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

LCRA BONANZA BEACH
PWS ID# 0270018, CCN# 11670

Prepared for:

THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Prepared by:

THE UNIVERSITY OF TEXAS BUREAU OF ECONOMIC GEOLOGY

AND

PARSONS

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

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EXECUTIVE SUMMARY

INTRODUCTION

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

The overall goal of this 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 Lower Colorado River Authority (LCRA) Bonanza Beach PWS, a small residential water system in Burnet County, Texas (the Bonanza Beach PWS). Recent sample results from the Bonanza Beach PWS exceeded the MCL for combined radium of 5 picoCuries per liter (pCi/L) (USEPA 2005; TCEQ 2004a). Basic system information for the Bonanza Beach PWS is shown in Table ES.1.

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Table ES.1 LCRA Bonanza Beach PWS
Basic System Information

Population served	143
Connections	56
Average daily flow rate	0.016 million gallons per day (mgd)
Water system peak capacity	0.064 mgd
Typical radium range	5.2 pCi/L – 7.8 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;

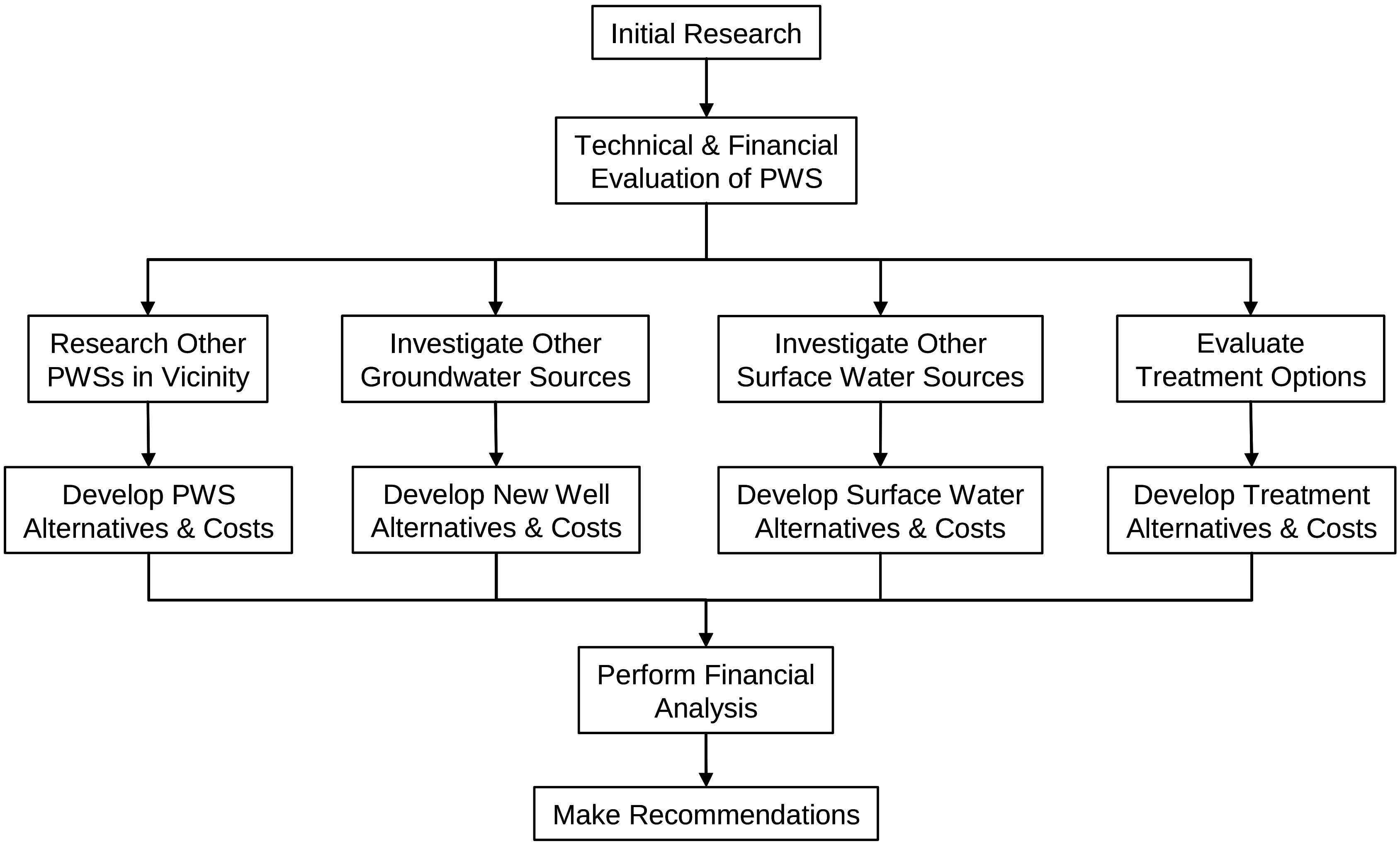
2. Conduct financial, managerial, and technical (FMT) evaluations of the PWS;
3. Perform a geologic and hydrogeologic assessment of the study area;
4. Develop treatment and non-treatment compliance alternatives which, in general, consist of the following possible options:
5. Connecting to neighboring 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;
6. Installing new wells within the vicinity of the PWS into other aquifers with confirmed water quality standards meeting the MCLs;
7. 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;
8. Treating the existing non-compliant water supply by various methods depending on the type of contaminant; and
9. Delivering potable water by way of a bottled water program or a treated water dispenser as an interim measure only.
10. Assess each of the potential alternatives with respect to economic and non-economic criteria;
11. Prepare a feasibility report and present the results to the PWS.

This basic approach is summarized in Figure ES-1.

HYDROGEOLOGICAL ANALYSIS

The Bonanza Beach PWS obtains groundwater from the Hickory aquifer and radionuclides are commonly found in area wells at concentrations greater than the MCL.). In central Texas, radium levels are generally higher (>5 pCi/L) within the Hickory and Ellenburger-San Saba aquifers and they are lower (<5 pCi/L) in southern and eastern parts of the study area. 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. There are currently no data available to help determine whether either of the Bonanza Beach PWS wells may have compliant water, so sampling is recommended to evaluate this. It may also be possible to do down-hole testing to determine the source of the contaminants. If the contaminants derive primarily from a single part of the formation, that part could be excluded by modifying the existing well, or avoided altogether by completing a new well.

Figure ES-1
Summary of Project Methods



COMPLIANCE ALTERNATIVES

The Bonanza Beach PWS is owned and operated by LCRA, an organization created by the Texas legislature whose mission is to provide reliable, low-cost utility and public services to communities in the central and south Texas area. LCRA operates water and wastewater utilities are operated out of four regions and the Bonanza Beach PWS is operated out of the LCRA Hill Country Region, which serves a total of 19 water systems. Overall, the PWS had a very good level of FMT capacity. The PWS had some areas that needed improvement to be able to address future compliance issues; however, the PWS does have many positive aspects, including staff longevity, good communication, in-house expertise, effective planning for system growth, and the regional nature of the LCRA organization. Other than the MCL compliance issue, areas of concern for the PWS primarily involve the current rate structure and the existing water storage tanks, both of which are in need of repair. LCRA is currently addressing both of these concerns.

There are several PWSs within 10 miles of the Bonanza Beach PWS. Many of these nearby PWSs also have problems with radionuclides, but there are some 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. Lake Buchanan is the nearest area source of surface water and LCRA are investigating a regional alternative that uses the lake as the source for several nearby PWSs. This alternative is called the Lake Buchanan Regional Water Project. In addition to this alternative, the cities of Burnet and Granite Shoals were evaluated as potential suppliers of compliant water. Alternatives involving the completion of new wells at two nearby PWSs with compliant groundwater, Deer Springs Water Company and Granite Shoals Sherwood Shores III, were also evaluated.

A number of centralized treatment alternatives for arsenic removal have been developed and were considered for this report, for example, ion exchange and the proprietary Water Remediation Technologies, Inc. Z-88™ treatment technology. Point-of-use and point-of-entry treatment alternatives were also evaluated. Temporary solutions such as providing bottled water or providing a centralized dispenser for treated or trucked-in water, were also considered as alternatives.

Developing a new well near the Bonanza Beach PWS is likely to be the best solution if compliant groundwater can be found. Having a new well near the Bonanza Beach PWS is likely to be one of the lower cost alternatives since the PWS already possesses the technical and managerial expertise needed to implement this option. Also, 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. However, based on the PWSs evaluated in the vicinity of the Bonanza Beach PWS, it is not clear whether a nearby compliant well is available to make this option economical. The cost of new well alternatives quickly increases with pipeline length, making proximity of the alternate source a key concern.

Central treatment can be cost-competitive with the alternative of new nearby wells, but would require greater 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. Additionally, these are interim measures rather than long-term solutions.

FINANCIAL ANALYSIS

Financial analysis of the Bonanza Beach PWS indicated that current water rates are sufficient to fund operations, and a rate increase would not be necessary to meet operating expenses. The current average water bill of $797 represents approximately 2.1 percent of the median household income (MHI). Table ES.2 provides a summary of the financial impact of implementing selected compliance alternatives, including the rate increase necessary to meet current operating expenses. The alternatives were selected to highlight results for the best alternatives from each different type or category.

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

Table ES.2 LCRA Bonanza Beach PWS
Selected Financial Analysis Results

Alternative	Funding Option	Average Annual Water Bill	Percent of MHI
Current	NA	$797	2.1
Lake Buchanan regional water project	100% Grant	$1,376	3.6
	Loan/Bond	$2,583	6.8
Purchase water from Burnet	100% Grant	$788	2.1
	Loan/Bond	$4,307	11
Central treatment – IX	100% Grant	$1,126	3.0
	Loan/Bond	$1,545	4.1
Point-of-use	100% Grant	$1,259	3.3
	Loan/Bond	$1,312	3.5

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ACRONYMS AND ABBREVIATIONS

µ	micrograms per liter
AFY	acre-feet per year
BAT	best available technology
BB	Bonanza Beach
BEG	Bureau of Economic Geology
BV	bed volume
CA	chemical analysis
CCN	Certificate of Convenience and Necessity
CFR	Code of Federal Regulations
CO	correspondence
ED	electrodialysis
EDR	electrodialysis reversal
FMT	financial, managerial, and technical
ft^2	square foot
GAM	Groundwater Availability Model
gpm	gallons per minute
IX	Ion exchange
$KMnO_4$	hydrous manganese oxide
LCRA	Lower Colorado River Authority
MCL	Maximum contaminant level
mg/L	milligrams per Liter
mgd	million gallons per day
MHI	median household income
MnO_2	Manganese dioxide
MOR	monthly operating report
NMEFC	New Mexico Environmental Financial Center
O&M	operation and maintenance
Parsons	Parsons Infrastructure and Technology Group Inc.
pCi/L	picoCuries per liter
POE	Point-of-entry
POU	Point-of-use
PSOC	potential source of contamination
PWS	public water system
RO	Reverse osmosis
RWHA	R.W. Harden & Associates, Inc
SDWA	Safe Drinking Water Act
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
WRT	Water Remediation Technologies, Inc.

SECTION 1
INTRODUCTION

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

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

It is anticipated 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 Bonanza Beach PWS, ID# 0270018, Certificate of Convenience and Necessity (CCN) #11670, located in Burnet County, Texas (the Bonanza Beach PWS). Recent sample results from the Bonanza Beach PWS exceeded the MCL for radium of 5 picoCuries per liter (pCi/L) (USEPA 2005; TCEQ 2004a). The location of the Bonanza Beach PWS, also referred to as the "study area" in this report, is shown on Figure 1.1. Various water supply and planning jurisdictions are shown on Figure 1.2. These water supply and planning jurisdictions are used in the evaluation of alternate water supplies that may be available in the area.

1.1 PUBLIC HEALTH AND COMPLIANCE WITH MCLS

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

1.2 METHOD

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

Other tasks of the feasibility study are as follows:

- Identifying available data sources;
- Gathering and compiling data;
- Conducting financial, managerial, and technical (FMT) evaluations of the selected PWSs;
- Performing a geologic and hydrogeologic assessment of the study area;
- Developing treatment and non-treatment compliance alternatives;
- Assessing potential alternatives with respect to economic and non-economic criteria;
- Preparing a feasibility report; and
- Suggesting refinements to the approach for future studies.

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

1.3 REGULATORY PERSPECTIVE

The Utilities & Districts and Public Drinking Water Sections of the TCEQ Water Supply Division are responsible for implementing requirements of the Federal Safe Drinking Water Act (SDWA) which include oversight of PWSs and water utilities (TCEQ 2004b). These responsibilities include:

- Monitoring public drinking water quality;
- Processing enforcement referrals for MCL violators;

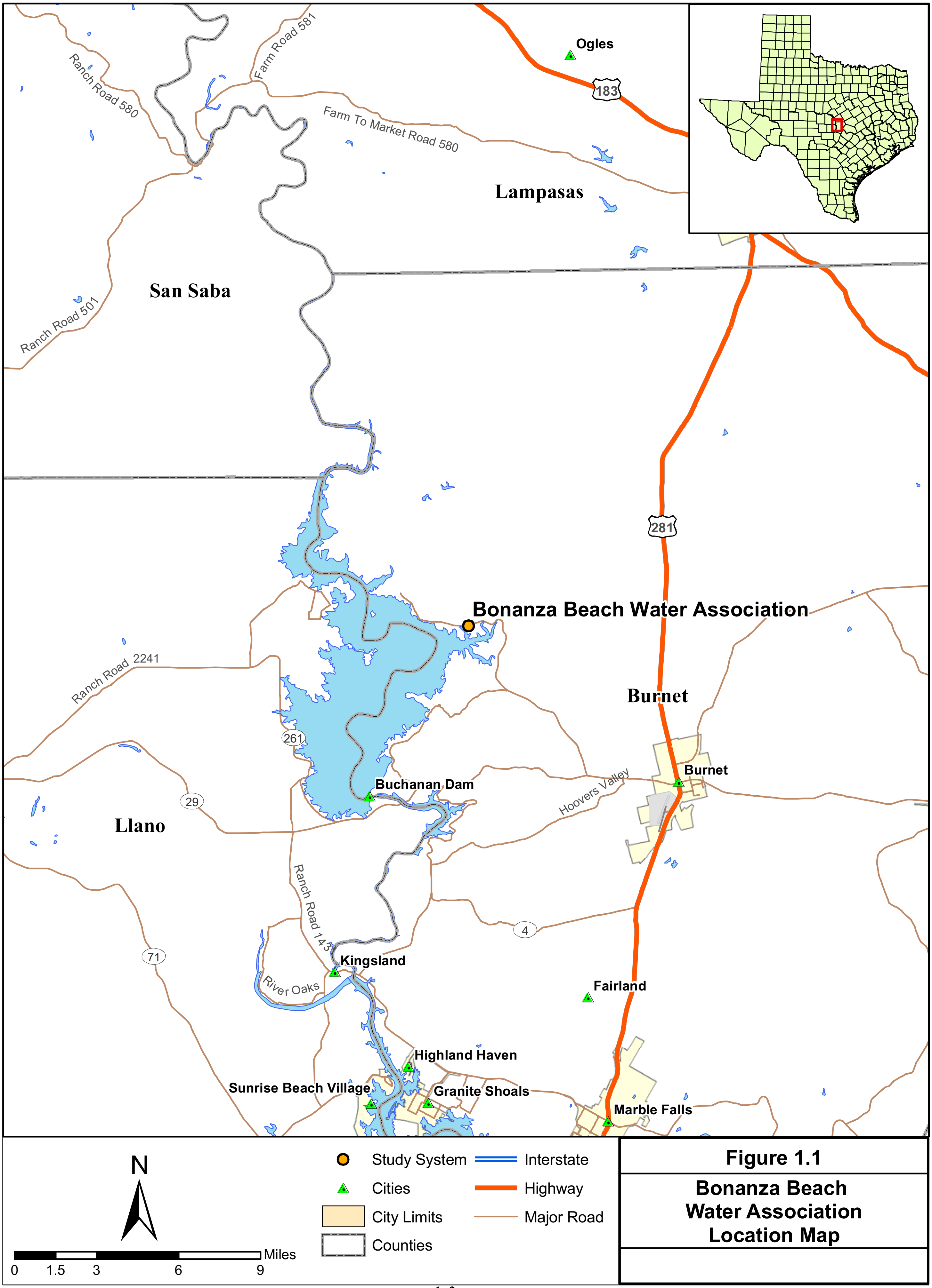

Figure 1.1

Bonanza Beach Water Association Location Map

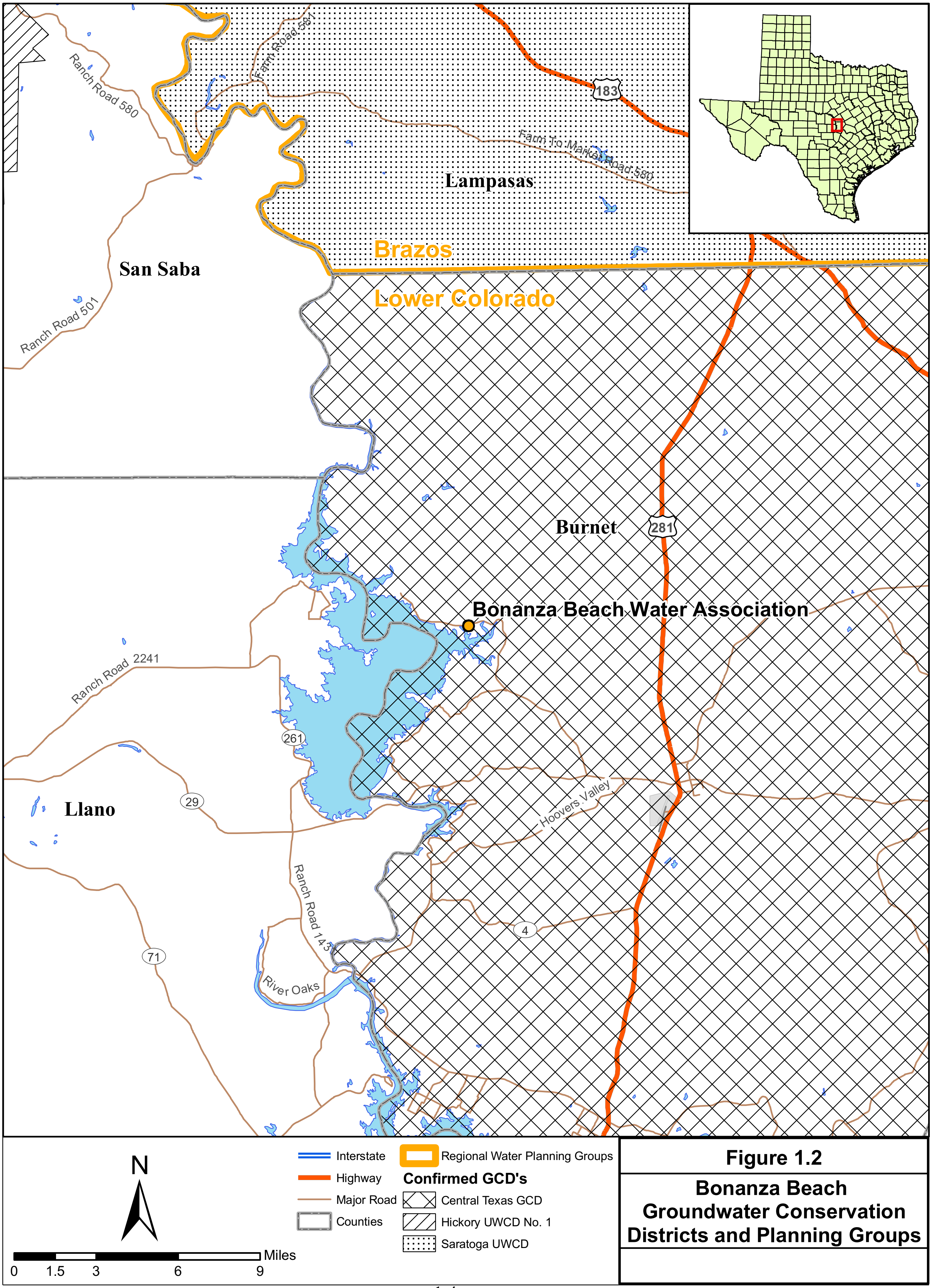

Figure 1.2

Bonanza Beach Groundwater Conservation Districts and Planning Groups

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

This project was conducted to assist in achieving these responsibilities.

1.4 ABATEMENT OPTIONS

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

1.4.1 Existing Public Water Supply Systems

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

1.4.1.1 Quantity

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

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

- Additional wells;
- Developing a new surface water supply,
- Additional or larger-diameter piping;

- Increasing water treatment plant capacity
- Additional storage tank volume;
- Reduction of system losses,
- Higher-pressure pumps; or
- Upsized, or additional, disinfection equipment.

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

1.4.1.2 Quality

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

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

1.4.2 Potential for New Groundwater Sources

1.4.2.1 Existing Non-Public Supply Wells

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

- Use existing data sources (see below) to identify wells in the areas that have satisfactory quality. For the Bonanza Beach, the following standards could be used in a rough screening to identify compliant groundwater in surrounding PWSs:

  - Radium (total radium for radium-226 and radium-228) less than 4 pCi/L (below the MCL of 5 pCi/L); and
  - Gross alpha less than 12 pCi/L (below the MCL of 15 pCi/L)
  - Total dissolved solids (TDS) concentrations less than 1,000 milligrams per liter (mg/L);

- Review the recorded well information to eliminate those wells that appear to be unsuitable for the application. Often, the "Remarks" column in the Texas Water Development Board (TWDB) hard-copy database provides helpful information. Wells eliminated from consideration generally include domestic and stock wells, dug wells, test holes, observation wells, seeps and springs, destroyed wells, wells used by other communities, *etc*.
- Identify wells of sufficient size which have been used for industrial or irrigation purposes. Often the TWDB database will include well yields, which may indicate the likelihood that a particular well is a satisfactory source.
- At this point in the process, the local groundwater control district (if one exists) should be contacted to obtain information about pumping restrictions. Also, preliminary cost estimates should be made to establish the feasibility of pursuing further well development options.
- If particular wells appear to be acceptable, the owner(s) should be contacted to ascertain their willingness to work with the PWS. Once the owner agrees to participate in the program, questions should be asked about the wells. Many owners have more than one well, and would probably be the best source of information regarding the latest test dates, who tested the water, flowrates, and other well characteristics.
- After collecting as much information as possible from cooperative owners, the PWS would then narrow the selection of wells and sample and analyze them for quality. Wells with good quality would then be potential candidates for test pumping. In some cases, a particular well may need to be refurbished before test pumping. Information obtained from test pumping would then be used in combination with information about the general characteristics of the aquifer to determine whether a well at this location would be suitable as a supply source.
- It is recommended that new wells be installed instead of using existing wells to ensure the well characteristics are known and the well meets construction standards.
- Permit(s) would then be obtained from the groundwater control district or other regulatory authority, and an agreement with the owner (purchase or lease, access easements, *etc*.) would then be negotiated.

