

Water Resources Plan

City of Boerne

Boerne, Texas
September 2015



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Water Resources Plan

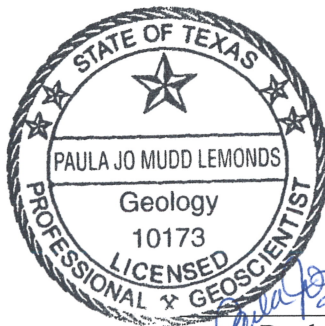
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Table of Contents

1	Executive Summary	9
1.1	Background and Objective	9
1.2	Population and Demand.....	9
1.3	Water Supply Alternatives	10
1.4	Recommendations	11
2	Introduction.....	11
2.1	Background	11
2.2	Objective.....	12
3	Population and Demand.....	12
4	Water Supply Alternatives	15
4.1	Selected Alternatives.....	16
5	Reclaimed Water Alternatives	16
5.1	Background	16
5.1.1	Types of Reclaimed Water	16
5.1.2	City of Boerne Reclaimed Water System.....	18
5.1.3	Future Reclaimed Supplies	19
5.2	Indirect Potable Reuse at Boerne City Lake Alternative	20
5.2.1	Description	20
5.2.2	Available Yield.....	22
5.2.3	Implementation.....	22
5.2.4	Operational Flexibility	23
5.2.5	Ownership of Water.....	23
5.2.6	Yield for Future Need	23
5.2.7	Engineering and Costing.....	23
5.3	Indirect Potable Reuse with ASR Alternative	23
5.3.1	Description	23
5.3.2	Available Yield.....	26
5.3.3	Implementation.....	26
5.3.4	Operational Flexibility	27
5.3.5	Ownership of Water.....	27
5.3.6	Yield for Future Need	27
5.3.7	Engineering and Costing.....	27
5.4	Direct Potable Reuse Alternative	29
5.4.1	Description	29
5.4.2	Available Yield.....	31
5.4.3	Implementation.....	31
5.4.4	Operational Flexibility	31
5.4.5	Ownership of Water.....	31
5.4.6	Yield for Future Need	31
5.4.7	Engineering and Costing.....	31
6	Groundwater Supply Alternatives.....	33
6.1	Background	33
6.2	Cow Creek Groundwater Conservation District	37
6.3	Brackish Groundwater Alternative.....	37
6.3.1	Description	37

6.3.2	Implementation.....	39
6.3.3	Engineering and Costing.....	39
6.4	Fresh Groundwater Well Alternative	40
6.4.1	Implementation.....	40
6.4.2	Engineering and Costing.....	41
7	Surface Water Alternatives.....	41
7.1	Background	41
7.2	Firm Yield Increase of Boerne City Lake Alternative	41
7.2.1	Available Yield.....	41
7.3	Surface Water with ASR Alternative	42
7.3.1	New Surface Water Right.....	42
7.4	Expanded GBRA Contract with ASR Alternative	47
8	Regional Alternatives	48
8.1	GBRA Canyon Lake Contract Increase Alternative	48
8.1.1	Description	48
8.1.2	Firm Yield	49
9	Summary and Recommendations.....	49
9.2	Cost Estimate Summary.....	50
9.3	Recommendations	52

List of Figures

Figure 3-1. City of Boerne Projected Population.....	14
Figure 3-2. City of Boerne Projected Water Demand	15
Figure 5-1. Planned Expansion of the Non-Potable Reclaimed Water System.....	19
Figure 5-2. Indirect Potable Reuse with Boerne City Lake	21
Figure 5-3. Indirect Potable Reuse with ASR	24
Figure 5-4. Direct Potable Reuse Operation.....	30
Figure 6-1. Surface Geology	34
Figure 6-2. Stratigraphic Units in the vicinity of Boerne	36
Figure 6-3. Schematic for Brackish Groundwater with Blending from Boerne City Lake Project.	38
Figure 7-1. Schematic for ASR with new Surface Water Right Project.	43
Figure 7-2. Approximate supply from new surface water right immediately downstream of Boerne City Lake Dam.....	45

