 7,500 | $ - |
| Pump Station Piping, 10" | - | EA | $ 4,000 | $ - |
| Gate valve, 10" | - | EA | $ 1,400 | $ - |
| Check valve, 10" | - | EA | $ 2,075 | $ - |
| Electrical/Instrumentation | - | EA | $ 10,000 | $ - |
| Site work | - | EA | $ 2,000 | $ - |
| Building pad | - | EA | $ 4,000 | $ - |
| Pump Building | - | EA | $ 10,000 | $ - |
| Fence | - | EA | $ 5,870 | $ - |
| Tools | - | EA | $ 1,000 | $ - |
| Storage Tank - 5,000 gals | - | EA | $ 7,025 | $ - |
| **Subtotal** | | | | **$ -** |
| *Well Installation* | | | | |
| Well installation | 1,200 | LF | $ 25 | $ 30,000 |
| Water quality testing | 4 | EA | $ 1,500 | $ 6,000 |
| Well pump | 2 | EA | $ 7,500 | $ 15,000 |
| Well electrical/instrumentation | 2 | EA | $ 5,000 | $ 10,000 |
| Well cover and base | 2 | EA | $ 3,000 | $ 6,000 |
| Piping | 2 | EA | $ 2,500 | $ 5,000 |
| **Subtotal** | | | | **$ 72,000** |
| **Subtotal of Component Costs** | | | | **$ 323,678** |
| Contingency | 20% | | | $ 64,736 |
| Design & Constr Management | 25% | | | $ 80,920 |
| **TOTAL CAPITAL COSTS** | | | | **$ 469,334** |

### Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Pipeline O&M* | | | | |
| Pipeline O&M | 1.0 | mile | $ 200 | $ 200 |
| **Subtotal** | | | | **$ 200** |
| *Pump Station(s) O&M* | | | | |
| Building Power | - | kWH | $ 0.095 | $ - |
| Pump Power | - | kWH | $ 0.095 | $ - |
| Materials | - | EA | $ 1,200 | $ - |
| Labor | - | Hrs | $ 30 | $ - |
| Tank O&M | - | EA | $ 1,000 | $ - |
| **Subtotal** | | | | **$ -** |
| *Well O&M* | | | | |
| Pump power | 37,279 | kWH | $ 0.095 | $ 3,542 |
| Well O&M matl | 2 | EA | $ 1,200 | $ 2,400 |
| Well O&M labor | 360 | Hrs | $ 30 | $ 10,800 |
| **Subtotal** | | | | **$ 16,742** |
| *O&M Credit for Existing Well Closure* | | | | |
| Pump power | 37,279 | kWH | $ 0.095 | $ (3,542) |
| Well O&M matl | 7 | EA | $ 1,200 | $ (8,400) |
| Well O&M labor | 1,260 | Hrs | $ 30 | $(37,800) |
| **Subtotal** | | | | **$(49,742)** |
| **TOTAL ANNUAL O&M COSTS** | | | | **$(32,800)** |

## Table C.14

**PWS Name** ***City of Mason***
**Alternative Name** ***Public Dispenser for Treated Drinking Water***
**Alternative Number** ***CM-14***

**Number of Treatment Units Recommended** 4

### Capital Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Public Dispenser Unit Installation* | | | | |
| POE-Treatment unit(s) | 4 | EA | $ 3,000 | $ 12,000 |
| Unit installation costs | 4 | EA | $ 5,000 | $ 20,000 |
| **Subtotal** | | | | **$ 32,000** |
| **Subtotal of Component Costs** | | | | **$ 32,000** |
| Contingency | 20% | | | $ 6,400 |
| Design & Constr Managemen | 25% | | | $ 8,000 |
| **TOTAL CAPITAL COSTS** | | | | **46,400** |

### Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Program Operation* | | | | |
| Treatment unit O&M, 1 per unit | 4 | EA | $ 500 | $ 2,000 |
| Contaminant analysis, 1/wk per unit | 208 | EA | $ 100 | $ 20,800 |
| Sampling/reporting, 1 hr/day | 1,460 | HRS | $ 30 | $ 43,800 |
| **Subtotal** | | | | **$ 66,600** |
| **TOTAL ANNUAL O&M COSTS** | | | | **$ 66,600** |