1.4.2.2 Develop New Wells

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

1.4.3 Potential for Surface Water Sources

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

1.4.3.1 Existing Surface Water Sources

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

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

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

1.4.3.2 New Surface Water Sources

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

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

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

1.4.4 Identification of Treatment Technologies for Radionuclides

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

The USEPA published a final rule in the Federal Register that established MCLs for radioactive contaminants ("radionuclides") on December 7, 2000 (USEPA 2000). The MCLs for radium (measured for radium-226 and radium-228) and uranium (combined uranium) are set at 5 pCi/L and 0.03 mg/L, respectively. The USEPA regulation applies to all community water systems and non-transient, non-community water systems, regardless of size. The radionuclide MCLs became effective on December 8, 2003, and new monitoring requirements are being phased in between that date and December 31, 2007. All PWSs must complete initial monitoring for the new radionuclide MCLs by December 31, 2007.

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 re-formed hydrous manganese oxide filtration ($KMnO_4$-filtration). A relatively new process using the Water Remediation Technologies, Inc.(WRT) Z-88™ medium specific for radium adsorption has also been demonstrated to be an effective radium technology. Lime softening and co-precipitation with barium sulfate are relatively complex technologies that require chemistry skills and are not practical for small systems with limited resources; consequently, these are not evaluated further.

1.4.5.1 Ion Exchange

<u>Process</u> – In solution, salts separate into positively charged cations and negatively-charged anions. Ion exchange is a reversible chemical process in which ions from an insoluble, permanent, solid resin bed are exchanged for ions in the water. The process relies on the fact that certain ions are preferentially adsorbed on the ion exchange resin. Operations begin with a fully charged cation or anion bed having enough positively or negatively charged ions to carry out the cation or anion exchange. Usually a polymeric resin bed is composed of millions of spherical beads about the size of medium sand grains. As water passes the resin bed, the charged ions are released into the water, being substituted or replaced with the contaminants in the water (ion exchange). When the resin becomes exhausted of positively or negatively charged ions, the bed must be regenerated by passing a strong, sodium chloride, solution over the resin, displacing the contaminants ions with sodium ions for cation exchange and chloride ion for anion exchange. Many different types of resins can be used to reduce dissolved contaminant concentrations. The IX treatment train for groundwater typically includes cation or anion resins beds with a regeneration system, chlorine disinfection, and clear well storage. Treatment trains for surface water may also include raw water pumps, debris screens, and filters for pre-treatment. Additional treatment or management of the concentrate and the removed solids would be necessary prior to disposal, especially for radium removal resins which have elevated radioactivity.

For radium removal, a strong acid cation exchange resin in sodium form can remove 99 percent of the radium. This is the same type of resin used for hardness removal in IX softeners. The strong acid resin has less capacity for radium adsorption in water with high hardness and it has the following adsorption preference: $Ra^{2+} > Ba^{2+} > Ca^{2+} > Mg^{2+} > Na^{+}$. Hardness breakthrough occurs much earlier than radium in the fresh IX resin. Because of this selectivity, radium and barium are much more difficult to remove from the resin during regeneration than calcium and magnesium. For economical reasons regeneration usually removes most of the hardness ions but leaves some of the radium and barium ions in the resin. Radium and barium can buildup on the resin after repeated cycles to the point where equilibrium is reached and then radium and barium would begin to break through shortly after hardness. In an operating IX system for radium removal, regeneration of the sodium forms a strong acid resin for water with 200 mg/L of hardness with application of 6.5 pounds $NaCl/ft^3$ of resin produced 2.4 bed volumes (BV) of 16,400 mg/L TDS brine per 100 BVs of product water (2.4%). The radium concentration in the regeneration waste was approximately 40 times the influent radium concentration in the groundwater.

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

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 PWSs 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 WRT. The Z-88 process is similar to IX except that no regeneration of the resin is conducted and the resin is disposed of upon exhaustion. The Z-88 does not remove calcium and magnesium and thus it can last for a long time (2-4 years, according to WRT) before replacement is necessary. The process is operated in an upflow, fluidized mode with a surface loading rate of 10.5 gpm/ft^2. Pilot testing of this technology has been conducted successfully for radium removal in many locations including in the State of Texas. Seven full-scale PWSs with capacities of 750 to 1,200 gpm have been constructed in the Village of Oswego, Illinois since July 2005. The treatment equipment is owned by WRT and the ownership of spent media would be transferred to an approved disposal site. The customer pays WRT based on an agreed upon treated water unit cost (*e.g.,* $3.00/thousand gallons for small systems).

<u>Pretreatment</u> – 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.

<u>Maintenance</u> – 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.

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

Advantages

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

Disadvantages

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

From a small utilities point of view, the Z-88 process is a desirable technology for radium removal as operation and maintenance (O&M) efforts are minimal and no regular liquid waste is generated. However, this technology is very new and has 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

<u>Process</u> – 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.
- Needs to dispose of concentrate.

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. Electrodialysis reversal (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.

Pretreatment – 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.

Maintenance – 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.

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

Advantages

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

Disadvantages

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

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

Pretreatment – The $KMnO_4$-greensand filtration process usually does not require pretreatment except if 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 iron and manganese removal process and is effective for radium removal. It is suitable for small and large systems and is cost competitive with other alternative technologies.

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

Point-of-entry (POE) and point-of-use (POU) treatment systems can be used to provide compliant drinking water. For radium removal, these systems typically use small adsorption or reverse osmosis treatment units that are installed "under the sink" in the case of POU, and where water enters a house or building in the case of POE. It should be noted that the POU treatment units would need to be more complex than units typically found in commercial retail outlets in order to meet regulatory requirements, making purchase and installation more expensive. POE and POU treatment units would be purchased and owned by the PWS. These solutions are decentralized in nature, and require utility personnel 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 primarily out of the control of the PWS, it is very difficult to ensure 100 percent compliance. Prior to selection of a point-of-entry or point-of-use program for implementation, consultation with TCEQ would be required to address measurement and determination of level of compliance.

The SDWA [§1412(b)(4)(E)(ii)] regulates the design, management and operation of POU and POE treatment units used to achieve compliance with an MCL. These restrictions, relevant to radium are:

- POU and POE treatment units must be owned, controlled, and maintained by the water system, although the utility may hire a contractor to ensure proper O&M and MCL compliance. The water system must retain unit ownership and oversight of unit installation, maintenance and sampling; the utility ultimately is the responsible party for regulatory compliance. The water system staff need not perform all installation, maintenance, or management functions, as these tasks may be contracted to a third party-but the final responsibility for the quality and quantity of the water supplied to the community resides with the water system, and the utility must monitor all contractors closely. Responsibility for O&M of POU or POE devices installed for SDWA compliance may not be delegated to homeowners.

- POU and POE units must have mechanical warning systems to automatically notify customers of operational problems. Each POU or POE treatment device must be equipped with a warning device (*e.g.*, alarm, light) that would alert users when their unit is no longer adequately treating their water. As an alternative, units may be equipped with an automatic shut-off mechanism to meet this requirement.
- If the American National Standards Institute has issued product standards for a specific type of POU or POE treatment unit, only those units that have been independently certified according to those standards may be used as part of a compliance strategy.

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

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

1.4.7 Water Delivery or Central Drinking Water Dispensers

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

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

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

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

The ideal system would:

- Completely identify the susceptible population. If bottled water is only provided to customers who are part of the susceptible population, the utility should have an active means of identifying the susceptible population. Problems with illiteracy, language fluency, fear of legal authority, desire for privacy, and apathy may be reasons that some members of the susceptible population do not become known to the utility, and do not take part in the water delivery program.
- Maintain customer privacy by eliminating the need for utility personnel to enter the home.
- Have buffer capacity (*e.g.*, two bottles in service, so 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 METHOD

2.1 DECISION TREE

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

Tree 3, which begins at the conclusion of the work for this report, starts with a comparison of the conceptual designs, selecting the two or three alternatives that appear to be most promising, and eliminating those alternatives which are obviously infeasible. It is envisaged that a process similar to this would be used by the study PWS to refine the list of viable alternatives. The selected alternatives are then subjected to intensive investigation, and highlighted by an investigation into the socio-political aspects of implementation. Designs are further refined and compared, resulting in the selection of a preferred alternative. The steps for assessing the financial and economic aspects of the alternatives (one of the steps in Tree 3) are given in Tree 4 in Figure 2-4.

2.2 DATA SOURCES AND DATA COLLECTION

2.2.1 Data Search

2.2.1.1 Water Supply Systems

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

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

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.

Figure 2.1
TREE 1 – EXISTING FACILITY ANALYSIS

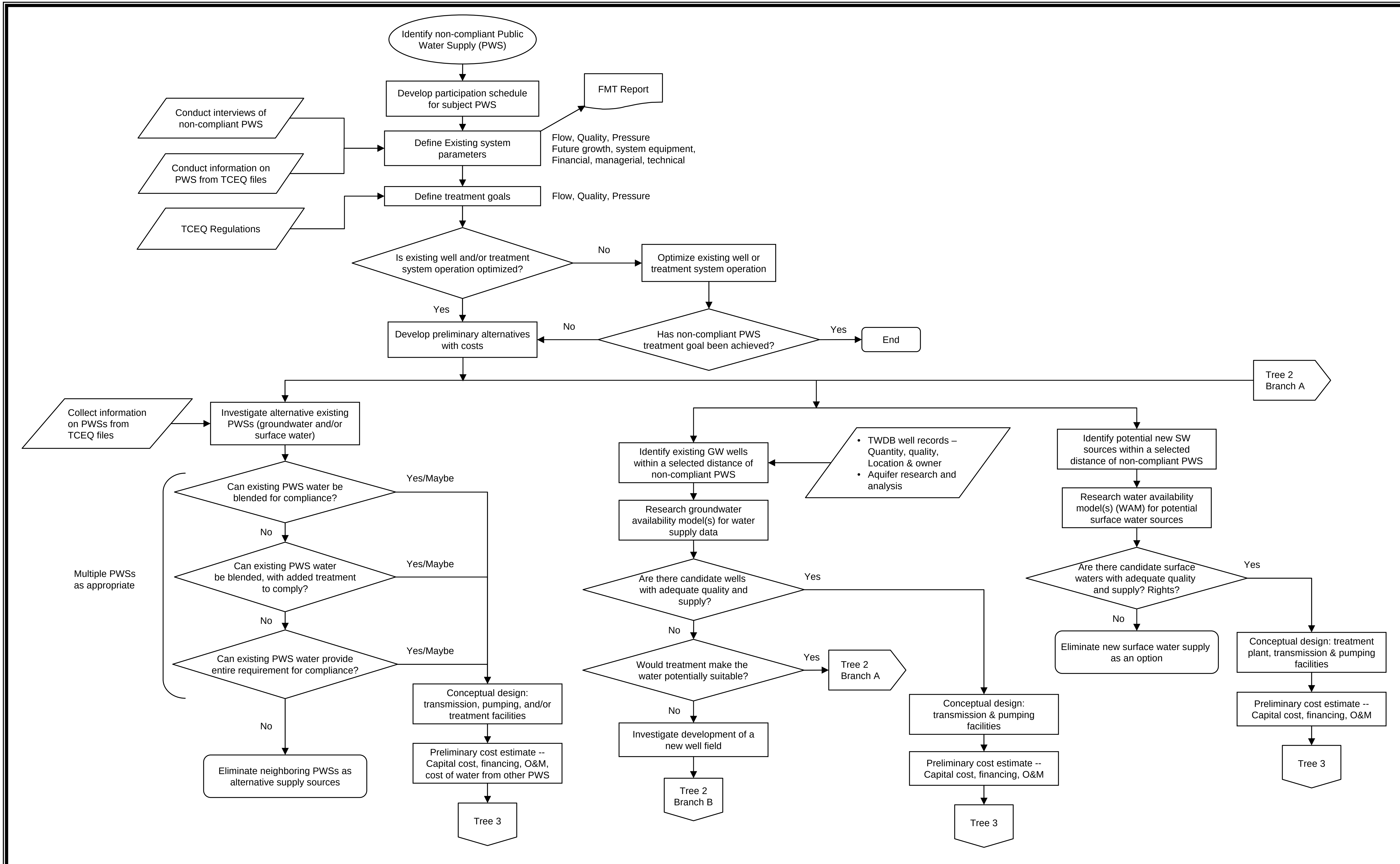


Figure 2.2
TREE 2 – DEVELOP TREATMENT ALTERNATIVES

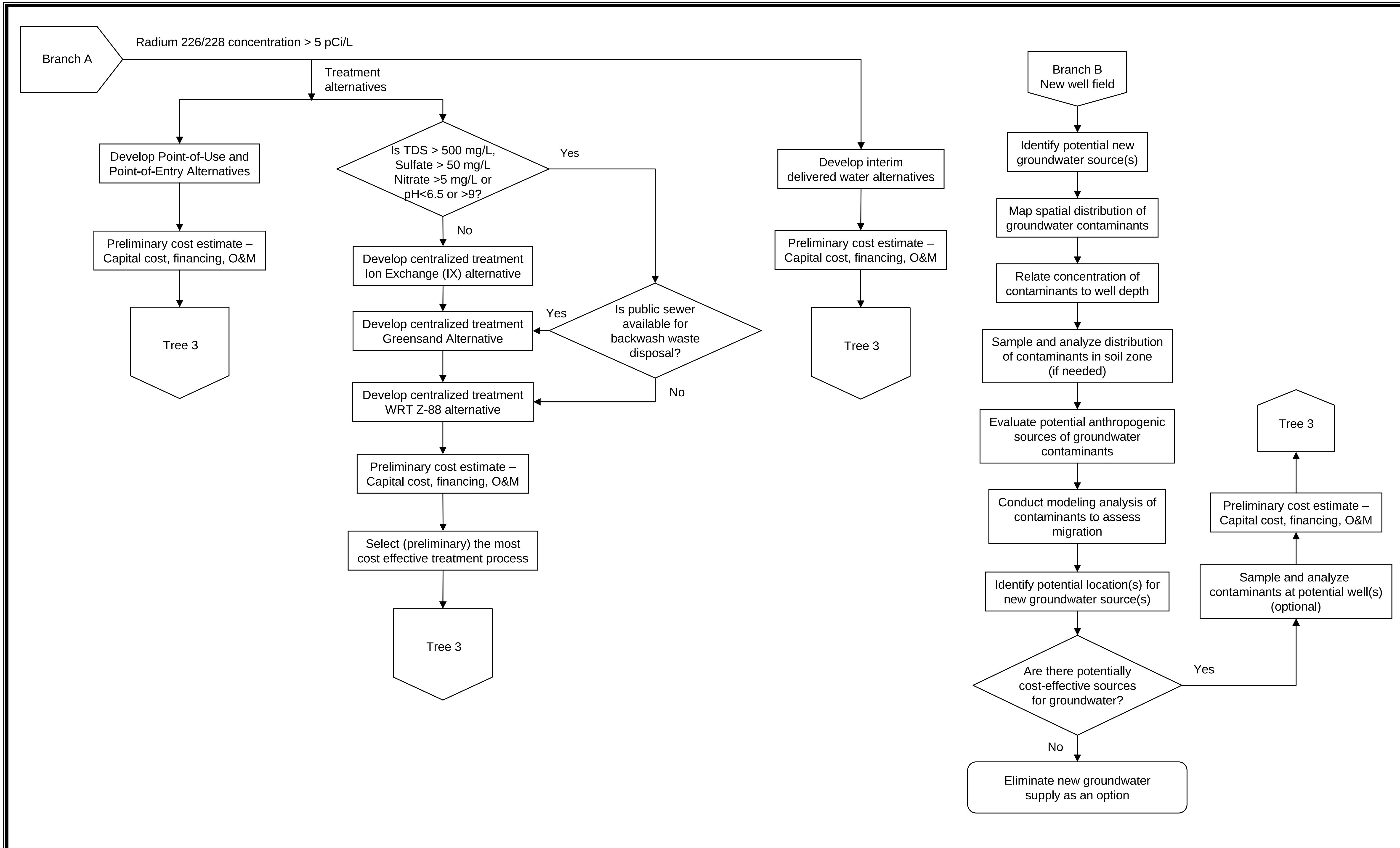


Figure 2.3
Tree 3 – PRELIMINARY ANALYSIS

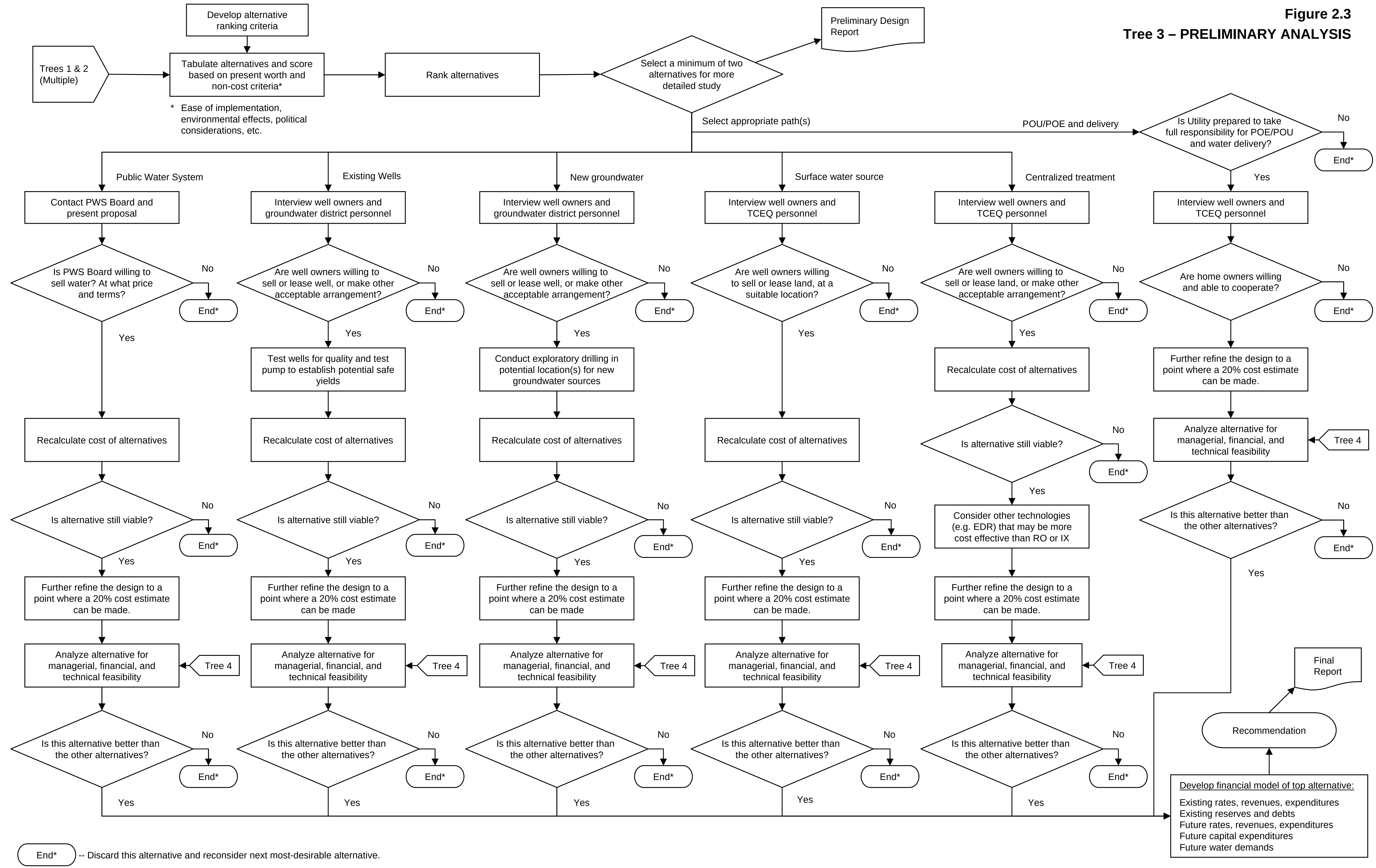
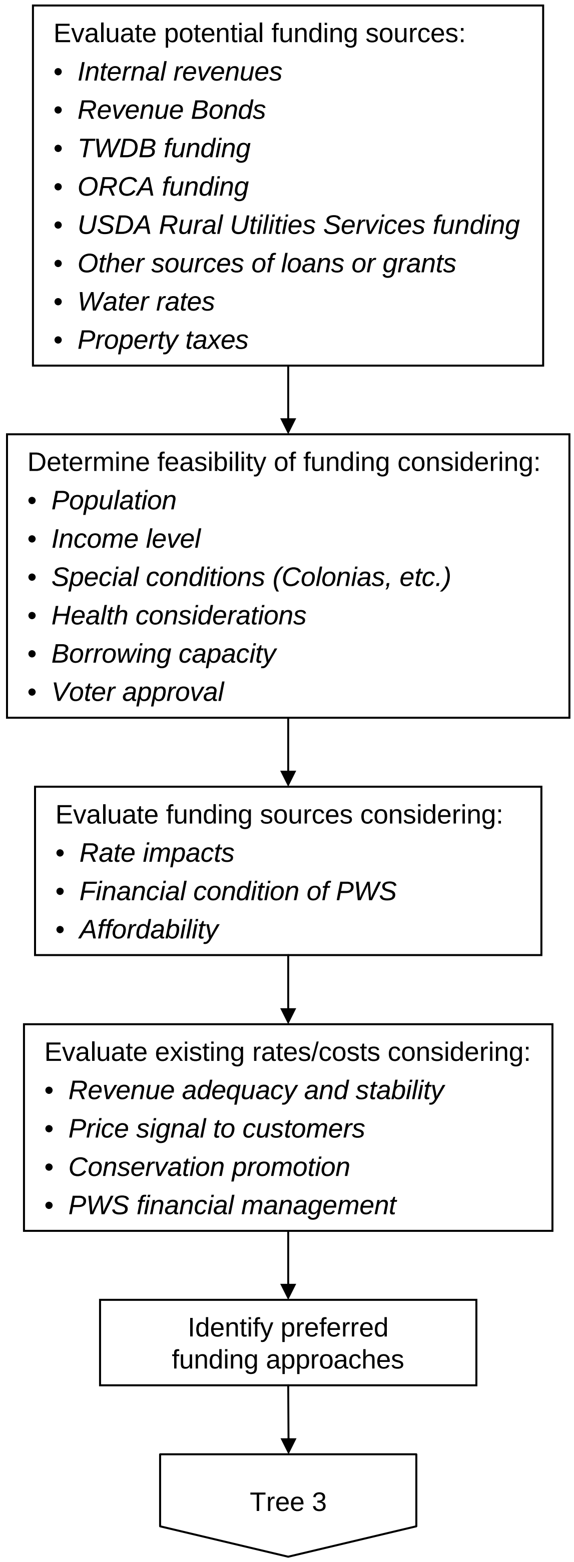


Figure 2.4
TREE 4 – FINANCIAL



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

- Texas Commission on Environmental Quality www3.tnrcc.state.tx.us/iwud/pws/index.cfm?. Under "Advanced Search", type in the name(s) of the county(ies) in the study area to get a listing of the public water supply systems.
- USEPA Safe Drinking Water Information System www.epa.gov/safewater/data/getdata.html

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

2.2.1.2 Existing Wells

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

2.2.1.3 Surface Water Sources

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

2.2.1.4 Groundwater Availability Model

GAMs, developed by the TWDB, are planning tools and should be consulted as part of a search for new or supplementary water sources. A GAM is under development by the TWDB for the Hickory aquifer but simulation data are not yet available. For this reason, the 2002 Texas Water Plan was reviewed to investigate groundwater availability.