List of Tables

Table 1-1. Water supply alternatives considered in this Plan	10
Table 3-1. City of Boerne water supply and demand.....	13
Table 3-2. 2016 South Central Texas (Region L) Regional Water Plan (SCTRWP) water supply and demand for City of Boerne	13
Table 5-1. Total Non-potable Demand for the Existing and Planned Reclaimed Water System (Source: 2014 Boerne Reuse Study, HDR)	18
Table 5-2. Projected Reclaimed Supplies	20
Table 5-3. Cost Estimate Summary for Indirect Potable Reuse with ASR southeast of Boerne (September 2013 Prices)	29
Table 5-4. Cost Estimate Summary for City of Boerne DPR (September 2013 Prices)	33
Table 6-1. Hydrogeologic Units and Descriptions.....	35
Table 6-2. Cost Estimate Summary for brackish groundwater alternative (September 2013 Prices)	40
Table 7-1. Cost estimate summary for ASR with new surface water right (September 2013 Prices)	47

List of Acronyms

acft/yr	acre-feet per year
ASR	aquifer storage and recovery
AWTP	advanced water treatment plant
BCL	Boerne City Lake
BOD5	5-day biological oxygen demand
CBOD5	5-day carbonaceous biological oxygen demand
CCGCD	Cow Creek Groundwater Conservation District
CEC	constituents of emerging concern
COC	constituents of concern
DBP	disinfection by-products
DPR	direct potable reuse
gal	gallons
GBRA	Guadalupe-Blanco River Authority
gpcd	gallons per capita per day
gpm	gallons per minute
GBRA	Guadalupe-Blanco River Authority
GSAWAM	Guadalupe-San Antonio River Basin Water Availability Model
IPP	Initially Prepared Plan, referring to a regional water plan
IPR	indirect potable reuse
MGD	million gallons per day
RO	reverse osmosis
SAWS	San Antonio Water System
SCTRWP	South Central Texas (Region L) Regional Water Plan
SDWA	Safe Drinking Water Act
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TDS	total dissolved solids
TWDB	Texas Water Development Board
WWTP	wastewater treatment plant
WWTRC	wastewater treatment and recycling center

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1 Executive Summary

1.1 Background and Objective

The City of Boerne (City) is experiencing rapid population growth. As with any other aspect of a City's operations, proper planning is imperative. This Water Resources Plan (Plan) is intended to be a guide that will be updated as new water supply alternatives become available or current ones are no longer feasible. The City has long realized that adequate water supply is necessary. In 1995, a Water Resources Plan was prepared by the W.E. Simpson Company with a subsequent update completed by HDR in 2003. The dynamic nature of meeting a community's water demands necessitates that a Plan be updated through time.

Current Water Supply Sources

Currently, the City obtains its potable water from surface and groundwater sources. Surface water is withdrawn from Boerne City Lake and treated at a City owned and operated surface water treatment plant at the lake. Other surface water supplies include purchase of treated surface water from Canyon Lake through a contract with the Guadalupe-Blanco River Authority (GBRA). Groundwater is withdrawn from the Trinity Aquifer from nine wells in and near the City. Additionally, the City is continuing to build upon its existing investments in that its reclaimed water is currently being used for irrigation and dust control purposes. Reclaimed water will be a vital part of the City's overall future supply. The reclaimed distribution system is built, and reclaimed system customers will be connected to the system as the Esperanza and Ranches at Creekside developments progress.

Water supplies from the GBRA contract for Canyon Lake water, which cannot be used as a peaking resource, and limited groundwater and surface water rights require planning for future water supplies, particularly for peaking water supply. This planning is intended to support the City's commitment in meeting the communities' water supply needs and improving reliability.

Project Scope

The scope of this project is to: (1) evaluate future water supply demands and needs of its customers through 2070, (2) prepare and describe a list of potentially feasible alternatives from diversified water sources and operational strategies, (3) evaluate selected alternatives by preparing cost estimates and implementation issues, and (4) consider projects that would improve reliability of water supplies.

1.2 Population and Demand

Population and demand projections were evaluated based on the City of Boerne Planning Department estimates through 2030 and the Texas Water Development Board (TWDB) estimates through 2070 used in the 2016 Initially Prepared South Central Texas (Region L) Regional Water Plan (SCTRWP). Since 1997, when Senate Bill 1 was passed, Boerne has been a part of the South Central Texas Region, or Region L, in the state water planning process as overseen by the TWDB.