# Table C.15

**PWS Name** ***City of Mason***
**Alternative Name** ***Supply Bottled Water to Population***
**Alternative Number** ***CM-15***

| | | |
|---|---|---|
| **Service Population** | 2,004 | |
| **Percentage of population requiring supply** | 100% | |
| **Water consumption per person** | 1.00 | gpcd |
| **Calculated annual potable water needs** | 731,460 | gallons |

## Capital Costs

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

## Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Program Operation* | | | | |
| Water purchase costs | 731,460 | gals | $ 1.60 | $ 1,170,336 |
| Program admin, 9 hrs/wk | 468 | hours | $ 40 | $ 18,673 |
| Program materials | 1 | EA | $ 5,000 | $ 5,000 |
| **Subtotal** | | | | **$ 1,194,009** |
| **TOTAL ANNUAL O&M COSTS** | | | | **$ 1,194,009** |

# Table C.16

**PWS Name** — ***City of Mason***
**Alternative Name** — ***Central Trucked Drinking Water***
**Alternative Number** — ***CM-16***

| | | |
|---|---|---|
| **Service Population** | 2,004 | |
| **Percentage of population requiring supply** | 100% | |
| **Water consumption per person** | 1.00 | gpcd |
| **Calculated annual potable water needs** | 731,460 | gallons |
| **Travel distance to compliant water source (roundtrip)** | 54 | miles |

## Capital Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Storage Tank Installation* | | | | |
| Storage Tank - 5,000 gals | 4 | EA | $ 7,025 | $ 28,100 |
| Site improvements | 4 | EA | $ 4,000 | $ 16,000 |
| Potable water truck | 1 | EA | $ 60,000 | $ 60,000 |
| **Subtotal** | | | | **$ 104,100** |
| **Subtotal of Component Costs** | | | | **$ 104,100** |
| Contingency | 20% | | | $ 20,820 |
| Design & Constr Management | 25% | | | $ 26,025 |
| **TOTAL CAPITAL COSTS** | | | | **$ 150,945** |

## Annual Operations and Maintenance Costs

| Cost Item | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| *Program Operation* | | | | |
| Water delivery labor, 4 hrs/wk | 832 | hrs | $ 30 | $ 24,960 |
| Truck operation, 1 round trip/wk | 11,232 | miles | $ 1.00 | $ 11,232 |
| Water purchase | 731 | 1,000 gals | $ 1.60 | $ 1,170 |
| Water testing, 1 test/wk | 208 | EA | $ 100 | $ 20,800 |
| Sampling/reporting, 2 hrs/wk | 416 | hrs | $ 30 | $ 12,480 |
| **Subtotal** | | | | **$ 70,642** |
| **TOTAL ANNUAL O&M COSTS** | | | | **$ 70,642** |