2.2.1.5 Water Availability Model

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

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

2.2.1.6 Financial Data

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

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

2.2.1.7 Demographic Data

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

2.2.2 PWS Interviews

2.2.2.1 PWS Capacity Assessment Process

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

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

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

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

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

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

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

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

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

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

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

2.2.2.2 Interview Process

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

2.3 ALTERNATIVE DEVELOPMENT AND ANALYSIS

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

2.3.1 Existing PWS

The neighboring PWSs were identified, and the extents of their systems were investigated. PWSs farther than 10 miles from the non-compliant PWSs were not considered because the length of the pipeline required would make the alternative cost prohibitive. The quality of water provided was also investigated. For neighboring PWSs with compliant water, options for water purchase and/or expansion of existing well fields were considered. The neighboring PWSs with non-compliant water were considered as possible partners in sharing the cost for obtaining compliant water either through treatment or developing an alternate source.

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

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

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

2.3.2 New Groundwater Source

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

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

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

2.3.3 New Surface Water Source

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

2.3.4 Treatment

Treatment technologies considered potentially applicable to radium removal are IX, WRT Z-88 media, RO, EDR, and $KMnO_4$-greensand filtration. RO and EDR are membrane processes that produce a liquid waste: a reject stream from RO treatment and a concentrate stream from EDR treatment. As a result, the treated volume of water is less than the volume of raw water that enters the treatment system. The amount of raw water used increases to produce the same amount of treated water if RO or EDR treatment is implemented. Because the radium concentration and the TDS are not very high and the use of RO or EDR would be considerably more expensive than the other technologies. And thus RO and EDR are not considered further. However, RO is considered for POU and POE alternatives. IX, WRT Z-88 media, and KMnO4-greensand filtration are considered as alternative central treatment technologies. The treatment units were sized based on flow rates, and capital and annual O&M cost estimates were made based on the size of the treatment equipment required. Neighboring non-compliant PWS's were identified to look for opportunities where the costs and benefits of central treatment could be shared between systems.

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

2.4 COST OF SERVICE AND FUNDING ANALYSIS

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

2.4.1 Financial Feasibility

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

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

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

2.4.2 Median Household Income

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

2.4.3 Annual Average Water Bill

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

2.4.4 Financial Plan Development

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

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

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

2.4.5 Financial Plan Results

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

2.4.5.1 Funding Options

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

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

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

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

2.4.5.2 General Assumptions Embodied in Financial Plan Results

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

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

2.4.5.3 Interpretation of Financial Plan Results

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

2.4.5.4 Potential Funding Sources

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

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

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

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

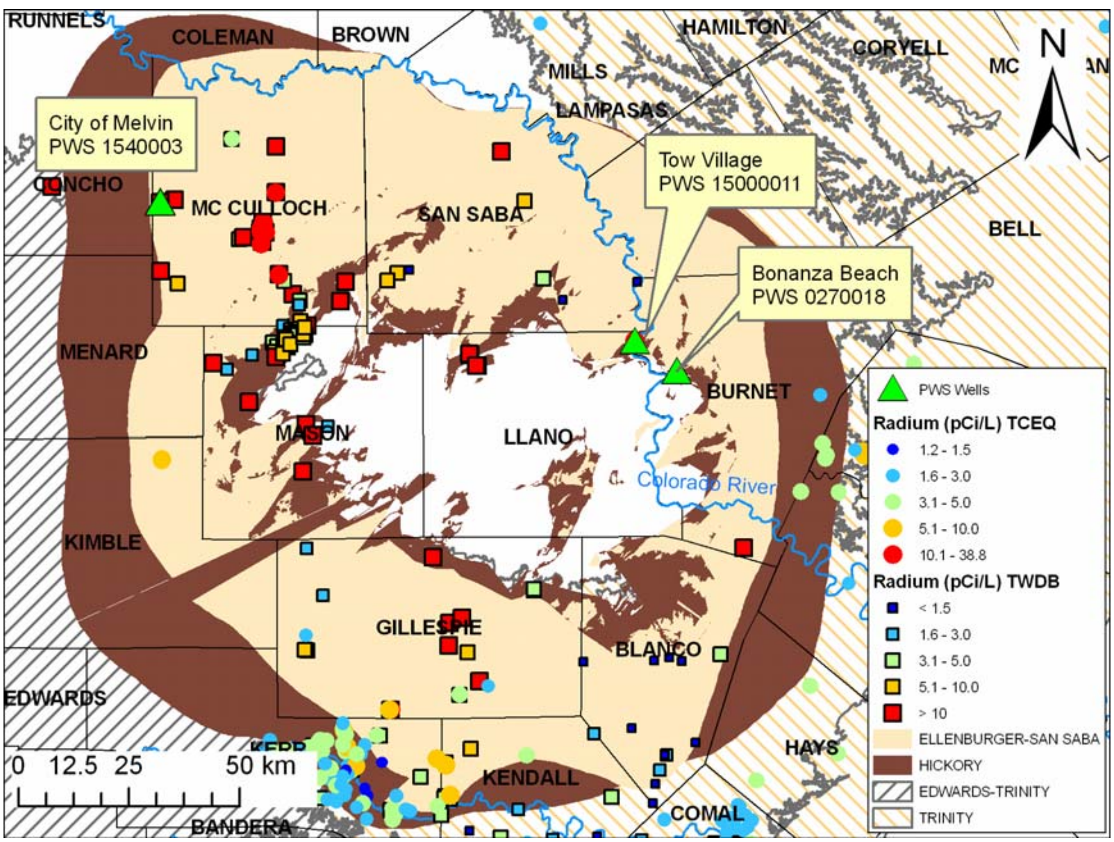
- United States Department of Agriculture, Rural Utilities Service, and
- United States Housing and Urban Development.

SECTION 3
UNDERSTANDING SOURCES OF CONTAMINANTS

3.1 RADIUM AND GROSS ALPHA IN CENTRAL TEXAS AQUIFERS

Aquifers in McCulloch, Llano, and Burnet Counties include aquifers of Cretaceous age (mainly within the Trinity Group) but mostly of Paleozoic age (Hickory and Ellenburger - San Saba aquifers) as a result of the presence of the Llano uplift, which is made up of Precambrian granite and schists and covers most of Llano County (Bluntzer 1992). The PWS wells of concern are located in those three counties and the wells are completed in the Hickory aquifer (except for one well in the Ellenburger-San Saba aquifer). In general, radium levels are higher (>5 pCi/L) within the Hickory and Ellenburger-San Saba aquifers and lower (<5 pCi/L) in southern and eastern parts of the study area within the Trinity aquifer (Figures 3-1 and 3-2).

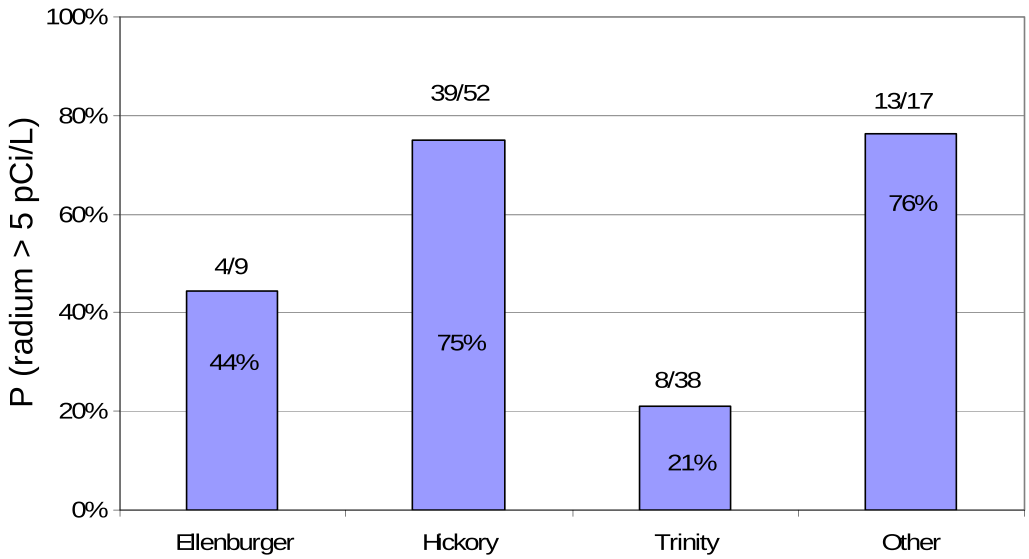
Figure 3-1 Radium Levels in Central Texas Aquifers



Data in Figure 3-1 show combined radium (radium-226 plus radium-228) from the TWDB groundwater database (storet codes 09503 and 81366) and TCEQ public water supply database (contaminant ID 4020 and 4030). The most recent values for wells in which both isotopes of radium were analyzed on the same day are shown. The data include raw samples from wells and samples from entry points which are connected to a single well.

In this study the terms *radium* or *radium combined* are generally used to refer to radium-226 plus radium-228, otherwise, radium-226 or radium-228 is specified. The values shown in Figure 3-1 generally represent the upper limit of the radium measurements because the detection limit was used for samples that are below the detection limit. Although TCEQ allows public water systems to subtract the reported error from the radium concentrations to assess compliance, the analysis of general trends used the most recent radium concentration and did not subtract the reported error.

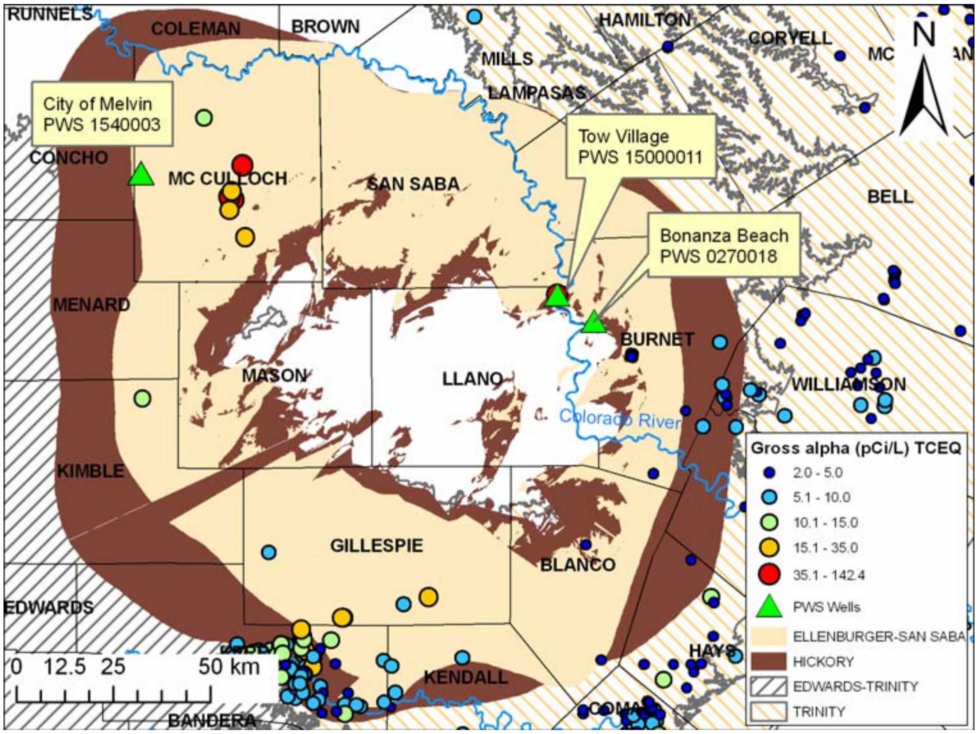
Figure 3-2 Percentage of Wells with Radium Exceeding the MCL (5 pCi/L) in Central Texas Aquifers



Data in Figure 3-2 are from the TWDB groundwater database. The most recent combined radium samples for each well are used in the analysis. Numbers on top of the graph bars show the number of samples >5 pCi/L and the total number of samples in each aquifer.

Gross alpha levels have a spatial distribution similar to radium. In general, levels of gross alpha in the Hickory and Ellenburger aquifers are higher than in the Trinity aquifer, and most of the gross alpha samples >15 pCi/L are from wells in the Hickory and Ellenburger-San Saba aquifers (Figure 3-3). The MCL for uranium is 30 micrograms per liter (µg/L), which is equivalent to 20 pCi/L (using a conservative factor of 0.67 pCi/µg for converting mass concentration to radiation concentration). Therefore, a gross alpha level of 35 pCi/L in a well reflects a level from which the well fails to comply with either the MCL for gross alpha minus alpha radiation due to uranium, which is 15 pCi/L, or with the uranium MCL (neglecting the activity due to radon which is rarely measured in PWS wells). Gross alpha >5 pCi/L requires analysis of radium-226. Radium-228 testing must be done regardless of gross alpha results (TCEQ 2004a).

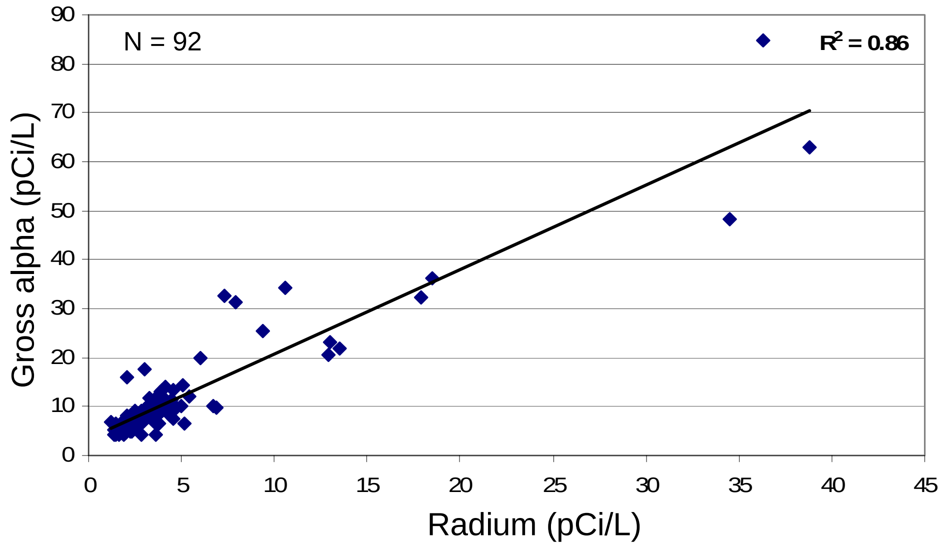
Figure 3-3 Gross Alpha in Groundwater in the Central Texas Aquifers



Data in Figure 3-3 are from the TCEQ public water supply database (contaminant ID 4109), and the most recent sample is shown for each well. The data include samples from entry points that are connected to a single well.

Correlation between radium and gross alpha is strong (R^2=0.86) and positive (Figure 3-4), showing that gross alpha in groundwater is mostly from radium.

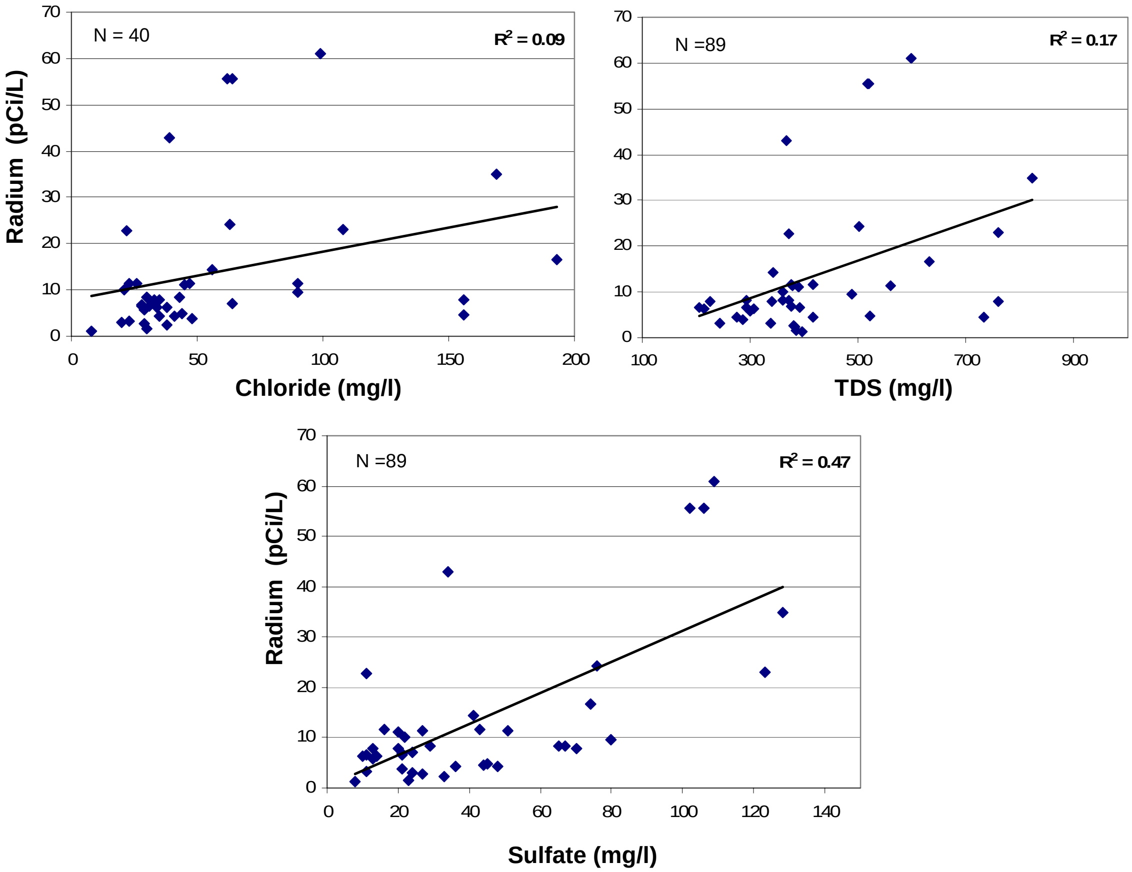
Figure 3-4 Relationship Between Radium and Gross Alpha in Central Texas Aquifers



Data in Figure 3-4 are from the TCEQ PWS database, and include samples from entry points that are connected to a single well. For each well the most recent sample is used in the analysis (data include only samples where both parameters were analyzed on the same day). N represents the number of samples used in the analysis.

The correlation of radium in the Hickory aquifer with general water quality parameters was assessed: correlation with chloride and TDS are weak (R^2 <0.2) while correlation with sulfate is somewhat stronger (R^2 = 0.47) (Figure 3-5).

Figure 3-5 Relationships Between Radium and Chloride, TDS, and Sulfate in the Hickory Aquifer



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

3.2 REGIONAL GEOLOGY

McCulloch, Llano, and Burnet Counties are centered on the Llano Uplift, a mostly granitic Precambrian core surrounded by rings of Paleozoic formations dipping away from it in all directions (Bluntzer 1992). Cretaceous formations, in direct contact with the Paleozoic sequence, complete the stratigraphic column in west McCulloch County (Anaya and Jones 2000) and east Burnet County (RWHA 2003).