In the current 2016 SCTRWP, the first water supply need of 650 acft/yr occurs in 2050, and using City of Boerne supply and demand information, the first water supply need of 192 acft/yr occurs in 2070. These values differ because of differences in population projections and the assessment of total water supplies available as discussed in Section 3.

At this time, it is understood that the emphasis for new water supply should be placed on summer peaking operations.

1.3 Water Supply Alternatives

The list of water supply alternatives considered in this Plan, for both new water supply and to satisfy peaking needs, include the following alternatives shown in Table 1-1. As previously mentioned, future updates of the Plan could include alternatives that are not currently available.

Table 1-1. Water supply alternatives considered in this Plan

Reclaimed water
Direct non-potable reuse
Indirect Potable Reuse to supplement Boerne City Lake
Indirect Potable Reuse with ASR
Direct Potable Reuse
Groundwater
Brackish groundwater desalination
Fresh groundwater supplies
Surface Water
New surface water right with ASR
Increased firm yield of Boerne City Lake
GBRA Canyon Lake water contract increase with ASR
Regional
GBRA Canyon Lake water contract increase

Through communication with City staff, cost estimates of five alternatives were completed in this study. Selected alternatives are evaluated at the planning level. In this study, a planning level evaluation includes estimation of the firm water supply of the alternative and a cost estimate to deliver raw or treated water (depending on the alternative) to within close proximity of the City's distribution system, but not full integration into the system.

Future phases of the Plan could include evaluation of integrating the alternative into the City's current water distribution system once it is determined where the proposed water will enter the City's distribution system and a full analysis of the permitting requirements.

Those alternatives that were selected through communication with the City's staff for further evaluation include the following.

- Indirect potable reuse with ASR
- Direct potable reuse
- Brackish groundwater desalination
- New surface water right with ASR

- GBRA Canyon Lake water contract increase

Costs associated with each of these alternatives vary in the method of analysis. Several of the alternatives can provide a long-term supply, while others are meant to alleviate the peaking needs of the City. The reader is referred to the descriptions of each alternative for further details. Below are brief summaries of the costs of each recommended alternative, as well as the estimated cost of construction of a fresh groundwater well. This latter option was not considered a selected alternative in discussions with City staff. The construction cost is presented for comparison purposes, as a new fresh groundwater well is considered to be the most cost effective alternative.

1.4 Recommendations

The highest priority recommended future work to advance the planning for future water supply needs for the City includes the following items.

- Evaluation of integrating alternatives into the City's current water distribution system once it is determined where the proposed water will enter the City's distribution system.
- Evaluation of integrating the alternatives to accommodate future demands in high growth areas.
- Updating of the yield of Boerne City Lake. Currently, the modeled yield of BCL is 645 acft/yr. However, with a new topographic survey, which are typically completed by the TWDB, and subsequent updates to the surface water availability model, a more accurate yield can be determined, leading to more informed water supply decisions.
- Evaluation of the reliability of existing supplies from Boerne City Lake and fresh groundwater.

2 Introduction

2.1 Background

Planning for future water supply is necessary because of the rapid growth of the City of Boerne's (Boerne or the City) population. The City is interested in meeting growing water supply needs and improving the reliability of existing water supplies. This Water Resources Plan (Plan) is intended to be a guide that will be updated as new water supply alternatives become available or current ones are no longer feasible. The City has long realized that adequate water supply is necessary. In 1995, a Water Resources Plan was prepared by the W.E. Simpson Company with a subsequent update completed by HDR in 2003. The dynamic nature of meeting a community's water demands necessitates that a Plan be updated through time.

Currently, the City obtains its potable water from surface and groundwater sources. The City owns and operates the surface water treatment plant at Boerne City Lake (BCL) and nine groundwater wells. The City purchases treated surface water from Canyon Lake through a contract with the Guadalupe-Blanco River Authority (GBRA). Additionally, the

City is continuing to build upon its existing investments in its reclaimed water system currently utilized for irrigation and dust control purposes. Reclaimed water will be a vital part of the City's overall future supply. The reclaimed distribution system is built, and reclaimed system customers will be connected to the system as the Esperanza and Ranches at Creekside developments progress.