# APPENDIX D
# EXAMPLE FINANCIAL MODEL

# Table D.1  Example Financial Model

Step 1

Water System: Mason

Step 2

Click Here to Update Verification and Raw

| Water System | Mason | | |
|---|---|---|---|
| Alternative Description | New Well at 1 Mile | | |
| | | | |
| Sum of Amount | | Year | Funding Alt |
| | | 2007 | |
| Group | Type | 100% Grant | Bond |
| Capital Expenditures | Capital Expenditures-Funded from Bonds | $ - | $ 469,334 |
| | Capital Expenditures-Funded from Grants | $ 469,334 | $ - |
| | Capital Expenditures-Funded from Revenue/Reserves | $ - | $ - |
| | Capital Expenditures-Funded from SRF Loans | $ - | $ - |
| Capital Expenditures Sum | | $ 469,334 | $ 469,334 |
| Debt Service | Revenue Bonds | $ - | $ 36,714 |
| | State Revolving Funds | $ - | $ - |
| Debt Service Sum | | $ - | $ 36,714 |
| Non Residential Operating Revenues | Non Residential Base Monthly Rate | $ - | $ - |
| | Non Residential Tier 1 Monthly Rate | $ - | $ - |
| | Non Residential Tier2 Monthly Rate | $ - | $ - |
| | Non Residential Tier3 Monthly Rate | $ - | $ - |
| | Non Residential Tier4 Monthly Rate | $ - | $ - |
| | Non Residential Unmetered Monthly Rate | $ - | $ - |
| Non Residential Operating Revenues Sum | | $ - | $ - |
| Operating Expenditures | Insurance | $ 13,600 | $ 13,600 |
| | Other Operating Expenditures 1 | $ 2,200 | $ 2,200 |
| | Other Operating Expenditures 2 | $ 550 | $ 550 |
| | Professional and Directors Fees | $ 3,280 | $ 3,280 |
| | Repairs | $ 95,000 | $ 95,000 |
| | Salaries & Benefits | $ 70,092 | $ 70,092 |
| | Supplies | $ 4,300 | $ 4,300 |
| | Utilities | $ 48,000 | $ 48,000 |
| | Maintenance | $ 55,450 | $ 55,450 |
| | Other Operating Expenditures 3 | $ 1,020 | $ 1,020 |
| | Other Operating Expenditures 4 | $ 1,690 | $ 1,690 |
| Operating Expenditures Sum | | $ 295,182 | $ 295,182 |
| Residential Operating Revenues | Residential Tier2 Annual Rate | $ - | $ - |
| | Residential Tier3 Annual Rate | $ - | $ - |
| | Residential Tier4 Annual Rate | $ - | $ - |
| | Residential Unmetered Annual Rate | $ - | $ - |
| | Residential Tier 1 Annual Rate | $ 118,504 | $ 118,504 |
| | Residential Base Annual Rate | $ 162,994 | $ 162,994 |
| Residential Operating Revenues Sum | | $ 281,497 | $ 281,497 |
| Other 1 | Other 1 | $ 7,200 | $ 7,200 |
| Other 1 Sum | | $ 7,200 | $ 7,200 |
| Other 2 | Other 2 | $ 15,000 | $ 15,000 |
| Other 2 Sum | | $ 15,000 | $ 15,000 |

| Location_Name | Mason | |
|---|---|---|
| Alt_Desc | New Well at 1 Mile | |
| | | |
| | Current_Year | Funding_Alt |
| | 2007 | |
| Data | 100% Grant | Bond |
| Sum of Beginning_Cash_Bal | $ (77,882) | $ (77,882) |
| Sum of Total_Expenditures | $ 764,516 | $ 801,230 |
| Sum of Total_Receipts | $ 773,031 | $ 773,031 |
| Sum of Net_Cash_Flow | $ 8,515 | $ (28,199) |
| Sum of Ending_Cash_Bal | $ (69,367) | $ (106,081) |
| Sum of Working_Cap | $ 49,197 | $ 49,197 |
| Sum of Repl_Resv | $ 15,000 | $ 15,000 |
| Sum of Total_Reqd_Resv | $ 64,197 | $ 64,197 |
| Sum of Net_Avail_Bal | $ (133,564) | $ (170,278) |
| Sum of Add_Resv_Needed | $ (133,564) | $ (170,278) |
| Sum of Rate_Inc_Needed | 47% | 60% |
| Sum of Percent_Rate_Increase | 0% | 0% |

# APPENDIX E
# CITY OF MASON POTABLE WATER DISTRIBUTION SYSTEM MAP


Connie Stockbridge

Date

| REVISION | BASE MAP: 02-08-01 | DWN: V.A. | CHK: | DATE: 08-18-05 |
|---|---|---|---|---|

## WATER SYSTEM

- Reducer
- 2" or Smaller Line
- 3" or Smaller Line
- 4" or Smaller Line
- 6" Line
- 8" Line
- 12" Line
- Service
- Valve
- Elevated Storage
- Ground Storage
- Fire Hydrants
- Well

## WASTEWATER SYSTEM

- 2" And Smaller
- 4" Service Conn.
- 6" Line
- 8" Line
- 10" Line
- 12" Line
- 15" Line
- Junction Box
- Lift Station
- Manhole
- Clean Out Valve
- 6x4 Wye Plugged
- Flow
- Cast Iron Pipe

# CITY OF MASON
## Mason, Texas

| UTILITIES | LAND USE |
|---|---|

TRC ENGINEERING SERVICES

TELEPHONE: (830) 257-7337 KERRVILLE, TEXAS 78028

## ZONING DISTRICTS MAP LEGEND

- MOBILE HOMES
- PUBLIC/FACILITY
- M1_MANUFACTURING
- M2_MANUFACTURING
- OPEN-SPACE
- R1_RESIDENTIAL
- R2_RESIDENTIAL
- C1_COMMERCIAL
- C2_COMMERCIAL
- HISTORIC OVERLAY