Llano County forms the core of the Llano Uplift where Precambrian igneous and metamorphic rocks are exposed. The geology is complex and its details are not pertinent to this section. The Hickory Member (mainly sandstone) represents the first formation of Cambrian age covering the Precambrian basement. The Ellenburger Group (mostly carbonates) of Ordovician age, to which is added the San Saba Member of Upper Cambrian age, contains several fully hydraulically connected water bearing formations. Another water bearing formation, appropriately called the Mid-Cambrian aquifer (mostly sandstone), is present between them. This Mid-Cambrian aquifer is not recognized by the State of Texas, as opposed to the Hickory and Ellenburger / San Saba aquifers which are classified as minor aquifers by the state (Ashworth and Hopkins 1995). A fourth unit, the Marble Falls formation (mainly carbonate) of Pennsylvanian age, is also listed as a minor aquifer. The rest of the Paleozoic contains formations able to produce some water but not in significant quantity. The Paleozoic aquifers are compartmentalized by faults that became inactive before the deposition of the Cretaceous sediments. However, the stratigraphic section does not change much from one compartment to the next. The general dip is <2.3 percent (120 feet/mile) (Mason 1961). The next preserved layers present in eastern Burnet and western McCulloch counties are of Cretaceous age and were deposited on a mostly flat platform. The first described formation is the Travis Peak formation, itself part of the Trinity Group: the Hosston Sand and Hensell Sand with intermediate confining beds. The Hosston Sand pinches out around the uplift and to the northwest as well and has mostly disappeared or merged with the Hensell Sand in McCulloch County. The Travis Peak formation (also called Twin Mountains formation farther north) is overlain by the Glen Rose formation, which acts as a confining unit, then by the Paluxy Sand, which disappears just south of Burnet County (RWHA, 2003) and does not exist in McCulloch County. Westward, the Trinity Group is much thinner (no or thin Glen Rose formation) and overall sandier and is called the Antlers Sand (Klemt, *et al*. 1975; Baker, *et al*. 1990). Covering the Trinity Group, the Fredericksburg Group (which includes the Edwards formation) completes the section. Mostly sandy units of the Trinity Group form the Trinity aquifer, a major aquifer according to the State of Texas (Ashworth and Hopkins 1995). The dip of the Cretaceous formation is generally small (<0.5%) and toward the south or east.

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

3.3 ASSESSMENT OF THE BONANZA BEACH PWS

3.3.1 Data Assessment

There are three wells in the Bonanza Beach PWS: G0270018A, G0270018B, and G0270018C. The wells have depths of 135 to 185 feet, and are designated in the Hickory aquifer (Table 3.1). The wells are connected to a single entry point (EP) in the water supply system; therefore, water samples taken at the EP cannot be associated with a specific well.

Radium levels measured at the PWS are above the 5 pCi/L MCL (Table 3.2), gross alpha levels are >15 pCi/L (Table 3.3), and uranium levels are about 10 pCi/L (Table 3.4). Gross alpha levels are below the 15 pCi/L MCL after deducting the activity from uranium.

Table 3.1 Well Depth and Screen Depth for Wells at Bonanza Beach PWS

Water source	Depth (ft)	Screen depth (ft)	Aquifer
G0270018A	135	-	Hickory (code 371HCKR)
G0270018B	185	-	Hickory (code 371HCKR)
G0270018C	170	60-170	Hickory (code 371HCKR)

Table 3.2 Radium Concentrations at Bonanza Beach PWS

Date	Source	Radium-226 (pCi/L)	Radium-228 (pCi/L)	Radium total (pCi/L)
7/5/2000	D	2.3	4.4	6.7
9/18/2001	EP 1	2.8	6.1	8.9
11/12/2003	EP 1	2.4	4.4	6.8
12/22/2004	EP 1	2.1	4.6	6.7

Table 3.3 Gross Alpha Concentrations at Bonanza Beach PWS

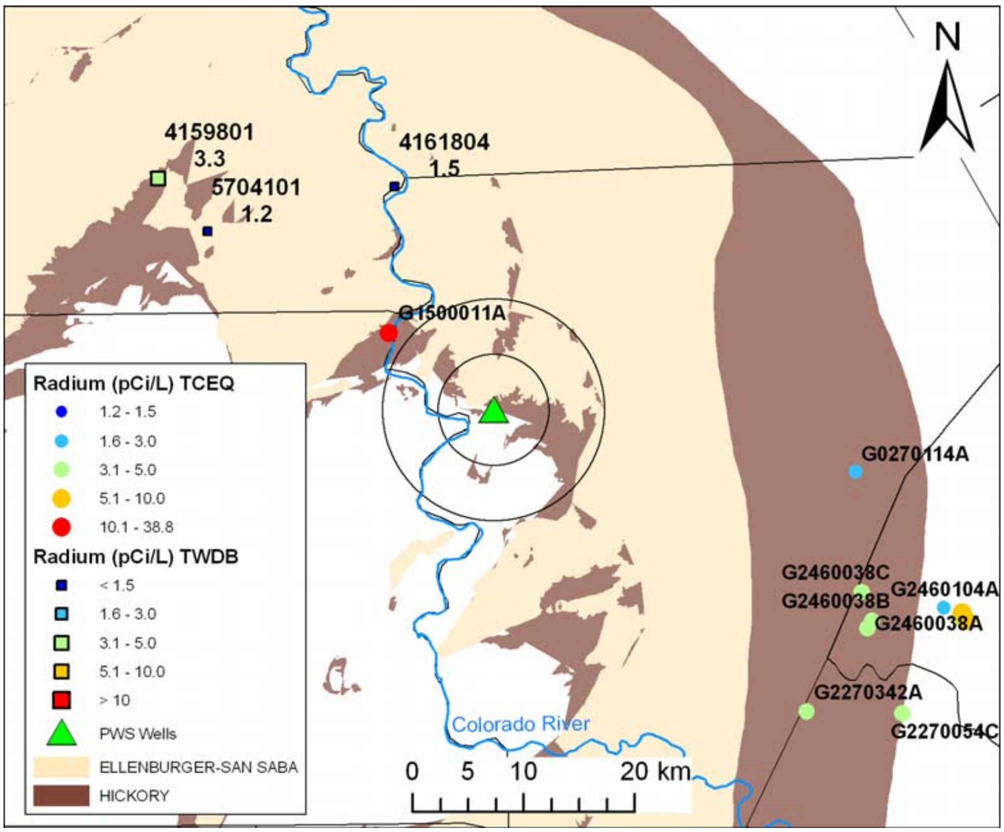
Date	Source	Gross alpha (pCi/L)
9/18/2001	EP 1	18.7
11/12/2003	EP 1	19.7
12/22/2004	EP 1	20.8

Table 3.4 Uranium Concentrations at Bonanza Beach PWS

Date	Source	Total Uranium (pCi/L)
9/18/2001	EP 1	10.4
11/12/2003	EP 1	9.8
12/22/2004	EP 1	9.8

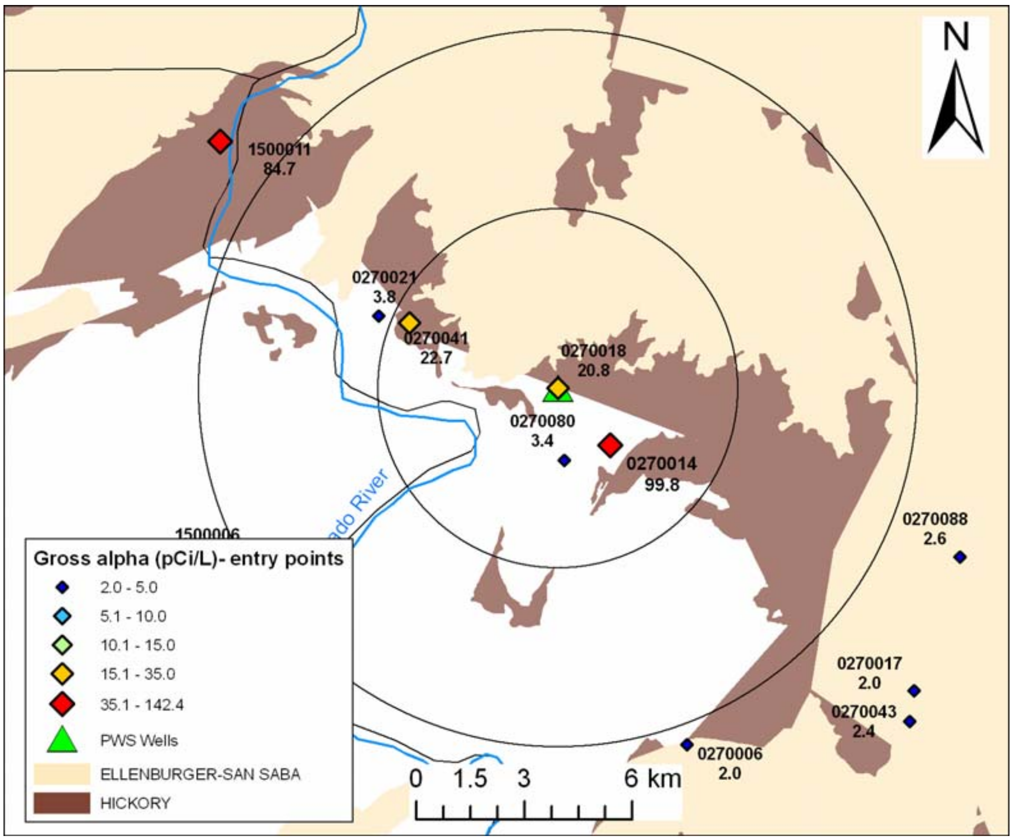
Data from the TWDB and TCEQ databases do not show wells with radium <5 pCi/L in the vicinity (10-km buffer) of the Bonanza Beach PWS (Figure 3-6). The nearest wells with radium concentrations <5 pCi/L are over 22 to 30 km northwest, or over 30 km southeast of the PWS.

Figure 3-6 Radium in the 5- and 10-km Buffers of the Bonanza Beach PWS Wells



Data from PWS entry points show a number of public water supply systems with gross alpha <5 pCi/L (Figure 3-7). PWS 0270021 (about 5.5 km northwest of the Bonanza Beach PWS) and PWS 0270080 (about 2 km south of the Bonanza Beach PWS) are the nearest PWSs with gross alpha <5 pCi/L. Wells in these PWSs are 125 to 380 feet deep and they are categorized as within the Hickory aquifer. There are a number of PWSs farther to the southeast; these include PWS 0270088, 0270017, 0270043, and 0270006, with gross alpha <3 pCi/L. Wells in these PWS have depths of 150 to 385 feet and are in the Hickory, Ellenburger-San Saba, and Trinity aquifers. In the vicinity of the Bonanza PWS, the wells in the Hickory aquifer with gross alpha <5 pCi/L (*i.e*., wells in PWS 0270021 and 0270080) are near the wells with gross alpha >20 pCi/L (*i.e*., wells in PWS 0270014 and 0270041). The depth ranges of these wells are similar; therefore, correlations between radium and well depths cannot be identified.

Figure 3-7 Gross Alpha in the 5- and 10-km Buffers of the Bonanza Beach PWS Wells



Potential Sources of Contamination (PSOC) are identified as part of TCEQ's Source Water Assessment Program. No radium PSOCs are identified in the vicinity of the Bonanza Beach PWS; therefore, point sources are not expected to influence radium concentrations at the Bonanza Beach PWS.

3.3.2 Summary of Alternative Groundwater Sources

No wells with radium <5 pCi/L are identified within the vicinity (10-km) of the Bonanza Beach PWS, but PWSs with low gross alpha may have low radium as well; therefore, potential alternative groundwater sources in the vicinity of the Bonanza Beach PWS are PWS 0270021 and PWS 0270080. Water from these systems could be used to replace or dilute existing water at the Bonanza Beach PWS.

SECTION 4
ANALYSIS OF THE BONANZA BEACH PWS

4.1 DESCRIPTION OF EXISTING SYSTEM

4.1.1. Existing System

The Bonanza Beach PWS, shown in Figure 4.1, is owned and operated by the LCRA, a conservation and reclamation district that manages water supplies for cities, farmers, and industries along a 600-mile stretch of the Texas Colorado River between San Saba and the Gulf Coast. The Bonanza Beach PWS serves 143 people and has 56 service connections.

The water sources for this PWS are two wells, both of which are completed in the Hickory Sandstone formation (Code 371HCKR). The wells are 185 feet and 170 feet deep, respectively. Chlorine disinfection occurs at each wellhead and then the water is pumped to three elevated storage tanks before going into the distribution system. Each storage tank has a capacity of 9,000 gallons.

Since 2000 total radium has been detected between 5.2 pCi/L to 7.8 pCi/L and these values exceed the MCL of 5 pCi/L. The Bonanza Beach PWS has not encountered any other water quality issues. Typical TDS concentrations average around 532 mg/L.

The treatment employed for disinfection is not appropriate or effective for removal of radium, so optimization is not expected to be effective for increasing removal of this contaminant. However, there is a potential opportunity for system optimization to reduce radium concentration. The system has more than one well, and since radium concentrations can vary significantly between wells, radium concentrations should be determined 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: 143
- Connections: 56
- Average daily flow: 0.016 million gallons per day (mgd)
- Water system peak capacity: 0.064 mgd
- Typical total radium range: 5.2 pCi/L – 7.8 pCi/L
- Typical total dissolved solids: 532 mg/L

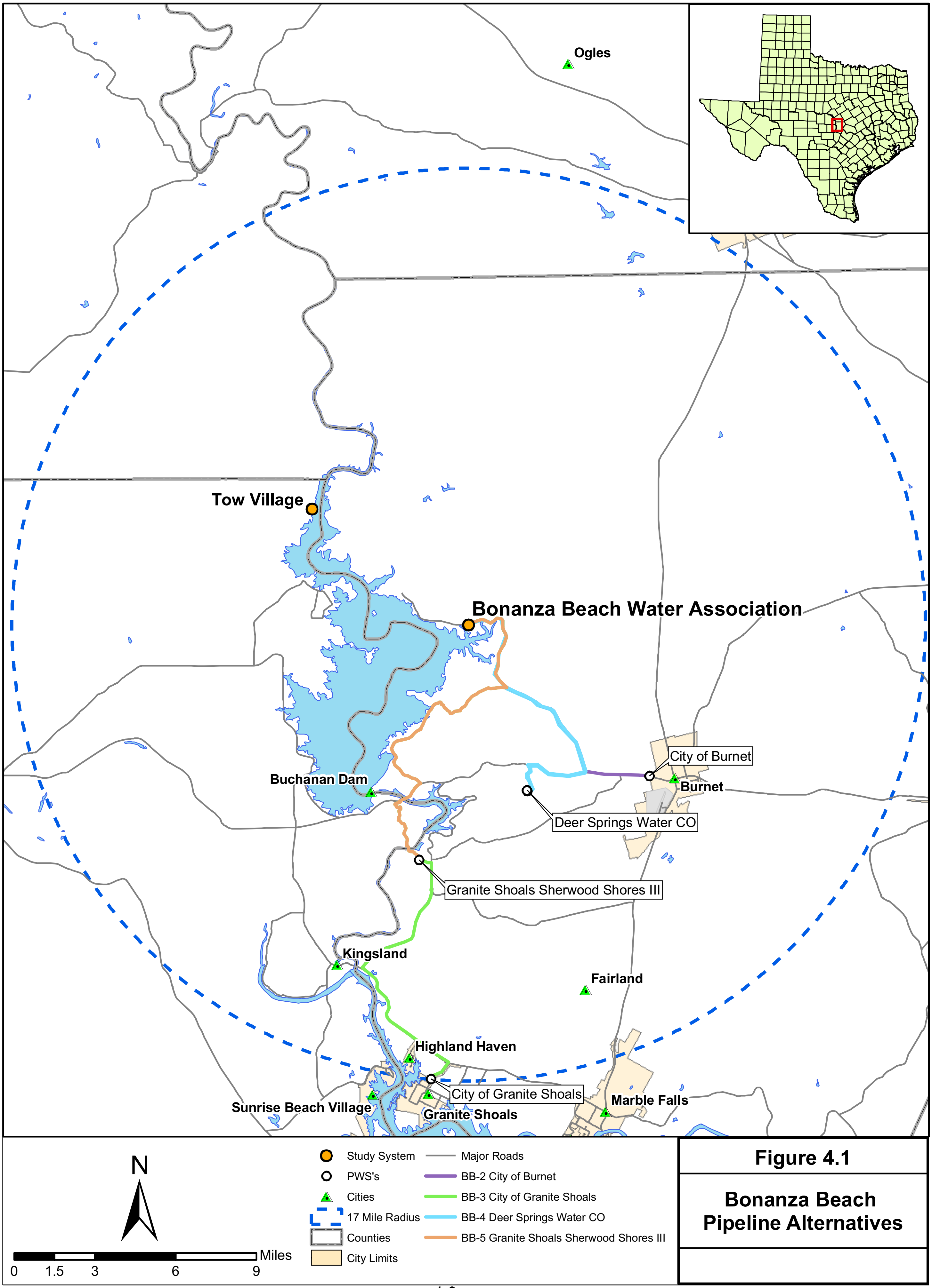


Figure 4.1

Bonanza Beach Pipeline Alternatives

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- Typical pH range: 7.0 to 7.7
- Single calcium result: 95.7 mg/L
- Single magnesium result: 63.9 mg/L
- Single sodium result: 27.8 mg/L
- Typical chloride range: 57.1 to 64 mg/L
- Typical bicarbonate (HCO_3) range: 335 to 493 mg/L
- Typical fluoride range: 0.3 to 0.4 mg/L
- Single iron result: 0.01 mg/L

4.1.2 Capacity Assessment for the Bonanza Beach

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

The project team interviewed the following individuals.

- Scott Ahlstrom – Manager, Water and Wastewater Utility Services, LCRA
- Mike Tomme – Regulatory, Process Coordinator, LCRA
- R. Darrin Barker – Manager, Hill Country Region, LCRA
- Angie Flores – Supervisor, Customer Rates and Financial Analysis – Water Services, LCRA
- Michelle Abrams – Customer Rates and Financial Analysis – Water Services, LCRA
- Wayne Lovelis – Operator, Hill Country Region, LCRA

4.1.2.1 General Structure of the Water System

The Bonanza Beach PWS on Lake Buchanan is owned and operated by LCRA. LCRA was created by the Texas legislature and is governed by a 15-member board of directors. Their mission is to provide reliable, low-cost utility and public services to communities in the central and south Texas area, and to protect and make constructive use of the area's natural resources. LCRA does not have any taxing authority and its revenues come from selling electricity, electric transmission, and water and wastewater services at its cost. LCRA has 5 major areas of operations: Energy Services; Water Services; Community Services; Financial and Corporate Operations; and, External Affairs. Water and wastewater systems are operated under the Water Services area, which also includes river management, irrigation districts, and hydroelectric.

While LCRA owns and operates several large regional water and wastewater systems, they also own and operate many small, rural systems. LCRA acquired the Bonanza Beach PWS in 2002. The Bonanza Beach PWS has 56 service connections serving 143 people. The system has two groundwater wells and three storage tanks. The well water is disinfected with sodium hypochlorite. Water and wastewater utilities are operated out of four regions. The Bonanza Beach PWS is operated out of the LCRA Hill Country Region, which serves 19 water systems. Water utility rates are set by the LCRA Board of Directors. There is a Hill Country Region schedule for rates, fees, charges, and conditions for water service. However, rates are different for each individual water system within the region. There is a separate operating budget for each water system within the Hill Country Region for directs costs, such as electricity, and labor.

LCRA has developed a 30-year plan which projects providing water and wastewater service to customers in high-growth areas in the Central Texas region.

4.1.2.2 General Assessment of Capacity

Based on the team's assessment, this system has a very good level of capacity. There are several positive managerial, financial and technical aspects of the water system. Any deficiencies noted could prevent the water system from being able to meet compliance now or in the future and may also impact the water system's long-term sustainability.

4.1.2.3 Positive Aspects of Capacity

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

- **Benefits from Economies of Scale** – Bonanza Beach water system is one of 19 water systems operated out of the Hill Country Region office of the LCRA. This structure allows a very small water system to benefit from the pool of operators and a central maintenance crew. While there is a primary operator assigned to the Bonanza Beach PWS, there are 10 additional staff available. All positions have written job descriptions. Operators receive safety training once a month through the Region's monthly safety meetings. The region has a written operation and maintenance manual as well as an excellent preventive maintenance program and a new computerized work order system. LCRA is able to keep spare parts at each water system as well as in a central location. Every system has a written emergency plan and there are three generators available in the Hill Country Region office. There is toll-free number customers can call after hours. The security dispatcher has a call-out list. In addition, the system benefits from an in-house Operations and Engineering Department which prioritizes repairs and replacements of utility assets. LCRA has centralized billing and collection system and their collection rate is almost 100 percent.

- **Communication –** There is excellent communication among the staff in the LCRA Hill Country regional office. There is a meeting every morning to discuss work orders. In addition, LCRA holds public meetings with individual water systems when deciding about a rate increase.

4.1.2.4 Capacity Deficiencies

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

- **Lack of Compliance with Radionuclides Standard –** The Bonanza Beach PWS is not in compliance with the radionuclides standard, and is currently under a compliance agreement with TCEQ. The system has historically exceeded radionuclide levels, which come from naturally occurring deposits. LCRA has been working to address the issues. LCRA received funding from the Texas Water Development Board for the North Lake Buchanan Project, which was planned to provide treated surface water to several communities, including the Bonanza Beach PWS, and fund improvements to other LCRA systems. Moving forward with this project is contingent on all parties making final agreement to participate.

- **Lack of Sufficient Revenues from Rate Structure for Long-Term Sustainability** - The Bonanza Beach PWS was not self-sufficient at the time of this assessment. Rates do not cover water costs nor do they encourage water conservation. In addition, there is no repair and replacement fund or capital projects reserve fund. As new compliance rules and regulations are introduced that will require more complex and expensive treatment, or as system upgrades and improvements are needed, the ability to take advantage of the economies of scale offered by a single rate structure is critical to maintaining affordability for the small systems. The LCRA stated that they would like to move to a single rate structure for the Hill County Region to be able to achieve the economies of scale necessary to operate the smaller systems, as the last rate increase for most of the systems in the Hill Country Region was in 2004.