2.2 Objective

The objective of this study is to identify a feasible plan of action that will allow Boerne to meet its water supply demands and future needs of its customers through 2070 and improve the reliability of existing supplies. These objectives are met through the following tasks:

- Task 1 – Compile and Analyze Information on Population, Water Demands, and Existing Supplies
- Task 2 – Identify and Evaluate Water Supply Alternatives
- Task 3 – Prepare Water Resources Plan Report

3 Population and Demand

Population and demand projections were evaluated based on the City of Boerne Planning Department estimates through 2030 and the TWDB estimates through 2070 used in the 2016 Initially Prepared South Central Texas (Region L) Regional Water Plan (SCTRWP). Since 1997, when Senate Bill 1 was passed, Boerne has been a part of the South Central Texas Region, or Region L, in the state water planning process as overseen by the TWDB.

The City's population estimate indicated a higher growth rate through 2030, compared to the TWDB values. Through coordination with City staff, it was determined that for this study, a water demand estimate using the City's population projection through 2030 and extended out to 2070, using the growth rate from the TWDB in the SCTRWP, and using the City's gpcd estimates is appropriate. The resulting population projection from 2020 through 2070 is shown in Figure 3-1. This methodology results in a higher growth through 2030 (based on the City's projections), then a plateauing of the growth rate through 2070 (TWDB projected growth rate). Total City population at 2070 using this method is estimated to be 43,637, as shown in Table 3-1. This Water Resources Plan (Plan) describes water resource alternatives to meet the demand based on this projected population.

The projected water demand for the City from 2020 through 2070 is shown in Table 3-1 and Figure 3-2, which shows an estimated 2070 demand of 7,617 acft/yr, which is slightly lower than the 2070 TWDB estimate of 7,863 acft/yr in the SCTRWP.

For comparison to the City's water supply and demand, Table 3-2 shows the TWDB population estimates through 2070 that were used in the SCTRWP, as well as demands. The water demand basis used by TWDB was reviewed and found that the gallons per capita per day (gpcd) estimate is comparable, but slightly higher than the City's estimate.

Table 3-1. City of Boerne water supply and demand

	2020	2030	2040	2050	2060	2070
Population	16,234	24,838	29,542	34,205	38,965	43,637
Water use per capita (gpcd) ¹	160	158	157	156	156	156
Demand (acft/yr)	2,910	4,382	5,184	5,971	6,801	7,617
Current Supplies (acft/yr)						
Trinity Wells ²	1,000 -1,850	1,000 -1,850	1,000 -1,850	1,000 -1,850	1,000 -1,850	1,000 -1,850
Boerne City Lake ³	833	833	833	833	833	833
Canyon Lake (GBRA)	3,611	3,611	3,611	3,611	3,611	3,611
Reclaimed ⁴	7*	232	669	1,103	1,546	1,981
Total	5,451	5,676	6,113	6,547	6,990	7,425
Balance/(Shortage) (acft/yr)	2,541	1,294	929	576	189	(192)
<p>Notes:</p> <p>¹ 160 gpcd based on average of Boerne's gpcd since 2009. Reduction in gpcd because of conservation through 2070 is based on the application of the Plumbing Fixtures Act between 2020 and 2045, which is consistent with the state water planning process.</p> <p>² Actual Cow Creek Groundwater Conservation District permit is 1,850 acft/yr. For calculations of supply, 1,000 acft/yr was used.</p> <p>³ Permitted diversion from Boerne City Lake is 833 acft/yr.</p> <p>⁴ Reclaimed supply based on 115 gpcd as low average residential wastewater flow from City Planning data. Refer to Section 5.1.3, Table 5-2.</p> <p>* Approximate available reclaimed supply in 2020 from SCTRWP.</p>						

Table 3-2. 2016 South Central Texas (Region L) Regional Water Plan (SCTRWP) water supply and demand for City of Boerne