FILE: MASONTST-2_1

SCALE: 1"-300'

# APPENDIX F
# RADIONUCLIDE GEOCHEMISTRY

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

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

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

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

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

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

**Table F.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)<br>Ra224 - (3.7 days) | Rn220 - (~1 min) |

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

## EPA Maximum Contaminant Levels

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

**Appendix References:**

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# APPENDIX G
# CITY OF MASON SAMPLING DATA

## CITY OF MASON SAMPLING DATA

| Samp. No. | Delay | Source (Well) | Location | | Ra 226 | Err ± | | Ra 228 | Err ± | Comb Ra | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mas-A-01 | 1 min | G1600001A | End of el Paso St. | | 1.8 | 0.2 | | 3.8 | 0.8 | 4.6 | *Well located on hill. Had been running for some time when 1st sample collected.* |
| Mas-A-15 | 15 mins | G1600001A | End of El Paso St. | | 2.0 | 0.2 | | 3.9 | 0.8 | 4.9 | |
| Mas-C-01 | 1 min | G1600001C | S of Rainey St. | | 5.0 | 0.3 | | 16.0 | 1.4 | 19.3 | *This well was sampled recently by City staff and high readings were reported* |
| Mas-C-15 | 15 mins | G1600001C | S of Rainey St. | | 4.0 | 0.3 | | 10.8 | 1.1 | 13.4 | |
| Mas-C-30 | 30 mins | G1600001C | S of Rainey St. | | 4.0 | 0.3 | | 11.4 | 1.2 | 13.9 | |
| Mas-D-01 | 1 min | G1600001D | Mill Creek Rd. | | 2.1 | 0.2 | | 3.6 | 0.8 | 4.7 | *Well not currently connected to system but it is planned to be. Difficult to collect multiple samples.* |
| Mas-E-01 | 1 min | G1600001E | W of Town | | 2.2 | 0.2 | | 3.6 | 0.8 | 4.8 | *Had been running for some time when 1st sample collected.* |
| Mas-E-15 | 15 mins | G1600001E | W of Town | | 2.2 | 0.3 | | 3.9 | 0.9 | 4.9 | |
| Mas-F-01 | 1 min | G1600001F | W of Town | | 2.6 | 0.3 | | 3.2 | 1.1 | 4.4 | *Well not been used in 4-5 yrs; had been idle for some time. Co-located with Well E.* |
| Mas-F-15 | 15 mins | G1600001F | W of Town | | 1.8 | 0.2 | | 1.6 | 0.7 | 2.5 | |
| Mas-F-30 | 30 mins | G1600001F | W of Town | | 1.3 | 0.2 | | 1.0 | 0.6 | 1.5 | |
| Mas-G-01 | 1 min | G1600001G | S of Town | | 1.9 | 0.2 | | 4.6 | 1.0 | 5.3 | *Had been running for some time when 1st sample collected.* |
| Mas-G-15 | 15 mins | G1600001G | S of Town | | 2.2 | 0.3 | | 4.8 | 1.1 | 5.6 | |
| Mas-H-01 | 1 min | G1600001H | Mill Creek Rd. | | 1.3 | 0.2 | | 6.8 | 1.1 | 6.8 | *Had been running for some time when 1st sample collected.* |
| Mas-H-15 | 15 mins | G1600001H | Mill Creek Rd. | | 1.4 | 0.2 | | 6.9 | 1.3 | 6.8 | |
| Mas-I-01 | 1 min | G1600001I | Golf Course | | 0.7 | 0.2 | < | 1.0 | 0.0 | 1.5 | *One of the shallow wells used for irrigation.* |
| Mas-I-15 | 15 mins | G1600001I | Golf Course | | 0.2 | 0.0 | < | 1.0 | 0.0 | 1.2 | |
| Mas-I-30 | 30 mins | G1600001I | Golf Course | | 0.2 | 0.0 | < | 1.0 | 0.0 | 1.2 | |

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.