4.1.2.5 Potential Capacity Concerns

The following items were concerns regarding capacity but no specific operational, managerial, or financial problems can be attributed to these items at this time. The system should address the items listed below to further improve technical, managerial, and financial capabilities and to improve the system's long-term sustainability.

- **Rate Review –** Water service rates are currently reviewed through the business plan process. LCRA reviews the revenue for the prior year and determines the rate based on affordability, not cost of service. However, LCRA recently completed a cost of service study in order to develop regional rates.
- **Leaking Storage Tank –** There are two concrete storage tanks that are currently leaking and need to be repaired. The Hill County Region manager indicated that they are on the prioritization list for repairs.

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 Bonanza Beach PWS were reviewed with regard to their reported drinking water quality and production capacity. PWSs that appeared to have water supplies with water quality issues were ruled out from evaluation as alternative sources, while those without identified water quality issues were investigated further. Owing to the large number of small (<1 mgd) water systems in the vicinity, small systems were only considered if they were established residential systems within 17 miles of the Bonanza Beach PWS. If it was determined that these PWSs had excess supply capacity and might be willing to sell the excess, or might be a suitable location for a new groundwater well, the system was taken forward for further consideration. In addition, large systems with possible excess capacity were considered out to 17 miles.

Table 4.1 is a list of the selected PWSs within approximately 17 miles of the Bonanza Beach PWS. This distance was selected as the radius for the evaluation owing to the relatively small number of PWSs in proximity to the Bonanza Beach PWS and because 17 miles was considered to be the upper limit of economic feasibility for constructing a new water line.

Table 4.1 Selected Public Water Systems within 15 Miles of the Bonanza Beach PWS

PWS ID	PWS Name	Distance from Bonanza Beach	Comments/Other Issues
0270058	Thunderbird Resort	1.0	Small system. No Radionuclide data.
0270080	South Council Creek 2	1.2	Small system. WQ issues: Gross alpha, Rd. In LCRA report.
0270014	Council Creek Village	1.3	Small system. WQ issues: Rd. In LCRA report.
0270041	South Silver Creek I II and III	2.8	Small system. WQ issues: Rd. In LCRA report.
0270021	Silver Creek Village WSC	3.3	Small system. No WQ issues. In LCRA report.
1500008	Paradise Point Water Supply Corp	4.7	Small system (surface WTP). No WQ issues. In LCRA report.

Table 4.1 Selected Public Water Systems within 15 Miles of the Bonanza Beach PWS

PWS ID	PWS Name	Distance from Bonanza Beach	Comments/Other Issues
1500061	Chism Lodges	5.0	Small system. No Radionuclide data.
1500070	Hi Line Lake Resort Rod & Reel Grill	5.1	Small system. No Radionuclide data.
1500083	Buchanan Village RV Park	5.4	Small system. No Radionuclide data.
0270115	Canyon of the Eagles Park	5.5	Small system. No Radionuclide data.
0270047	Cassie Water System	5.5	Small system. No Radionuclide data.
1500003	Buchanan Lake Village	5.6	Small system. No WQ issues. In LCRA report.
1500048	Bluffton Trailer Park	5.7	Small system. No Radionuclide data. WQ issues: Nitrate
1500104	Village Quick Stop	5.8	Small system. No Radionuclide data.
1500113	Kountry Kitchen	6.5	Small system. No Radionuclide data. WQ issues: Nitrate
0270006	Deer Springs Water Co	6.6	Small system. No WQ issues. Evaluate further.
0270008	Buena Vista Subdivision	6.7	Small SW system. No WQ issues. In LCRA report.
1500095	Rock A Way Park	7.0	Small system. No Radionuclide data.
1500033	Rhodes End Mobile Home Park	7.1	Small system. No Radionuclide data.
1500049	Beachcombers Park	7.1	Small system. No Radionuclide data.
1500024	Stover Mobile Home Park	7.1	Small system. No Radionuclide data.
1500045	Camp Longhorn Main Camp	7.2	Small system. No Radionuclide data.
1500011	Tow Village Property Owners Assn	7.2	STUDY SYSTEM. Small system. WQ issues: Gross alpha, Rd. In LCRA report.
1500037	LCRA Upper Highland Lakes Ws Sys	7.3	Large system (surface WTP). No WQ issues. In LCRA report.
1500006	3 G Water Cooperative	7.3	Small system. No WQ issues. Opposite side of lake.
0270088	Laco Mobile Home Park	7.5	Small system. No Radionuclide data.
1500018	Water Works 1 Floyd Acres	7.8	Small system. No WQ issues. Purchases SW from Upper Highland Lakes.
1500099	Shady Oaks RV Park	7.9	Small system. No Radionuclide data.
0270017	Skyline Terrace Subdivision	8.1	Small system. No Radionuclide data.
0270001	Burnet City Of	8.1	Large system. No WQ issues. Evaluate Further
1500019	Water Works 2 Island Lodges	8.3	Small system. No WQ issues. Purchases SW from Upper Highland Lakes.
0270043	Sunset Hills Subdivision	8.4	Small system. No Radionuclide data.
1500039	Edgewater The	8.6	Small system. No Radionuclide data.
1500023	Graves Long Mountain R V Park Inc	8.6	Small system. No Radionuclide data. WQ issues: Nitrate
0270065	River Oaks Subd Water System	8.8	Small system. No Radionuclide data.

Table 4.1 Selected Public Water Systems within 15 Miles of the Bonanza Beach PWS

PWS ID	PWS Name	Distance from Bonanza Beach	Comments/Other Issues
0270053	Camp Longhorn Indian Springs	8.9	Small system. No Radionuclide data.
0270022	Granite Shoals Sherwood Shores III	9.0	Small system. No WQ issues. Evaluate further.
0270049	Granite Shoals, City of	17.0	Large system. No WQ issues. Evaluate Further

Systems were screened out from further consideration if:

- they had identified water quality issues;
- insufficient data were available to assess their water quality;
- the system was already included in the LCRA Lake Buchanan Regional Water Project (Subsection 4.2.1.1);
- the system was located on the opposite side of Lake Buchanan from Bonanza Beach; or
- the system was purchasing compliant water from another PWS.

Based on this initial screening and the information summarized in Table 4.1 above, four surrounding systems were selected for further evaluation. These systems are summarized in Table 4.2.

Table 4.2 Public Water Systems Within the Vicinity of the Bonanza Beach PWS Selected for Further Evaluation

System Name	Pop	Conn	Total Production (mgd)	Ave Daily Usage (mgd)	Approx. Dist. from Bonanza Beach	Comments/Other Issues
Deer Springs Water Co	175	84	0.082	0.079	6.6	Small system. No WQ issues. Evaluate further.
Burnet City Of	6,171	2,598	3.024	0.816	8.1	Small system. No WQ issues. Evaluate further.
Granite Shoals Sherwood Shores III	350	159	0.060	0.030	9.0	Small system. No WQ issues. Evaluate further.
Granite Shoals, City of	5,205	1,735	1.440	0.326	17.0	Small system. No WQ issues. Evaluate further.

In addition to the four alternatives shown in Table 4.2 above, the LCRA Lake Buchanan Regional Water Project (Subsection 4.2.1.1) was also included in this evaluation.

4.2.1.1 Lake Buchanan Regional Water Project

LCRA performed a feasibility study in 2004 that examined solutions to the radium issues for the Tow Village POA PWS and several other PWSs in the vicinity. This study proposed expanding the surface water treatment plant that currently serves the Paradise Point PWS (ID# 1500008) on the west side of Lake Buchanan in Llano County, and then running a pipeline north to bring service to Tow Village, then across the lake to Bonanza Beach. The full details of this study are summarized in the *Engineering Feasibility Study for the Lake Buchanan Regional Water Project* (LCRA 2004). LCRA is still exploring this solution.

4.2.1.2 Deer Springs Water Company

Deer Springs Water Company is located approximately 7 miles southeast of the Bonanza Beach PWS. The Deer Springs PWS is privately owned and operated, and is supplied by two groundwater wells completed in the Hickory Sandstone formation (Code 371HCKR). Both wells are 580 feet deep and have a combined production of 0.082 mgd. Water is disinfected using hypochlorite before being distributed. The Deer Springs PWS serves a population of 175 and has 84 metered connections.

The Deer Springs PWS does not have sufficient excess capacity to supplement the Bonanza Beach PWS'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 Burnet

The City of Burnet (PWS #0270001) is located in Burnet County approximately 8 miles southeast from the Bonanza Beach PWS. The City has a population of 6,171 people and a total of 2,598 metered connections. The City of Burnet's water is provided by a 2.8 mgd surface water treatment plant that draws water from Inks Lake via a 7.5-mile pipeline. There are also three ground water wells that are available only for emergency use. These three wells were the primary water source for Burnet prior to 1987 but, owing to continual bacteria growth in these wells, the City switched to surface water. They are currently making plans to recase one of the wells to address the bacterial growth.

With the 2.8 mgd water treatment plant and a current consumption rate ranging from 1.3 to 1.5 mgd, there is a current excess of 1.4 mgd. The planning and zoning department investigates all requests for receiving potable water from the City of Burnet. After the request has been evaluated by the Planning and Zoning Department, it is then submitted to the City Council for approval. According to the water/waste water department, there are three new subdivisions planned for the City and they plan to double the capacity of the treatment plant by 2010. Consequently, they may have sufficient water to supply surrounding systems, assuming that an agreement can be successfully negotiated.

4.2.1.4 Granite Shoals Sherwood Shores III

Granite Shoals Sherwood Shores III is located approximately 9 miles south of Bonanza Beach. The Granite Shoals PWS is owned and operated by the City of Granite Shoals, and is supplied by three shallow groundwater wells completed in alluvium (Code 100ALVM). Each of the three wells is 60 feet deep and have a combined production of 0.060 mgd. Water is disinfected using chlorine before being distributed. The Granite Shoals PWS serves a population of 350 and has 159 metered connections.

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

4.2.1.5 City of Granite Shoals

The City of Granite Shoals (PWS # 0270049) is located in Burnet County approximately 17 miles from Bonanza Beach. The water source for the City is Lake Lyndon B. Johnson, although the City also owns two water wells that are available for emergency use. The City's treatment plant has a production capacity of 1.44 mgd, though a new 3 mgd treatment plant is currently being built nearby. The City has a population of 5,205 people and a total of 1,735 metered connections. The average annual usage for the City of Granite Shoals is between 0.8 and 1.0 mgd.

Once the new treatment plant begins full-time operation (March 2007), the City anticipates having an excess capacity of 2.0 to 2.2 mgd. Consequently, they are looking for additional customers to purchase the treated water. Water is currently being provided to one area that is not within the city limits of Granite Shoals: a subdivision called Debbie Acres that is located in Sunset Woods. Costs for installation of the pipeline were covered through grants and the potential water usage via a negotiated rate. The decision to sell water to a surrounding system is made by the seven-member city council.

4.2.2 Potential for New Groundwater Sources

4.2.2.1 Installing New Compliant Wells

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

Although BEG stated in Section 3 that compliant water was not likely to be found within a 6-mile radius, 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., The PWS is already familiar with operating a water well. As a result, existing nearby wells with good water quality should be investigated. Re-sampling and test pumping would be required to verify and determine the quality and quantity of water at those wells.

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

Some of the alternatives suggest new wells be drilled in areas where existing wells are compliant with the MCL for combined radium of 5 pCi/L. In developing the cost estimates, Parsons assumed that the aquifer in these areas would produce the required amount of water with only one well. Site investigations and geological research, which are beyond the scope of this study, could indicate whether the aquifer at a particular site and depth would provide the amount of water needed or if more than one well would need to be drilled in separate areas.

4.2.2.2 Results of Groundwater Availability Modeling

The Hickory aquifer and Ellenburger-San Saba aquifer are the primary groundwater sources in the PWS vicinity. According to TCEQ records, the Hickory aquifer is the groundwater supply for the Bonanza Beach PWS in Burnet County.

Pockets of water-bearing rock layers of the aquifer that appear at the land surface (outcrop) are scattered throughout Blanco, Burnet, Gillespie, Llano, Mason, McColloch and San Saba Counties, while deeper aquifer formations (downdip) are present in throughout Burnet County and 11 adjacent counties. The Hickory aquifer is underlain by the Ellenburger-San Saba aquifer. A GAM is under development by the TWDB for the Hickory aquifer but simulation data are not yet available. The 2002 Texas Water Plan indicates that the groundwater supply from the Hickory aquifer will steadily decline over several decades. The estimated supply decline is 9 percent, from 50,699 acre-feet per year (AFY) in 2000 to 46,133 AFY in 2050. Wells completed in the aquifer commonly yield as much as 1,000 gallons per minute (gpm) (USGS 2006).

The Ellenburger-San Saba aquifer crops out from Llano County in a circular pattern and dips radially into the subsurface of 12 adjacent counties. According to the spatial distribution provided by the 2002 Texas Water Plan, the aquifer outcrop covers western Burnet County, where the Bonanza Beach PWS is located, and the aquifer downdip extends throughout most of the county. Wells completed in the aquifer commonly yield between 200 and 500 gpm (USGS 2006). No GAM has yet been developed for the Ellenburger-San Saba aquifer. The 2002 Texas Water Plan estimates that current supply of this aquifer will remain near its current value of 22,580 AFY over the next 50 years.

4.2.3 Potential for New Surface Water Sources

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

There is a potential for development of a new surface water source for the PWS, as indicated by a November 2004 feasibility study of a Lake Buchanan Regional Water Project. The feasibility study included both the Bonanza Beach and Tow Village PWSs. The Bonanza Beach PWS, located east of the lake, would be tied to an expanded water treatment plant located in the community of Paradise Point via a pipeline that would run beneath Lake Buchanan.

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. LCRA Lake Buchanan Regional Water Project. The planned regional project would be implemented and the Bonanza Beach PWS would be connected to the proposed expanded LCRA surface water treatment plant at Paradise Point via a pipeline (Alternative BB-1).

2. City of Burnet. Treated water would be purchased from the City of Burnet to be used by the Bonanza Beach PWS. A pipeline would be constructed to convey water from the City of Burnet to Bonanza Beach (Alternative BB-2).

3. City of Granite Shoals. Treated water would be purchased from the City of Granite Shoals to be used by the Bonanza Beach PWS. A pipeline would be constructed to convey water from the City of Granite Shoals to Bonanza Beach (Alternative BB-3).

4. Deer Springs Water Company. A new groundwater well would be completed in the vicinity of the well at the Deer Springs Water Company PWS. A pipeline would be constructed and the water would be piped to the Bonanza Beach PWS (Alternative BB-4).

5. Granite Shoals Sherwood Shores III. A new groundwater well would be completed in the vicinity of the well at the Granite Shoals Sherwood Shores III PWS. A pipeline would be constructed and the water would be piped to the Bonanza Beach PWS (Alternative BB-5).

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 Bonanza Beach 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 Bonanza Beach. These alternatives are BB-6, BB-7, and BB-8.

4.3 TREATMENT OPTIONS

4.3.1 Centralized Treatment Systems

Centralized treatment of the well water is identified as a potential option. Ion exchange, WRT Z-88, and $KMnO_4$ treatment could all be potentially applicable. The central IX treatment alternative is BB-9, the central WRT Z-88 treatment alternative is BB-10, and the central $KMnO_4$ treatment alternative is BB-11.

4.3.2 Point-of-Use Systems

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

4.3.3 Point-of-Entry Systems

POE treatment using resin based adsorption technology or RO is valid for total radium removal. The POE treatment alternative is BB-13.

4.4 BOTTLED WATER

Providing bottled water is considered an interim measure to be used until a compliance alternative is implemented. Even though the community is small and people know each other; it would be reasonable to require a quarterly communication advising customers of the need to take advantage of the bottled water program. An alternative to providing delivered bottled water is to provide a central, publicly accessible dispenser for treated drinking water. Alternatives addressing bottled water are BB-14, BB-15, and BB-16.

4.5 ALTERNATIVE DEVELOPMENT AND ANALYSIS

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

4.5.1 Alternative BB-1: Lake Buchanan Regional Water Project

As described in Paragraph 4.2.1.1, this alternative involves implemented the proposal described in the *Engineering Feasibility Study for the Lake Buchanan Regional Water Project* (LCRA 2004). This proposal is a regional solution that involves the expansion of the existing surface water treatment plant at the Paradise Point PWS (ID# 1500008) on the west side of Lake Buchanan in Llano County, and the construction of pipelines to transfer the treated water to various surrounding PWSs, including the Bonanza Beach PWS.

By definition, this alternative provides a regional solution so the other PWSs involved would share the cost of the treatment plant upgrades and the pipeline construction.

The estimated capital cost for this alternative includes expanding the Paradise Point treatment plant, and constructing the associated pipeline and pump stations. These costs are apportioned between the participating systems, based on their number of metered connections as specified by LCRA (LCRA 2005). The estimated O&M cost for this alternative includes the maintenance cost for the pipelines, and power and O&M labor and materials for the pump stations. These costs were estimated by Parsons and apportioned between the participating systems based on their number of metered connections. The estimated capital cost for Bonanza Beach's share of this alternative is $846,510, and the alternative's estimated annual O&M cost is $47,022.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of the LCRA, 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 LCRA personnel currently operate pipelines and pump stations. Under this regional alternative, LCRA personnel would also be required to operate the expanded treatment plant at Paradise Point, which may represent a significant O&M effort and would likely necessitate operator training.

The implementation of this alternative at the costs estimated here would require the participation of all the planned PWSs.

4.5.2 Alternative BB-2: Purchase Treated Water from the City of Burnet

This alternative involves purchasing treated water from the City of Burnet, which will be used to supply the Bonanza Beach PWS. The City of Burnet currently has sufficient excess capacity for this alternative to be feasible, although any agreement to supply water would have to be negotiated and approved by the City Council. For purposes of this report, to allow direct and straightforward comparison with other alternatives, this alternative assumes that water would be purchased from the City. Also, it assumes that the Bonanza Beach PWS would obtain all its water from the City of Burnet.

This alternative would require constructing a pipeline from the City of Burnet water main to the existing storage tank for the Bonanza Beach PWS. A pump station would also be required to overcome pipe friction and the elevation differences between the two systems. The required pipeline would be approximately 11.2 miles long, and be constructed of 4-inch pipe.

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

By definition this alternative involves regionalization, since the Bonanza Beach PWS would be obtaining drinking water from an existing larger supplier. Also, other PWSs near Bonanza Beach are in need of compliant drinking water and could share in implementation of this alternative.

The estimated capital cost for this alternative includes constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost related to current operation of the Bonanza Beach PWS wells, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $2.47 million, and the alternatives' estimated annual O&M cost is $14,762.

The reliability of adequate amounts of compliant water under this alternative should be good. The City of Burnet provides treated surface water on a large scale, facilitating adequate O&M resources. From the perspective of the LCRA, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood. If the decision were made to perform blending, then the operational complexity would increase.

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

4.5.3 Alternative BB-3: Purchase Water from the City of Granite Shoals

This alternative involves purchasing compliant water from the City of Granite Shoals, which would be used to supply the Bonanza Beach PWS. The City has indicated that it does have excess production capacity and may be willing to consider selling water to other PWSs, assuming a suitable agreement could be negotiated.

This alternative would require constructing a pipeline from the City of Granite Shoals water main to the existing storage tank for the Bonanza Beach PWS. A pump station would also be required to overcome pipe friction and the elevation differences between the two systems. The required pipeline would be 27.8 miles long, and be constructed of 4-inch pipe.

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

By definition this alternative involves regionalization, since the Bonanza Beach PWS would be obtaining drinking water from an existing larger supplier. Also, other PWSs near Bonanza Beach are in need of compliant drinking water and could share in implementation of this alternative.

The estimated capital cost for this alternative includes constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost related to current operation of the Bonanza Beach PWS wells, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $5.99 million, and the alternatives' estimated annual O&M cost is $17,798.

The reliability of adequate amounts of compliant water under this alternative should be good. The City of Granite Shoals provides treated surface water on a large scale, facilitating adequate O&M resources. From the perspective of the LCRA, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood. If the decision were made to perform blending, then the operational complexity would increase.

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

4.5.4 Alternative BB-4: New Well in the Vicinity of Deer Springs Water Co.

This alternative involves completing a new well in the vicinity of the Deer Springs Water Company, and constructing a pump station and pipeline to transfer the pumped groundwater to the Bonanza Beach PWS. Based on the water quality data in the TCEQ database, it is expected that groundwater from this well would be compliant with drinking water MCLs. An agreement would need to be negotiated with Deer Springs Water Company to expand its well field.

This alternative would require completing a new well and storage tank in the vicinity of the Deer Springs Water Company well field, and constructing a pipeline from that well to an existing storage tank at the Bonanza Beach PWS. A pump station would also be required to overcome pipe friction and the elevation differences between the two systems. The new well would be 580 feet deep and the required pipeline would be constructed of 4-inch PVC pipe and would be 12.4 miles in length.

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

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

The estimated capital cost for this alternative includes completing the new well, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $2.79 million, and the alternative's estimated annual O&M cost is $13,932. If the purchased water was used for blending rather than for the full water supply, the annual O&M cost for this alternative could be reduced because of reduced pumping costs and reduced water purchase costs. However, additional costs would be incurred for equipment to ensure proper blending, and additional monitoring to ensure the finished water is compliant.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of the LCRA, 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 LCRA personnel currently operate pipelines and a pump station. If the decision were made to perform blending, then the operational complexity would increase.

The feasibility of this alternative would be dependent on LCRA being able to reach an agreement with the Deer Springs Water Company to install a new groundwater well.

4.5.5 Alternative BB-5: New Well at Granite Shoals Sherwood Shores III

This alternative involves completing a new well in the vicinity of the Granite Shoals Sherwood Shores III PWS, and constructing a pump station and pipeline to transfer the pumped groundwater to the Bonanza Beach PWS. Based on the water quality data in the TCEQ database, it is expected that groundwater from this well would be compliant with drinking water MCLs. An agreement would need to be negotiated with the City of Granite Shoals to expand the Granite Shoals Sherwood Shores III well field.

This alternative would require completing a new well and storage tank in the vicinity of the Granite Shoals Sherwood Shores III well field, and constructing a pipeline from that well to an existing storage tank at the Bonanza Beach PWS. A pump station would also be required to overcome pipe friction and the elevation differences between the two systems. The new well would be 70 feet deep and the required pipeline would be constructed of 4-inch PVC pipe and would be 16.1 miles in length.

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

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

The estimated capital cost for this alternative includes completing the new well, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $3.55 million, and the alternative's estimated annual O&M cost is $14,408. If the purchased water was used for blending rather than for the full water supply, the annual O&M cost for this alternative could be reduced because of reduced pumping costs and reduced water purchase costs. However, additional costs would be incurred for equipment to ensure proper blending, and additional monitoring to ensure the finished water is compliant.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of the LCRA, 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 LCRA personnel currently operate pipelines and a pump station. If the decision were made to perform blending, then the operational complexity would increase.

The feasibility of this alternative would be dependent on LCRA being able to reach an agreement with the City of Granite Shoals to install the new groundwater well.

4.5.6 Alternative BB-6: New Well at 10 miles

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

This alternative would require constructing one new 200-foot well, a new pump station with storage tank near the new well, and a pipeline from the new well/tank to the existing intake point for the Bonanza Beach PWS. The pump station and storage tank would be necessary to overcome pipe friction and changes in land elevation. For this alternative, the pipeline is assumed to be approximately 10 miles long, and would be a 4-inch PVC line that discharges to an existing storage tank at the Bonanza Beach PWS. The pump station would include two pumps, including one standby, and would be housed in a building.

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

The estimated capital cost for this alternative includes installing the wells, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes O&M for the pipeline and pump station, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing Bonanza Beach PWS wells. The estimated capital cost for this alternative is $2.25 million, and the estimated annual O&M cost for this alternative is $12,877.

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 LCRA, this alternative would be similar to operate as the existing system. LCRA personnel have 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 that an alternate groundwater source would not be found on land owned by LCRA, so landowner cooperation would likely be required.

4.5.7 Alternative BB-7: New Well at 5 miles

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

This alternative would require constructing one new 200-foot well, a new pump station with storage tank near the new well, and a pipeline from the new well/tank to the existing intake point for the Bonanza Beach PWS. The pump station and storage tank would be necessary to overcome pipe friction and changes in land elevation. For this alternative, the pipeline is assumed to be approximately 5 miles long, and would be a 4-inch PVC line that discharges to an existing storage tank at the Bonanza Beach PWS. The pump station would include two pumps, including one standby, and would be housed in a building.

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

The estimated capital cost for this alternative includes installing the well, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes O&M for the pipeline and pump station, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing Bonanza Beach PWS wells. The estimated capital cost for this alternative is $1.33 million, and the estimated annual O&M cost for this alternative is $11,442.

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 LCRA, this alternative would be similar to operate as the existing system. LCRA personnel have 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 an alternate groundwater source would not be found on land owned by LCRA, so landowner cooperation would likely be required.

4.5.8 Alternative BB-8: New Well at 1 mile

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

This alternative would require constructing one new 200-foot well and a pipeline from the new well/tank to the existing intake point for the Bonanza Beach PWS. For this alternative, the pipeline is assumed to be approximately 1 mile long, and would be a 4-inch PVC line that discharges to an existing storage tank at the Bonanza Beach PWS. The pump station would include two pumps, including one standby, and would be housed in a building.

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

The estimated capital cost for this alternative includes installing the well, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes O&M for the pipeline and pump station, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing Bonanza Beach PWS wells. The estimated capital cost for this alternative is $247,473, and the estimated annual O&M cost savings for this alternative are $8,198 by eliminating the two existing wells from the system.

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

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

4.5.9 Alternative BB-9: Central IX Treatment

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

The IX treatment plant, located at the Eden well field, features a 400 square foot (ft^2) building with a paved driveway; the pre-constructed IX equipment on a skid, a 24-inch x 50-inch commercial brine drum with regeneration equipment, two transfer pumps, a 6,000-gallon tank for storing spent backwash water, and a 2,000 gallon tank for storing regenerant waste. The spent backwash would be allowed to settle in the spent backwash tank, and the water would be recycled to the head of the plant, and there would be periodic disposal of accumulated sludge. The 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 $293,770, and the estimated annual O&M cost is $33,292.

Reliability of supply of adequate amounts of compliant water under this alternative is good, since IX treatment is a common and well-understood treatment technology. IX treatment does not require high pressure, but can be affected by interfering constituents in the water. The

O&M efforts required for the central IX treatment plant may be significant, and operating personnel would require training with ion exchange.

4.5.10 Alternative BB10: Central WRT Z-88 Treatment

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

This alternative consists of constructing the Z-88 treatment system at the existing well field. WRT owns the Z-88 equipment and the City pays for the installation of the system and auxiliary facilities. The plant comprises a 500 ft^2 building with a paved driveway; the pre-constructed Z-88 adsorption system (2- 30" diameter x 72" tall vessels) owned by WRT; and piping system. The entire facility is fenced. The treated water will be chlorinated prior to distribution. It is assumed that the well pumps have adequate pressure to pump the water through the Z-88 system and to the distribution system without requiring new pumps.

The estimated capital cost for this alternative is $267,380 and the annual O&M cost is estimated to be $37,794.

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

4.5.11 Alternative BB-11: Central $KMnO_4$ Treatment

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

The greensand plant, located at the Bonanza Beach PWS well field, features a 400 ft^2 building with a paved driveway; the pre-constructed filters and a $KMnO_4$ solution tank on a skid; a 10,000 gallon spent backwash tank, and piping systems. The spent backwash would be allowed to settle in the spent backwash tank, and the water would be recycled to the head of the plant, and there would be periodic disposal of accumulated sludge. The entire facility is fenced.

The estimated capital cost for this alternative is $345,680 and the annual O&M is estimated to be $36,315.

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

4.5.12 Alternative BB-12: Point-of-Use Treatment

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

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

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

This alternative does not present options for a shared solution.

The estimated capital cost for this alternative includes the cost to purchase and install the POU treatment systems. The estimated O&M cost for this alternative includes the purchase and replacement of filters and media or membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $36,960, and the estimated annual O&M cost for this alternative is $40,600. For the cost estimate, it is assumed that one POU treatment unit will be required for each metered connection in the Bonanza Beach PWS. It should be noted that the POU treatment units would need to be more complex than units typically found in commercial retail outlets in order to meet regulatory requirements, making purchase and installation more expensive.

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

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

4.5.13 Alternative BB-13: Point-of-Entry Treatment

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

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

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

This alternative does not present options for a shared solution.

The estimated capital cost for this alternative includes cost to purchase and install the POE treatment systems. The estimated O&M cost for this alternative includes the purchase and replacement of filters and media or membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $646,800, and the estimated annual O&M cost for this alternative is $84,000. For the cost estimate, it is assumed that one POU treatment unit will be required for each metered connection at Bonanza Beach.

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

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

4.5.14 Alternative BB-14: Public Dispenser for Treated Drinking Water

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

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

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing and installing the treatment system to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes purchasing and replacing filters and media or membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $11,600, and the estimated annual O&M cost for this alternative is $20,300.

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 Bonanza Beach PWS has not provided this type of service in the past. From the perspective of the LCRA, 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 BB-15: 100 Percent Bottled Water Delivery

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

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

This alternative does not present options for a regional solution.

The estimated initial capital cost is for setting up the program. The estimated O&M cost for this alternative includes program administration and purchase of the bottled water. The estimated capital cost for this alternative is $31,920, and the estimated annual O&M cost for this alternative is $113,410. For the cost estimate, it is assumed that each person requires one gallon of bottled water per day.

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

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

4.5.16 Alternative BB-16: Public Dispenser for Trucked Drinking Water

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

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

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

The estimated capital cost for this alternative includes purchasing a water truck and construction of the storage tank to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes O&M for the truck, maintenance for the tank, water quality testing, record keeping, and water purchase, The estimated capital cost for this alternative is $102,986, and the estimated annual O&M cost for this alternative is $20,634.

The reliability of adequate amounts of compliant water under this alternative is fair because of the large amount of effort required from the customers and the associated inconvenience. Current personnel have not provided this type of service in the past. From the perspective of the LCRA, 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 Bonanza Beach PWS.

Table 4.3 Summary of Compliance Alternatives for Bonanza Beach PWS

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
BB-1	Lake Buchanan Regional Water Project	- Expanded STP - Pump station - Shared pipeline	$846,510	$47,022	$120,825	Good	N	Regional solution under consideration by LCRA. Requires expansion of Paradise Point STP.
BB-2	Purchase water from City of Burnet	- Pump station - Storage tank - 11-mile pipeline	$2,468,874	$14,762	$230,010	Good	N	Agreement must be successfully negotiated with the City of Burnet. Blending may be possible. Costs could possibly be shared with small systems along pipeline route.
BB-3	Purchase water from City of Granite Shoals	- Pump station - Storage tank - 28-mile pipeline	$5,991,720	$17,798	$540,184	Good	N	Agreement must be successfully negotiated with the City of Granite Shoals. Blending may bet possible. Costs could possibly be shared with small systems along pipeline route.
BB-4	New well at Deer Springs Water Company	- New well - Pump station - Storage tank - 12-mile pipeline	$2,792,925	$13,932	$257,432	Good	N	Agreement must be successfully negotiated with the Deer Springs Water Company. Blending may be possible. Costs could possibly be shared with small systems along pipeline route.
BB-5	New well at Granite Shoals Sherwood Shores III	- New well - Pump station - Storage tank - 16-mile pipeline	$3,546,570	$14,408	$323,614	Good	N	Agreement must be successfully negotiated with City of Granite Shoals. Blending may be possible. Costs could possibly be shared with small systems along pipeline route.
BB-6	Install new compliant well within 10 miles	- New well - Storage tank - Pump station - 10-mile pipeline	$2,250,075	$12,877	$209,049	Good	N	May be difficult to find well with good water quality. Costs could possibly be shared with small systems along pipeline route.
BB-7	Install new compliant well within 5 miles	- New well - Storage tank - Pump station - 5-mile pipeline	$1,325,185	$11,442	$126,977	Good	N	May be difficult to find well with good water quality. Costs could possibly be shared with small systems along pipeline route.
BB-8	Install new compliant well within 1 mile	- New well - Storage tank - Pump station - 1-mile pipeline	$247,473	$(8,198)	$13,378	Good	N	May be difficult to find well with good water quality.
BB-9	Continue operation of Bonanza Beach well field with central IX treatment	- Central IX treatment plant	$293,770	$33,292	$58,904	Good	T	Costs could possibly be shared with nearby small systems.
BB-10	Continue operation of Bonanza Beach well field with central WRT Z-88 treatment	- Central WRT Z-88 treatment plant	$267,380	$37,794	$61,105	Good	T	Costs could possibly be shared with nearby small systems.
BB-11	Continue operation of Bonanza Beach well field with central $KMnO_4$ treatment	- Central $KMnO_4$ treatment plant	$345,680	$36,315	$66,452	Good	T	Costs could possibly be shared with nearby small systems.

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
BB-12	Continue operation of Bonanza Beach well field, and POU treatment	- POU treatment units.	$36,960	$40,600	$43,822	Fair	T, M	Only one compliant tap in home. Cooperation of residents required for installation, maintenance, and testing.
BB-13	Continue operation of Bonanza Beach well field, and POE treatment	- POE treatment units.	$646,800	$84,000	$140,391	Fair (*better than POU*)	T, M	All home taps compliant and less resident cooperation required.
BB-14	Continue operation of Bonanza Beach well field, but furnish public dispenser for treated drinking water	- Water treatment and dispenser unit	$11,600	$20,300	$21,311	Fair/interim measure	T	INTERIM SOLUTION: Does not provide compliant water to all taps, and requires a lot of effort by customers.
BB-15	Continue operation of Bonanza Beach well field, but furnish bottled drinking water for all customers	- Set up bottled water system	$31,920	$113,410	$116,193	Fair/interim measure	M	INTERIM SOLUTION: Does not provide compliant water to all taps, and requires customers to order and use. Management of program may be significant.
BB-16	Continue operation of Bonanza Beach well field, but furnish public dispenser for trucked drinking water.	- Construct storage tank and dispenser - Purchase potable water truck	$102,986	$20,634	$29,613	Fair/interim measure	M	INTERIM SOLUTION: Does not provide compliant water to all taps, and requires a lot of effort by customers.

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

4.6 COST OF SERVICE AND FUNDING ANALYSIS

To evaluate the financial impact of implementing the compliance alternatives, a 30-year financial planning model was developed. This model can be found in Appendix D. The financial model is based on estimated cash flows, with and without implementation of the compliance alternatives. Data for such models are typically derived from established budgets, audited financial reports, published water tariffs, and consumption data. Information that was available to complete the financial analysis included consolidated 2005 revenues and expenses for the water and sewer districts and current water rates for the Bonanza Beach Water Association PWS (Bonanza Beach PWS) provided by the Lower Colorado River Authority (LCRA). The Bonanza Beach PWS customers use on average 281 gpd per connection.

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

Total revenues reported by LCRA for Bonanza Beach PWS were $36,429/year based on the extrapolation of 9 months of 2005 fiscal year data. Water sales accounted for 92.8 percent of the total revenues generated, or $33,817. The water base rate is $43.00 per month for single family dwellings.

The basic monthly water charge of includes an allowance of 2,000 gallons of water. LCRA employs a tiered water usage rate structure of $3.50 per 1,000 gallons from 2001 to 10,000 gallons, $4.50 per 1,000 gallons from 10,000 gallons. These values were entered into the financial model.

Total Expenses reported by LCRA for Bonanza Beach were estimated to be $30,445/year based on the extrapolation of 9 months of 2005 fiscal year data.

4.6.2 Current Financial Condition

4.6.2.1 Cash Flow Needs

Using the base rate and water usage rates as noted above, the current average annual water bill for LCRA's Bonanza Beach PWS customers is estimated at $690.24 or about 1.8 percent of the Bonanza Beach County Block Group MHI of $37,892.

LCRA's FY 2005 Financial Report reveals that the consolidated revenues are greater than the consolidated expenses. The long-term financial plan indicates that Bonanza Beach PWS has a cash reserve sufficient to maintain operations. However, Bonanza Beach PWS will likely need to raise rates in the future to pay for any capital improvements.

4.6.2.2 Ratio Analysis

The following ratios were based on the financial data of the LCRA water services and not Bonanza Beach, since it will be LCRA which will be implementing and financing any treatment alternatives.

Current Ratio= Not available

The Current Ratio is a measure of liquidity. Information was not available to calculate the current ratio for LCRA's water services.

Debt to Net Worth Ratio=Not available

A Debt to Net Worth ratio is another measure of financial liquidity and stability. Information was not available to calculate the debt to net worth ratio for LCRA's water services.

Operating Ratio = 1.18

In 2005 LCRA had operating revenues of $802,624,000 and operating expenses of $680,470,000 resulting in an Operating Ratio equal to 1.18. Thus, for fiscal year 2005 the actual operating revenues were sufficient to cover the operating expenses and return an income of nearly 18 percent.

4.6.3 Financial Plan Results

Each of the compliance alternatives for the Bonanza Beach Water Association was evaluated using the financial model to determine the overall increase in water rates that would be necessary to pay for the improvements. Each alternative was examined under the various funding options described in Subsection 2.4.

For State Revolving Fund (SRF) funding options, customer MHI compared to the state average determines the availability of subsidized loans. According the 2000 U.S. Census data, the Block group MHI for customers of LCRA in Bonanza Beach was $37,892, which is 95 percent of the statewide income average of $39,927. Consequently, Bonanza Beach District may qualify for a loan at an interest rate of 3.8 percent from the SRF.

The financial model results are summarized in Table 4.4. Table 4.4 presents rate impacts assuming that any deficiencies in reserve accounts are funded immediately in the year following the occurrence of the deficiency, which would cause the first few years' water rates to be higher than they would be if the reserve account was built-up over a longer period of time. Figure 4.2 shows that the current estimated average annual bill for Bonanza Beach customers of $690.24 is just sufficient to fully fund existing operations. Figure 4.2 provides a bar chart that in terms of the yearly billing to an average customer (7,643 gallons/month consumption), shows the following:

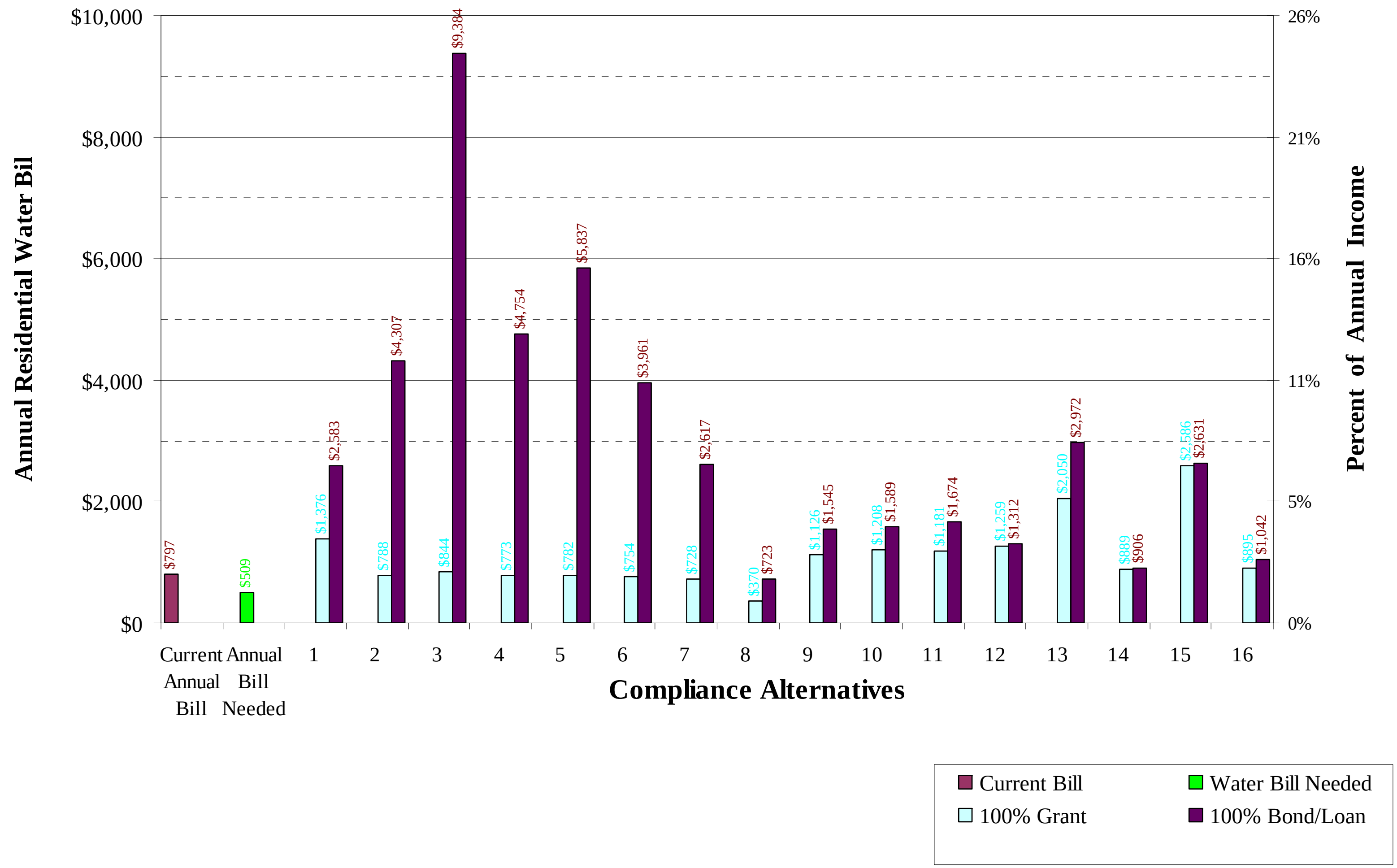
- Current annual average bill,
- Projected annual average bill including rate increase, if needed, to match existing expenditures, and
- Projected annual bill including rate increases needed to fund implementation of a compliance alternative (this does not include funding for reserve accounts).

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

Table 4.4 Financial Impact on Households

Alternative	Description		All Revenue	100% Grant	75% Grant	50% Grant	SRF	Bond
1	Lake Buchanan Regional Water Project	Max % of HH Income	43%	7%	8%	10%	12%	13%
		Max % Rate Increase Compared to Current	1954%	213%	288%	364%	479%	516%
		Average Water Bill Required by Alternative	$ 15,340	$ 2,256	$ 2,811	$ 3,365	$ 4,207	$ 4,475
2	City of Burnet	Max % of HH Income	119%	3%	8%	12%	19%	22%
		Max % Rate Increase Compared to Current	5577%	41%	261%	482%	817%	924%
		Average Water Bill Required by Alternative	$ 42,376	$ 1,039	$ 2,657	$ 4,275	$ 6,729	$ 7,510
3	City of Granite Shoals	Max % of HH Income	289%	3%	15%	26%	43%	48%
		Max % Rate Increase Compared to Current	13640%	57%	593%	1128%	1941%	2200%
		Average Water Bill Required by Alternative	$ 102,484	$ 1,154	$ 5,080	$ 9,006	$ 14,961	$ 16,858
4	New Well at Deer Springs Water Co.	Max % of HH Income	135%	3%	8%	13%	21%	24%
		Max % Rate Increase Compared to Current	6316%	36%	286%	536%	915%	1035%
		Average Water Bill Required by Alternative	$ 47,883	$ 1,008	$ 2,838	$ 4,668	$ 7,444	$ 8,328
5	New Well at Granite Shoals Sherwood Shores III	Max % of HH Income	171%	3%	10%	16%	26%	30%
		Max % Rate Increase Compared to Current	8040%	39%	356%	673%	1154%	1307%
		Average Water Bill Required by Alternative	$ 60,739	$ 1,026	$ 3,350	$ 5,674	$ 9,199	$ 10,321
6	New Well at 10 Miles	Max % of HH Income	109%	3%	7%	11%	18%	20%
		Max % Rate Increase Compared to Current	5072%	31%	232%	433%	738%	835%
		Average Water Bill Required by Alternative	$ 38,610	$ 968	$ 2,443	$ 3,917	$ 6,153	$ 6,866
7	New Well at 5 Miles	Max % of HH Income	64%	3%	5%	8%	11%	13%
		Max % Rate Increase Compared to Current	2954%	23%	141%	260%	440%	497%
		Average Water Bill Required by Alternative	$ 22,816	$ 914	$ 1,782	$ 2,651	$ 3,968	$ 4,387
8	New Well at 1 Mile	Max % of HH Income	12%	2%	2%	2%	2%	2%
		Max % Rate Increase Compared to Current	478%	0%	0%	0%	0%	7%
		Average Water Bill Required by Alternative	$ 4,363	$ 797	$ 797	$ 797	$ 797	$ 822
9	Central Treatment - IX	Max % of HH Income	16%	5%	6%	6%	7%	7%
		Max % Rate Increase Compared to Current	654%	139%	166%	192%	232%	245%
		Average Water Bill Required by Alternative	$ 5,655	$ 1,738	$ 1,931	$ 2,123	$ 2,415	$ 2,508
10	Central Treatment - WRT Z-88	Max % of HH Income	15%	6%	6%	7%	7%	8%
		Max % Rate Increase Compared to Current	606%	164%	187%	211%	248%	259%
		Average Water Bill Required by Alternative	$ 5,291	$ 1,908	$ 2,083	$ 2,258	$ 2,524	$ 2,609
11	Central Treatment - KMnO4	Max % of HH Income	19%	5%	6%	7%	8%	8%
		Max % Rate Increase Compared to Current	781%	156%	187%	217%	264%	279%
		Average Water Bill Required by Alternative	$ 6,597	$ 1,852	$ 2,079	$ 2,305	$ 2,649	$ 2,758
12	Point-of-Use Treatment	Max % of HH Income	6%	6%	6%	6%	6%	6%
		Max % Rate Increase Compared to Current	178%	178%	182%	185%	190%	192%
		Average Water Bill Required by Alternative	$ 2,057	$ 2,014	$ 2,038	$ 2,062	$ 2,099	$ 2,111
13	Point-of-Entry Treatment	Max % of HH Income	36%	11%	12%	13%	15%	16%
		Max % Rate Increase Compared to Current	1596%	410%	468%	526%	613%	641%
		Average Water Bill Required by Alternative	$ 12,646	$ 3,651	$ 4,075	$ 4,498	$ 5,141	$ 5,346
14	Public Dispenser for Treated Drinking Water	Max % of HH Income	4%	4%	4%	4%	4%	4%
		Max % Rate Increase Compared to Current	70%	70%	71%	72%	74%	74%
		Average Water Bill Required by Alternative	$ 1,262	$ 1,248	$ 1,256	$ 1,263	$ 1,275	$ 1,279
15	Supply Bottled Water to 100% of Population	Max % of HH Income	14%	14%	14%	14%	14%	14%
		Max % Rate Increase Compared to Current	567%	567%	570%	573%	577%	578%
		Average Water Bill Required by Alternative	$ 4,798	$ 4,760	$ 4,781	$ 4,802	$ 4,834	$ 4,844
16	Central Trucked Drinking Water	Max % of HH Income	6%	4%	4%	4%	4%	4%
		Max % Rate Increase Compared to Current	184%	72%	81%	90%	104%	109%
		Average Water Bill Required by Alternative	$ 2,159	$ 1,261	$ 1,328	$ 1,396	$ 1,498	$ 1,531

Figure 4-2 Alternative Cost Summary



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

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

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

Electrical power cost is estimated to be $0.136 per kWh. The annual cost for power to a pump station is calculated based on the pumping head and volume, and includes 11,800 kWH for pump building heating, cooling, and lighting, as recommended in USEPA publication, *Standardized Costs for Water Supply Distribution Systems* (1992).

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

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

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

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

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

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

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

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

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

Table B.1
Summary of General Data
LCRA Bonanza Beach Water Association
PWS # 0270018
General PWS Information

Service Population 143
Total PWS Daily Water Usage 0.016 (mgd)
Number of Connections 56
Source LCRA Flow Data

Unit Cost Data
Central Texas

General Items	Unit	Unit Cost
Treated water purchase cost	*See alternative*	
Water purchase cost (trucked)	$/1,000 gals	$ 1.80
Contingency	20%	n/a
Engineering & Constr. Management	25%	n/a
Procurement/admin (POU/POE)	20%	n/a

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

Pump Station Unit Costs	Unit	Unit Cost
Pump	EA	$ 7,500
Pump Station Piping, 04"	EA	$ 4,000
Gate valve, 04"	EA	$ 460
Check valve, 04"	EA	$ 540
Electrical/Instrumentation	EA	$ 10,000
Site work	EA	$ 2,000
Building pad	EA	$ 4,000
Pump Building	EA	$ 10,000
Fence	EA	$ 5,870
Tools	EA	$ 1,000

Well Installation Unit Costs	Unit	Unit Cost
Well installation	*See alternative*	
Water quality testing	EA	$ 1,500
Well pump	EA	$ 7,500
Well electrical/instrumentation	EA	$ 5,000
Well cover and base	EA	$ 3,000
Piping	EA	$ 2,500
Storage Tank - 10,000 gals	EA	$ 19,900
Electrical Power	$/kWH	$ 0.136
Building Power	kWH	11,800
Labor	$/hr	$ 40
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	$ 40

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	$ 53
Bottled water cost (inc. delivery)	gallon	$ 1.60
Water use, per capita per day	gpcd	1.0
Bottled water program materials	EA	$ 5,000
Storage Tank - 5,000 gals	EA	$ 7,025
Site improvements	EA	$ 4,000
Potable water truck	EA	$ 60,000
Water analysis, per sample	EA	$ 100
Potable water truck O&M costs	$/mile	$ 1.00

Central Treatment Unit Costs	Unit	Unit Cost
General		
Site preparation	acre	$ 4,000
Slab	CY	$ 1,000
Building	SF	$ 60
Building electrical	SF	$ 8.00
Building plumbing	SF	$ 8.00
Heating and ventilation	SF	$ 7.00
Fence	LF	$ 15
Paving	SF	$ 2.00
Chlorination point	EA	$ 2,000
Building power	kwh/yr	$ 0.095
Equipment power	kwh/yr	$ 0.095
Labor, O&M	hr	$ 40
Analyses	test	$ 200
Ion exchange		
Electrical	JOB	$ 50,000
Piping	JOB	$ 20,000
Ion exchange package plant	UNIT	$ 30,000
Transfer pumps (10 hp)	EA	$ 5,000
Clean water tank	gal	$ 1.00
Regenerant tank	gal	$ 1.50
Backwash tank	gal	$ 2.00
Sewer connection fee	EA	$ 15,000
Ion exchange materials	year	$ 1,000
Ion exchange chemicals	year	$ 1,000
Backwash discharge to sewer	kgal/year	$ 5.00
Waste haulage truck rental	days	$ 700
Mileage charge	mile	$ 1.00
Waste disposal fee	kgal/yr	$ 200
WRT Z-88 package		
Electrical	JOB	$ 50,000
Piping	JOB	$ 20,000
WRT Z-88 package plant	UNIT	$ 45,000
(Initial setup *cost for WRT Z-88 package*)		
WRT treated water charge	1,000 gal/yr	$ 3.00
KMnO4-greensand package		
Electrical	JOB	$ 50,000
Piping	JOB	$ 20,000
KMnO4-greensand package plant	UNIT	$ 80,000
Backwash tank	gal	$ 2.00
Sewer connection fee	EA	$ 15,000
KMnO4-greensand materials	year	$ 3,000
KMnO4-greensand chemicals	year	$ 2,000
Backwash discharge to sewer	1,000 gal/yr	$ 5.00
Sludge truck rental	days	$ 700
Sludge truck mileage fee	miles	$ 1.00
Sludge disposal fee	1,000 gal/yr	$ 200

APPENDIX C
COMPLIANCE ALTERNATIVE CONCEPTUAL COST ESTIMATES

This appendix presents the conceptual cost estimates developed for the compliance alternatives. The conceptual cost estimates are given in Tables C.1 through C.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 *LCRA Bonanza Beach Water Association*
Alternative Name *Lake Buchanan Regional Water Project*
Alternative Number *BB-1*

Source of Capital Costs Response to comments from the TWDB. Prepared for LCRA by Alan Plummer Assoc. Apr 26, 2005.
Source of WTP and Waste Disposal O&M Parsons cost estimate
Source of Pump Station O&M Parsons cost estimate (Based on assumption of 33% of pump station capital cost)
Source of Pipeline O&M Parsons cost estimate (based on $200/mile/yr standard, $600/mile/yr under lake)

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Construction Costs				
WTP improvements	1	EA	$ 146,100	$ 146,100
Elevated storage	1	EA	$ 17,000	$ 17,000
Ground storage	1	EA	$ -	$ -
Subtotal				**$ 163,100**
Water Transmission Costs				
Distribution lines	1	EA	$ 11,200	$ 11,200
Transmission lines	1	EA	$ 353,000	$ 353,000
Pump Station	1	EA	$ 56,500	$ 56,500
Subtotal				**$ 420,700**
Subtotal of Component Costs				**$ 583,800**
Contingency	20%			$ 116,760
Design & Constr Management	25%			$ 145,950
TOTAL CAPITAL COSTS				**$ 846,510**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Treatment Plant O&M				
Building Power	2,117	kwh/yr	$ 0.136	$ 288
Equipment Power	6,352	kwh/yr	$ 0.136	$ 864
Labor	440	Hrs	$ 40.00	$ 17,615
Materials	1	EA	$ 2,117	$ 2,117
Chemicals	1	EA	$ 2,117	$ 2,117
Analyses	1	test	$ 2,117	$ 2,117
Subtotal				**$ 25,118**
Waste Disposal				
Sludge Disposal	24	tons/yr	$ 110	$ 2,678
CIP Waste Disposal			$ 2,000	$ 212
Subtotal				**$ 2,890**
Water Transmission O&M				
Pump Station O&M	33%	Cost	$ 56,500	$ 18,645
Pipeline O&M				$ 369
Subtotal				**$ 19,014**
Subtotal of Component Costs				**$ 47,022**
TOTAL CAPITAL COSTS				**$ 47,022**

Table C.2

PWS Name	***LCRA Bonanza Beach Water Association***
Alternative Name	***City of Burnet***
Alternative Number	***BB-2***

Distance from Alternative to PWS (along pipe)	11.2	miles
Total PWS annual water usage	5.731	MG
Treated water purchase cost	$ 1.60	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	17	n/a	n/a	n/a
PVC water line, Class 200, 04"	59,051	LF	$ 26.50	$ 1,564,852
Bore and encasement, 10"	-	LF	$ 60.00	$ -
Open cut and encasement, 10"	850	LF	$ 35.00	$ 29,750
Gate valve and box, 04"	12	EA	$ 395.00	$ 4,665
Air valve	11	EA	$ 1,000.00	$ 11,000
Flush valve	12	EA	$ 750.00	$ 8,858
Metal detectable tape	59,051	LF	$ 0.15	$ 8,858
Subtotal				**$ 1,627,982**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 460	$ 1,840
Check valve, 04"	2	EA	$ 540	$ 1,080
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 10,000 gals	1	EA	$ 19,900	$ 19,900
Subtotal				**$ 74,690**
Subtotal of Component Costs				**$ 1,702,672**
Contingency	20%			$ 340,534
Design & Constr Management	25%			$ 425,668
TOTAL CAPITAL COSTS				**$ 2,468,874**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	11.2	mile	$ 200	$ 2,237
Subtotal				**$ 2,237**
Water Purchase Cost				
City of Burnet	5,731	1,000 gal	$ 1.60	$ 9,169
Subtotal				**$ 9,169**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	13,074	kWH	$ 0.136	$ 1,778
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 40	$ 14,600
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 20,183**
O&M Credit for Existing Well Closure				
Pump power	192	kWH	$ 0.136	$ (26)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 40	$ (14,400)
Subtotal				**$ (16,826)**
TOTAL ANNUAL O&M COSTS				**$ 14,762**

Table C.3

PWS Name *LCRA Bonanza Beach Water Association*
Alternative Name *City of Granite Shoals*
Alternative Number *BB-3*

Distance from Alternative to PWS (along pipe)	27.8	miles
Total PWS annual water usage	5.731	MG
Treated water purchase cost	$ 1.60	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	1	n/a	n/a	n/a
Number of Crossings, open cut	40	n/a	n/a	n/a
PVC water line, Class 200, 04"	146,863	LF	$ 26.50	$ 3,891,870
Bore and encasement, 10"	200	LF	$ 60.00	$ 12,000
Open cut and encasement, 10"	2,000	LF	$ 35.00	$ 70,000
Gate valve and box, 04"	29	EA	$ 395.00	$ 11,602
Air valve	28	EA	$ 1,000.00	$ 28,000
Flush valve	29	EA	$ 750.00	$ 22,029
Metal detectable tape	146,863	LF	$ 0.15	$ 22,029
Subtotal				**$ 4,057,531**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 460	$ 1,840
Check valve, 04"	2	EA	$ 540	$ 1,080
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 10,000 gals	1	EA	$ 19,900	$ 19,900
Subtotal				**$ 74,690**
Subtotal of Component Costs				**$ 4,132,221**
Contingency	20%			$ 826,444
Design & Constr Management	25%			$ 1,033,055
TOTAL CAPITAL COSTS				**$ 5,991,720**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	27.8	mile	$ 200	$ 5,563
Subtotal				**$ 5,563**
Water Purchase Cost				
City of Granite Sh	5,731	1,000 gal	$ 1.60	$ 9,169
Subtotal				**$ 9,169**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	10,940	kWH	$ 0.136	$ 1,488
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 40	$ 14,600
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 19,893**
O&M Credit for Existing Well Closure				
Pump power	192	kWH	$ 0.136	$ (26)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 40	$ (14,400)
Subtotal				**$ (16,826)**
TOTAL ANNUAL O&M COSTS				**$ 17,798**

Table C.4

PWS Name *LCRA Bonanza Beach Water Association*
Alternative Name *New Well at Deer Springs Water Co.*
Alternative Number *BB-4*

Distance from PWS to new well location	12.35	miles
Estimated well depth	580	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	3	n/a	n/a	n/a
Number of Crossings, open cut	9	n/a	n/a	n/a
PVC water line, Class 200, 04"	65,189	LF	$ 26.50	$ 1,727,509
Bore and encasement, 10"	600	LF	$ 60.00	$ 36,000
Open cut and encasement, 10"	450	LF	$ 35.00	$ 15,750
Gate valve and box, 04"	13	EA	$ 395.00	$ 5,150
Air valve	12	EA	$ 1,000.00	$ 12,000
Flush valve	13	EA	$ 750.00	$ 9,778
Metal detectable tape	65,189	LF	$ 0.15	$ 9,778
Subtotal				**$ 1,815,965**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 460	$ 1,840
Check valve, 04"	2	EA	$ 540	$ 1,080
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 10,000 gals	1	EA	$ 19,900	$ 19,900
Subtotal				**$ 74,690**
Well Installation				
Well installation	580	LF	$ 25	$ 14,500
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 35,500**
Subtotal of Component Costs				**$ 1,926,155**
Contingency	20%			$ 385,231
Design & Constr Management	25%			$ 481,539
TOTAL CAPITAL COSTS				**$ 2,792,925**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	12.3	mile	$ 200	$ 2,469
Subtotal				**$ 2,469**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	10,316	kWH	$ 0.136	$ 1,403
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 40	$ 14,600
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 19,808**
Well O&M				
Pump power	594	kWH	$ 0.136	$ 81
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 40	$ 7,200
Subtotal				**$ 8,481**
O&M Credit for Existing Well Closure				
Pump power	192	kWH	$ 0.136	$ (26)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 40	$ (14,400)
Subtotal				**$ (16,826)**
TOTAL ANNUAL O&M COSTS				**$ 13,932**

Table C.5

PWS Name *LCRA Bonanza Beach Water Association*
Alternative Name *New Well at Granite Shoals Sherwood Shores III*
Alternative Number *BB-5*

Distance from PWS to new well location	16.09	miles
Estimated well depth	70	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	1	n/a	n/a	n/a
Number of Crossings, open cut	21	n/a	n/a	n/a
PVC water line, Class 200, 04"	84,963	LF	$ 26.50	$ 2,251,520
Bore and encasement, 10"	200	LF	$ 60.00	$ 12,000
Open cut and encasement, 10"	1,050	LF	$ 35.00	$ 36,750
Gate valve and box, 04"	17	EA	$ 395.00	$ 6,712
Air valve	16	EA	$ 1,000.00	$ 16,000
Flush valve	17	EA	$ 750.00	$ 12,744
Metal detectable tape	84,963	LF	$ 0.15	$ 12,744
Subtotal				**$ 2,348,470**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 460	$ 1,840
Check valve, 04"	2	EA	$ 540	$ 1,080
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 10,000 gals	1	EA	$ 19,900	$ 19,900
Subtotal				**$ 74,690**
Well Installation				
Well installation	70	LF	$ 25	$ 1,750
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 22,750**
Subtotal of Component Costs				**$ 2,445,910**
Contingency	20%			$ 489,182
Design & Constr Management	25%			$ 611,478
TOTAL CAPITAL COSTS				**$ 3,546,570**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	16.1	mile	$ 200	$ 3,218
Subtotal				**$ 3,218**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	8,832	kWH	$ 0.136	$ 1,201
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 40	$ 14,600
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 19,606**
Well O&M				
Pump power	72	kWH	$ 0.136	$ 10
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 40	$ 7,200
Subtotal				**$ 8,410**
O&M Credit for Existing Well Closure				
Pump power	192	kWH	$ 0.136	$ (26)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 40	$ (14,400)
Subtotal				**$ (16,826)**
TOTAL ANNUAL O&M COSTS				**$ 14,408**

Table C.6

PWS Name *LCRA Bonanza Beach Water Association*
Alternative Name *New Well at 10 Miles*
Alternative Number *BB-6*

Distance from PWS to new well location	10.0	miles
Estimated well depth	200	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	1	n/a	n/a	n/a
Number of Crossings, open cut	13	n/a	n/a	n/a
PVC water line, Class 200, 04"	52,800	LF	$ 26.50	$ 1,399,200
Bore and encasement, 10"	200	LF	$ 60.00	$ 12,000
Open cut and encasement, 10"	650	LF	$ 35.00	$ 22,750
Gate valve and box, 04"	11	EA	$ 395.00	$ 4,171
Air valve	10	EA	$ 1,000.00	$ 10,000
Flush valve	11	EA	$ 750.00	$ 7,920
Metal detectable tape	52,800	LF	$ 0.15	$ 7,920
Subtotal				**$ 1,463,961**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 460	$ 1,840
Check valve, 04"	2	EA	$ 540	$ 1,080
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 10,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 61,815**
Well Installation				
Well installation	200	LF	$ 25	$ 5,000
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 26,000**

Subtotal of Component Costs			**$ 1,551,776**
Contingency	20%		$ 310,355
Design & Constr Management	25%		$ 387,944
TOTAL CAPITAL COSTS			**$ 2,250,075**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	10.0	mile	$ 200	$ 2,000
Subtotal				**$ 2,000**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	6,400	kWH	$ 0.136	$ 870
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 40	$ 14,600
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 19,275**
Well O&M				
Pump power	205	kWH	$ 0.136	$ 28
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 40	$ 7,200
Subtotal				**$ 8,428**
O&M Credit for Existing Well Closure				
Pump power	192	kWH	$ 0.136	$ (26)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 40	$ (14,400)
Subtotal				**$ (16,826)**

TOTAL ANNUAL O&M COSTS **$ 12,877**

Table C.7

PWS Name *LCRA Bonanza Beach Water Association*
Alternative Name *New Well at 5 Miles*
Alternative Number *BB-7*

Distance from PWS to new well location	5.0	miles
Estimated well depth	200	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	6	n/a	n/a	n/a
PVC water line, Class 200, 04"	26,400	LF	$ 26.50	$ 699,600
Bore and encasement, 10"	1,800	LF	$ 60.00	$ 108,000
Open cut and encasement, 10"	100	LF	$ 35.00	$ 3,500
Gate valve and box, 04"	5	EA	$ 395.00	$ 2,086
Air valve	5	EA	$ 1,000.00	$ 5,000
Flush valve	5	EA	$ 750.00	$ 3,960
Metal detectable tape	26,400	LF	$ 0.15	$ 3,960
Subtotal				**$ 826,106**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 460	$ 1,840
Check valve, 04"	2	EA	$ 540	$ 1,080
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 10,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 61,815**
Well Installation				
Well installation	200	LF	$ 25	$ 5,000
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 26,000**
Subtotal of Component Costs				**$ 913,921**
Contingency	20%			$ 182,784
Design & Constr Management	25%			$ 228,480
TOTAL CAPITAL COSTS				**$ 1,325,185**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	5.0	mile	$ 200	$ 1,000
Subtotal				**$ 1,000**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	3,200	kWH	$ 0.136	$ 435
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 40	$ 14,600
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 18,840**
Well O&M				
Pump power	205	kWH	$ 0.136	$ 28
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 40	$ 7,200
Subtotal				**$ 8,428**
O&M Credit for Existing Well Closure				
Pump power	192	kWH	$ 0.136	$ (26)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 40	$ (14,400)
Subtotal				**$ (16,826)**
TOTAL ANNUAL O&M COSTS				**$ 11,442**

Table C.8

PWS Name	***LCRA Bonanza Beach Water Association***
Alternative Name	***New Well at 1 Mile***
Alternative Number	***BB-8***

Distance from PWS to new well location	1.0	miles
Estimated well depth	200	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	0	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	1	n/a	n/a	n/a
PVC water line, Class 200, 04"	5,280	LF	$ 26.50	$ 139,920
Bore and encasement, 10"	-	LF	$ 60.00	$ -
Open cut and encasement, 10"	50	LF	$ 35.00	$ 1,750
Gate valve and box, 04"	1	EA	$ 395.00	$ 417
Air valve	1.00	EA	$ 1,000.00	$ 1,000
Flush valve	1	EA	$ 750.00	$ 792
Metal detectable tape	5,280	LF	$ 0.15	$ 792
Subtotal				**$ 144,671**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 460	$ -
Check valve, 04"	-	EA	$ 540	$ -
Electrical/Instrumentation	-	EA	$ 10,000	$ -
Site work	-	EA	$ 2,000	$ -
Building pad	-	EA	$ 4,000	$ -
Pump Building	-	EA	$ 10,000	$ -
Fence	-	EA	$ 5,870	$ -
Tools	-	EA	$ 1,000	$ -
Storage Tank - 10,000 gals	-	EA	$ 7,025	$ -
Subtotal				**$ -**
Well Installation				
Well installation	200	LF	$ 25	$ 5,000
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 26,000**
Subtotal of Component Costs				**$ 170,671**
Contingency	20%			$ 34,134
Design & Constr Management	25%			$ 42,668
TOTAL CAPITAL COSTS				**$ 247,473**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	1.0	mile	$ 200	$ 200
Subtotal				**$ 200**
Pump Station(s) O&M				
Building Power	-	kWH	$ 0.136	$ -
Pump Power	-	kWH	$ 0.136	$ -
Materials	-	EA	$ 1,200	$ -
Labor	-	Hrs	$ 40	$ -
Tank O&M	-	EA	$ 1,000	$ -
Subtotal				**$ -**
Well O&M				
Pump power	205	kWH	$ 0.136	$ 28
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 40	$ 7,200
Subtotal				**$ 8,428**
O&M Credit for Existing Well Closure				
Pump power	192	kWH	$ 0.136	$ (26)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 40	$ (14,400)
Subtotal				**$ (16,826)**
TOTAL ANNUAL O&M COSTS				**$ (8,198)**

Table C.9

PWS Name	***LCRA Bonanza Beach Water Association***
Alternative Name	***Central Treatment - IX***
Alternative Number	***BB-9***

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Ion Exchange Unit Purchase/Installation				
Site preparation	0.75	acre	$ 4,000	$ 3,000
Slab	30	CY	$ 1,000	$ 30,000
Building	400	SF	$ 60	$ 24,000
Building electrical	400	SF	$ 8	$ 3,200
Building plumbing	400	SF	$ 8	$ 3,200
Heating and ventilation	400	SF	$ 7	$ 2,800
Fence	-	LF	$ 15	$ -
Paving	3,200	SF	$ 2	$ 6,400
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 20,000	$ 20,000
Ion exchange package including:				
Regeneration system				
Brine tank				
IX resins & FRP vessels	1	UNIT	$ 30,000	$ 30,000
Transfer pumps (10 hp)	2	EA	$ 5,000	$ 10,000
Clean water tank	5,000	gal	$ 1.00	$ 5,000
Regenerant tank	2,000	gal	$ 1.50	$ 3,000
Backwash Tank	6,000	gal	$ 2.00	$ 12,000
Sewer Connection Fee	-	EA	$ 15,000	$ -
Subtotal of Component Costs				**$ 202,600**
Contingency	20%			$ 40,520
Design & Constr Management	25%			$ 50,650
TOTAL CAPITAL COSTS				**$ 293,770**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Ion Exchange Unit O&M				
Building Power	12,000	kwh/yr	$ 0.136	$ 1,632
Equipment power	10,000	kwh/yr	$ 0.136	$ 1,360
Labor	400	hrs/yr	$ 40	$ 16,000
Materials	1	year	$ 1,000	$ 1,000
Chemicals	1	year	$ 1,000	$ 1,000
Analyses	24	test	$ 200	$ 4,800
Backwash discharge disposal	3.0	kgal/yr	$ 200.00	$ 600
Subtotal				**$ 26,392**
Haul Regenerant Waste and Brine				
Waste haulage truck rental	6	days	$ 700	$ 4,200
Mileage charge	300	miles	$ 1.00	$ 300
Waste disposal	12	kgal/yr	$ 200.00	$ 2,400
Subtotal				**$ 6,900**
TOTAL ANNUAL O&M COSTS				**$ 33,292**

Table C.10

PWS Name *LCRA Bonanza Beach Water Association*
Alternative Name *Central Treatment - WRT Z-88*
Alternative Number *BB-10*

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Coagulation/Filtration Unit Purchase/Installation				
Site preparation	0.75	acre	$ 4,000	$ 3,000
Slab	30	CY	$ 1,000	$ 30,000
Building	400	SF	$ 60	$ 24,000
Building electrical	400	SF	$ 8	$ 3,200
Building plumbing	400	SF	$ 8	$ 3,200
Heating and ventilation	400	SF	$ 7	$ 2,800
Fence	-	LF	$ 15	$ -
Paving	1,600	SF	$ 2	$ 3,200
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 20,000	$ 20,000
WRT Z-88 package including:				
Z-88 vessels				
Adsorption media	1	UNIT	$ 45,000	$ 45,000
(Initial Setup Cost for WRT Z-88 package plant)				
Subtotal of Component Costs				**$ 184,400**
Contingency	20%			$ 36,880
Design & Constr Management	25%			$ 46,100
TOTAL CAPITAL COSTS				**$ 267,380**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Coagulation/Filtration Unit O&M				
Building Power	6,000	kwh/yr	$ 0.136	$ 816
Equipment power	5,000	kwh/yr	$ 0.136	$ 680
Labor	400	hrs/yr	$ 40	$ 16,000
Analyses	24	test	$ 200	$ 4,800
WRT treated water charge	5,740	kgal/yr	$ 2.70	$ 15,498
Subtotal				**$ 37,794**
TOTAL ANNUAL O&M COSTS				**$ 37,794**

Table C.11

PWS Name ***LCRA Bonanza Beach Water Association***
Alternative Name ***Central Treatment - KMnO4***
Alternative Number ***BB-11***

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Coagulation/Filtration Unit Purchase/Installation				
Site preparation	0.50	acre	$ 4,000	$ 2,000
Slab	30	CY	$ 1,000	$ 30,000
Building	400	SF	$ 60	$ 24,000
Building electrical	400	SF	$ 8	$ 3,200
Building plumbing	400	SF	$ 8	$ 3,200
Heating and ventilation	400	SF	$ 7	$ 2,800
Fence	-	LF	$ 15	$ -
Paving	1,600	SF	$ 2	$ 3,200
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 20,000	$ 20,000
KMnO4-Greensand package including:				
Greensand filters				
Solution tank	1	UNIT	$ 80,000	$ 80,000
Backwash tank	10,000	gal	$ 2.00	$ 20,000
Sewer connection fee	-	EA	$ 15,000	$ -
Subtotal of Component Costs				**$ 238,400**
Contingency	20%			$ 47,680
Design & Constr Management	25%			$ 59,600
TOTAL CAPITAL COSTS				**$ 345,680**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Coagulation/Filtration Unit O&M				
Building Power	6,000	kwh/yr	$ 0.136	$ 816
Equipment power	6,000	kwh/yr	$ 0.136	$ 816
Labor	500	hrs/yr	$ 40	$ 20,000
Materials	1	year	$ 3,000	$ 3,000
Chemicals	1	year	$ 2,000	$ 2,000
Analyses	24	test	$ 200	$ 4,800
Backwash discharge to sewer	11	kgal/yr	$ 7.50	$ 83
Subtotal				**$ 31,515**
Sludge Disposal				
Truck rental	5.0	days	$ 700	$ 3,500
Mileage	300	miles	$ 1.00	$ 300
Disposal fee	5	kgal/yr	$ 200.00	$ 1,000
Subtotal				**$ 4,800**
TOTAL ANNUAL O&M COSTS				**$ 36,315**

Table C.12

PWS Name ***LCRA Bonanza Beach Water Association***
Alternative Name ***Point-of-Use Treatment***
Alternative Number ***BB-12***

Number of Connections for POU Unit Installation 56

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POU-Treatment - Purchase/Installation				
POU treatment unit purchase	56	EA	$ 250	$ 14,000
POU treatment unit installation	56	EA	$ 150	$ 8,400
Subtotal				**$ 22,400**
Subtotal of Component Costs				**$ 22,400**
Contingency	20%			$ 4,480
Design & Constr Management	25%			$ 5,600
Procurement & Administration	20%			$ 4,480
TOTAL CAPITAL COSTS				**$ 36,960**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POU materials, per unit	56	EA	$ 225	$ 12,600
Contaminant analysis, 1/yr per unit	56	EA	$ 100	$ 5,600
Program labor, 10 hrs/unit	560	hrs	$ 40	$ 22,400
Subtotal				**$ 40,600**
TOTAL ANNUAL O&M COSTS				**$ 40,600**

Table C.13

PWS Name ***LCRA Bonanza Beach Water Association***
Alternative Name ***Point-of-Entry Treatment***
Alternative Number ***BB-13***

Number of Connections for POE Unit Installation 56

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POE-Treatment - Purchase/Installation				
POE treatment unit purchase	56	EA	$ 3,000	$ 168,000
Pad and shed, per unit	56	EA	$ 2,000	$ 112,000
Piping connection, per unit	56	EA	$ 1,000	$ 56,000
Electrical hook-up, per unit	56	EA	$ 1,000	$ 56,000
Subtotal				**$ 392,000**
Subtotal of Component Costs				**$ 392,000**
Contingency	20%			$ 78,400
Design & Constr Management	25%			$ 98,000
Procurement & Administration	20%			$ 78,400
TOTAL CAPITAL COSTS				**$ 646,800**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POE materials, per unit	56	EA	$ 1,000	$ 56,000
Contaminant analysis, 1/yr per unit	56	EA	$ 100	$ 5,600
Program labor, 10 hrs/unit	560	hrs	$ 40	$ 22,400
Subtotal				**$ 84,000**
TOTAL ANNUAL O&M COSTS				**$ 84,000**

Table C.14

PWS Name ***LCRA Bonanza Beach Water Association***
Alternative Name ***Public Dispenser for Treated Drinking Water***
Alternative Number ***BB-14***

Number of Treatment Units Recommended 1

Capital Costs

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

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Treatment unit O&M, 1 per unit	1	EA	$ 500	$ 500
Contaminant analysis, 1/wk per u	52	EA	$ 100	$ 5,200
Sampling/reporting, 1 hr/day	365	HRS	$ 40	$ 14,600
Subtotal				**$ 20,300**
TOTAL ANNUAL O&M COSTS				**$ 20,300**

Table C.15

PWS Name ***LCRA Bonanza Beach Water Association***
Alternative Name ***Supply Bottled Water to Population***
Alternative Number ***BB-15***

Service Population	143	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	52,195	gallons

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Implementation				
Initial program set-up	500	hours	$ 53	$ 26,600
Subtotal				**$ 26,600**
Subtotal of Component Costs				**$ 26,600**
Contingency	20%			$ 5,320
TOTAL CAPITAL COSTS				**$ 31,920**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water purchase costs	52,195	gals	$ 1.60	$ 83,512
Program admin, 9 hrs/wk	468	hours	$ 53	$ 24,898
Program materials	1	EA	$ 5,000	$ 5,000
Subtotal				**$ 113,410**
TOTAL ANNUAL O&M COSTS				**$ 113,410**

Table C.16

PWS Name ***LCRA Bonanza Beach Water Association***
Alternative Name ***Central Trucked Drinking Water***
Alternative Number ***BB-16***

Service Population	143	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	52,195	gallons
Travel distance to compliant water source (roundtrip)	55	miles

Capital Costs

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

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water delivery labor, 4 hrs/wk	208	hrs	$ 40	$ 8,320
Truck operation, 1 round trip/wk	2,860	miles	$ 1.00	$ 2,860
Water purchase	52	1,000 gals	$ 1.80	$ 94
Water testing, 1 test/wk	52	EA	$ 100	$ 5,200
Sampling/reporting, 2 hrs/wk	104	hrs	$ 40	$ 4,160
Subtotal				**$ 20,634**
TOTAL ANNUAL O&M COSTS				**$ 20,634**

APPENDIX D
EXAMPLE FINANCIAL MODEL

Table D.1 Example Financial Model

Water System	Bonanza
Funding Alternative	Bond
Alternative Description	City of Burnet

Sum of Amount		Year																					
Group	Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Capital Expenditures	Capital Expenditures-Funded from Bonds	$ -	$ -	$ -	$2,468,874	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from Grants	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from Revenue/Reserves	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from SRF Loans	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Expenditures Sum		$ -	$ -	$ -	$2,468,874	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt Service	Revenue Bonds				$ 193,132	$193,132	$193,132	$193,132	$193,132	$193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132
	State Revolving Funds				$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt Service Sum					$ 193,132	$193,132	$193,132	$193,132	$193,132	$193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132	$ 193,132
Operating Expenditures	Other Operating Expenditures 1			$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500	$ 28,500
	O&M Associated with Alternative					$ 14,762	$ 14,762	$ 14,762	$ 14,762	$ 14,762	$ 14,762	$ 14,762	$ 14,762	$ 14,762	$ 14,762	$ 14,762	$ 14,762	$ 14,762	$ 14,762	$ 14,762	$ 14,762	$ 14,762	$ 14,762
Operating Expenditures Sum				$ 28,500	$ 28,500	$ 43,262	$ 43,262	$ 43,262	$ 43,262	$ 43,262	$ 43,262	$ 43,262	$ 43,262	$ 43,262	$ 43,262	$ 43,262	$ 43,262	$ 43,262	$ 43,262	$ 43,262	$ 43,262	$ 43,262	$ 43,262
Residential Operating Revenues	Residential Base Monthly Rate			$ 28,318	$ 28,318	$128,587	$259,381	$289,906	$289,906	$289,906	$ 289,906	$ 289,906	$ 289,906	$ 289,906	$ 289,906	$ 289,906	$ 289,906	$ 289,906	$ 289,906	$ 289,906	$ 289,906	$ 289,906	$ 289,906
	Residential Tier 1 Monthly Rate			$ 15,421	$ 15,421	$ 70,025	$141,252	$157,875	$157,875	$157,875	$ 157,875	$ 157,875	$ 157,875	$ 157,875	$ 157,875	$ 157,875	$ 157,875	$ 157,875	$ 157,875	$ 157,875	$ 157,875	$ 157,875	$ 157,875
	Residential Tier2 Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier3 Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier4 Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Unmetered Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Residential Operating Revenues Sum				$ 43,739	$ 43,739	$198,612	$400,632	$447,781	$447,781	$447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781

Location_Name	Bonanza
Alt_Desc	City of Burnet

		Current_Year																					
Funding_Alt	Data	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Bond	Sum of Beginning_Cash_Bal	$ 21,593	$ 29,926	$(154,872)	$ (202,021)	$ (47,149)	$154,872	$356,893	$558,914	$760,935	$ 962,956	$1,164,977	$1,366,997	$1,569,018	$1,771,039	$1,973,060	$2,175,081	$2,377,102	$2,579,123	$2,781,144	$2,983,164	$3,185,185	$3,387,206
	Sum of Total_Expenditures	$ 28,500	$2,690,506	$ 236,394	$ 236,394	$236,394	$236,394	$236,394	$236,394	$236,394	$ 236,394	$ 236,394	$ 236,394	$ 236,394	$ 236,394	$ 236,394	$ 236,394	$ 236,394	$ 236,394	$ 236,394	$ 236,394	$ 236,394	$ 236,394
	Sum of Total_Receipts	$ 43,739	$2,512,613	$ 198,612	$ 400,632	$447,781	$447,781	$447,781	$447,781	$447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781	$ 447,781
	Sum of Net_Cash_Flow	$ 15,239	$ (177,893)	$ (37,782)	$ 164,239	$211,387	$211,387	$211,387	$211,387	$211,387	$ 211,387	$ 211,387	$ 211,387	$ 211,387	$ 211,387	$ 211,387	$ 211,387	$ 211,387	$ 211,387	$ 211,387	$ 211,387	$ 211,387	$ 211,387
	Sum of Ending_Cash_Bal	$ 36,832	$ (147,966)	$(192,655)	$ (37,782)	$164,239	$366,259	$568,280	$770,301	$972,322	$1,174,343	$1,376,364	$1,578,385	$1,780,406	$1,982,426	$2,184,447	$2,386,468	$2,588,489	$2,790,510	$2,992,531	$3,194,552	$3,396,573	$3,598,593
	Sum of Working_Cap	$ 4,750	$ 4,750	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210	$ 7,210
	Sum of Repl_Resv	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156	$ 2,156
	Sum of Total_Reqd_Resv	$ 6,906	$ 6,906	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366	$ 9,366
	Sum of Net_Avail_Bal	$ 29,926	$ (154,872)	$(202,021)	$ (47,149)	$154,872	$356,893	$558,914	$760,935	$962,956	$1,164,977	$1,366,997	$1,569,018	$1,771,039	$1,973,060	$2,175,081	$2,377,102	$2,579,123	$2,781,144	$2,983,164	$3,185,185	$3,387,206	$3,589,227
	Sum of Add_Resv_Needed	$ -	$ (154,872)	$(202,021)	$ (47,149)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Sum of Rate_Inc_Needed	0%	354%	102%	12%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0
	Sum of Percent_Rate_Increase	0%	0%	354%	816%	924%	924%	924%	924%	924%	924%	924%	924%	924%	924%	924%	924%	924%	924%	924%	924%	924%	924%

APPENDIX E
RADIONUCLIDE GEOCHEMISTRY

Radionuclide impact on water quality is measured according to two scales: intrinsic measurement of radioactivity and impact on human beings. Activity or number of disintegrations per unit time is typically measured in pico Curies (pCi) while impact on living organisms is measured in mRem. Radioactive decay can generate alpha or beta particles as well as gamma rays. Two radioactive elements with the same activity may have vastly different impacts on life depending on the energy released during decay. Each radionuclide has a conversion factor from pCi to mRem as a function of the exposure pathway. Activity is related to contaminant concentration and its half-life. A higher concentration and a shorter half-life lead to an increase in activity. Given the ratio of their half-life (Table 1) it is apparent that radium is approximately one million times more radioactive than uranium. Concentrations of gross alpha and beta emitters take into account the whole decay series and not just uranium and radium as well as other elements such as K40.

Uranium and thorium (atomic number 92 and 90, respectively), both radium sources, are common trace elements and have a crustal abundance of 2.6 and 10 mg/kg, respectively. They are abundant in acidic rocks. Intrusive rocks such as granites will partly sequester uranium and thorium in erosion-resistant accessory minerals (*e.g.*, monazite, thorite) while uranium in volcanic rocks is much more labile and can be leached by surface water and groundwater. Lattice substitution in minerals (*e.g.*, Ca^{+2} and U^{+4} have almost the same ionic radius) as well as micrograins of uranium and thorium minerals are other possibilities. In sedimentary rock, uranium and thorium aqueous concentrations are controlled mainly by the sorbing potential of the rock (metal oxide, clay, and organic matter).

The geochemistry of uranium is complicated but can be summarized by the following. Uranium(VI) in oxidizing conditions exists as the soluble positively charged uranyl ion UO_2^{+2}. Solubility is higher at low pH (acid), decreases at neutral pHs, and increases at high pH (alkaline). The uranyl ion can easily form aqueous complexes, such as with hydroxyl, fluoride and carbonate and phosphate ligands. Hence in the presence of carbonates, uranium solubility is considerably enhanced in the form of uranyl-carbonate (UO_2CO_3) and other higher order carbonate complexes: uranyl-di-carbonate $(UO_2(CO_3)_2^{-2}$ and uranyl-tri-carbonates $UO_2(CO_3)_3^{-4})$. Adsorption of uranium is inversely related to its solubility and is highest at neutral pHs (De Soto 1978, p.11). Uranium sorbs strongly to metal oxide and clay. Uranium (IV) is the other commonly found redox state. In that state, however, uranium is not very soluble and precipitates as uranite, UO_2, coffinite, $USiO_4.nH_2O$ (if SiO_2 >60 mg/L, Henry, *et al*. 1982), or related minerals. In most aquifers, there is no mineral controlling uranium solubility in oxidizing conditions. However, uranite and coffinite are the controlling minerals if the Eh drops below 0-100 mV.

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

Radium has an atomic number of 88. Radium originates from the radioactive decay of uranium and thorium. Radum-226 is an intermediate product of U238 (the most common uranium isotope >99%, Table 1) decay while radium-228 belongs to the thorium 232 (~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. Radium-223 and radium-224 isotopes are also naturally present but in minute quantities. Ra224 belongs to the thorium decay series while radium-223 derives from the much rarer U235 (~0.7%). Radium is an alkaline earth element and belongs to the same group (2A in periodic table) as magnesium, calcium, strontium, and barium. It most resembles barium chemically as evidenced by removal technologies such as ion exchange with Na and lime softening. Sorption on iron and manganese oxides is also a common trait of alkaline earth elements. Radium exists only under one oxidation state, the divalent cation Ra^{+2}, similarly to other alkaline earth element (Ca^{+2}, Mg^{+2}, Sr^{+2}, and Ba^{+2}). $RaSO_4$ is extremely insoluble (more so than barium sulfate) with a log K solubility product of -10.5 compared to that of barium sulfate at ~-10. Radium solubility is mostly controlled by sulfate activity.

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

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

NOTE: half-life from Parrington, et al. 1996

USEPA Maximum Contaminant Levels

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

Appendix References

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