	2020	2030	2040	2050	2060	2070
Population	14,367	18,820	23,524	28,187	32,947	37,619
Water use per capita (gpcd) ¹	192	189	188	187	187	187
Demand (acft/yr)	3,091	3,985	4,942	5,900	6,889	7,863
Current Supplies (acft/yr)						
Trinity Wells	987	987	987	987	987	987
Boerne City Lake	645	645	645	645	645	645
Canyon Lake (GBRA)	3,611	3,611	3,611	3,611	3,611	3,611
Reclaimed	7	7	7	7	7	7
Total	5,250	5,250	5,250	5,250	5,250	5,250
Balance/(Shortage) (acft/yr)	2,159	1,265	308	(650)	(1,639)	(2,613)
<p>Notes:</p> <p>¹ Reduction in gpcd because of conservation through 2070 is based on the application of the Plumbing Fixtures Act between 2020 and 2045.</p>						

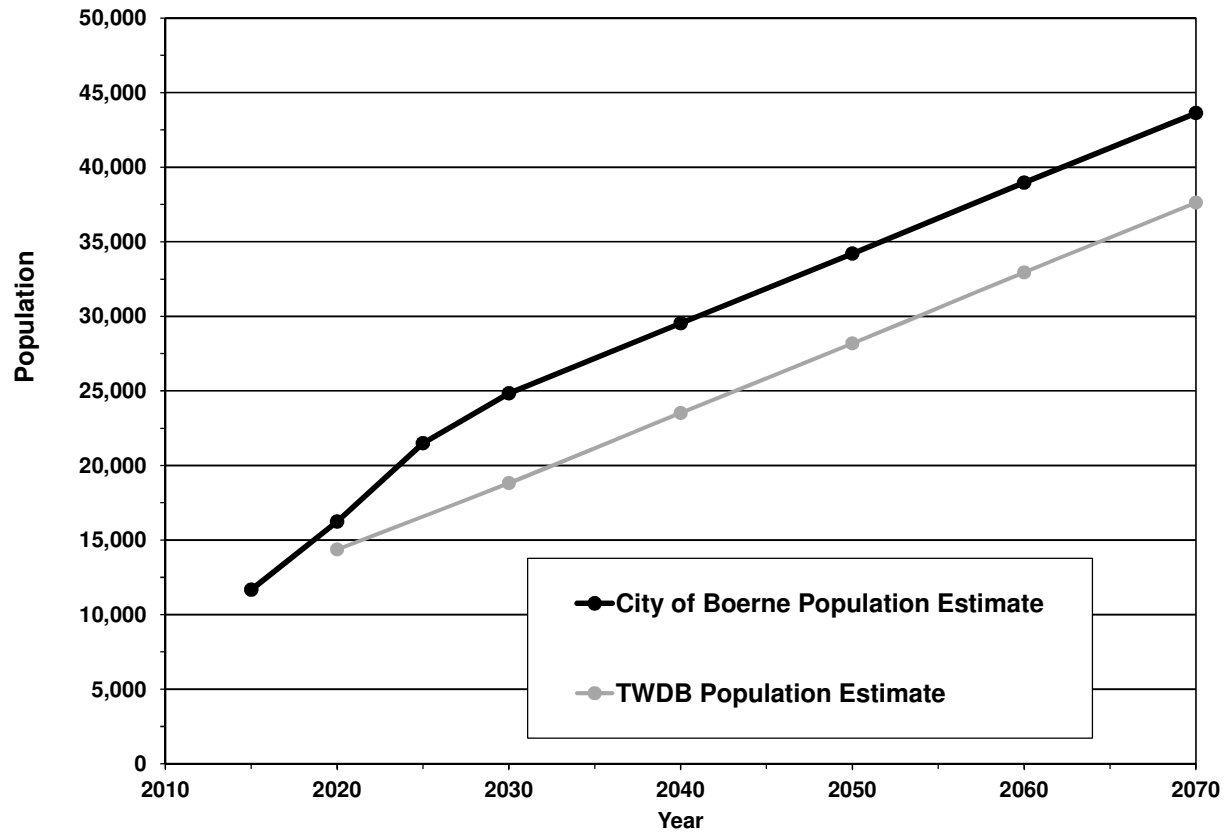


Figure 3-1. City of Boerne Projected Population

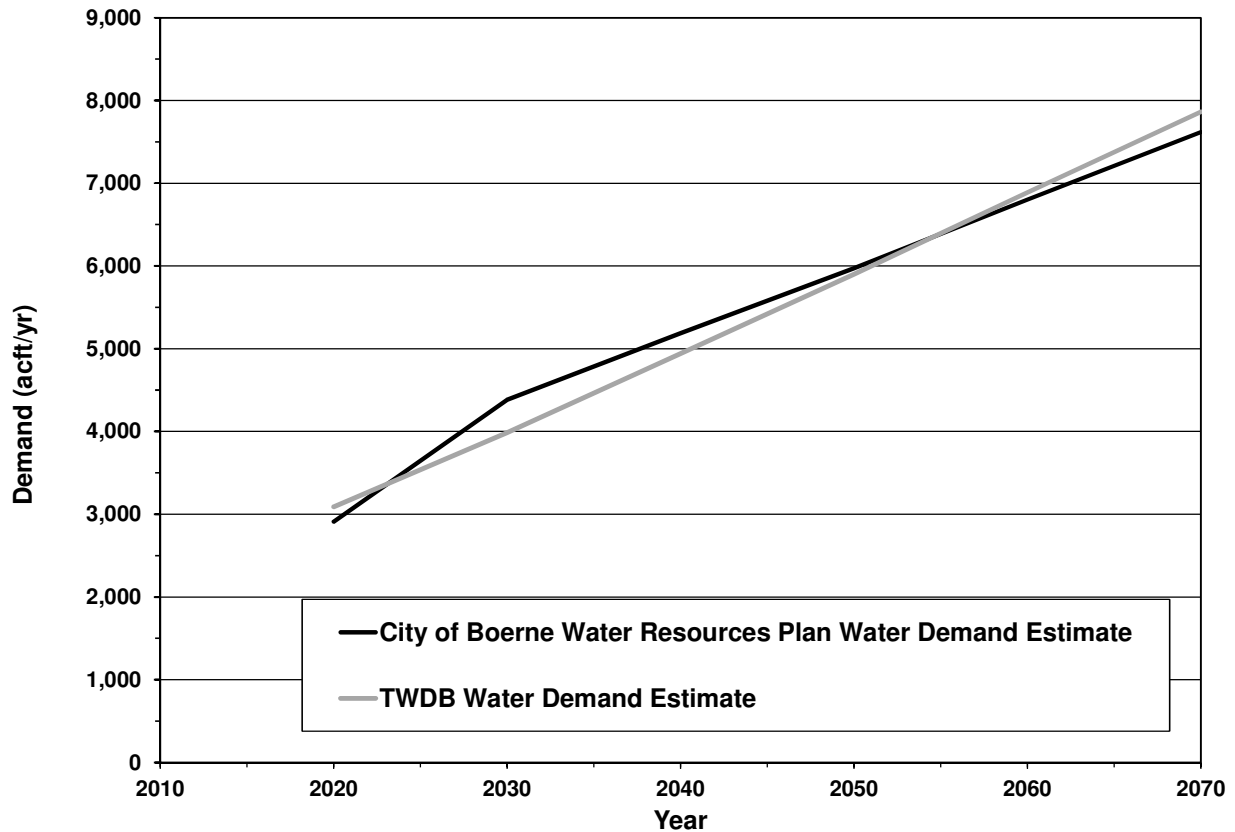


Figure 3-2. City of Boerne Projected Water Demand

4 Water Supply Alternatives

Potential water supply alternatives were identified and evaluated for consideration as future water supply for Boerne. These alternatives include:

Reclaimed Water

- Direct non-potable reuse
- Indirect potable reuse to supplement water in Boerne City Lake
- Indirect potable reuse with Aquifer Storage and Recovery (ASR)
- Direct potable reuse

Groundwater

- Brackish groundwater desalination
- Fresh groundwater supplies

Surface Water

- Increased firm yield of Boerne City Lake

- New surface water right with ASR
- GBRA Canyon Lake water contract increase with ASR

Regional

- GBRA Canyon Lake water contract increase

4.1 Selected Alternatives

The alternatives presented above were discussed in detail with City staff. These discussions resulted in a list of alternatives selected for evaluation at the planning level. In this study, a planning level evaluation includes estimation of the firm water supply of the alternative and a cost estimate to deliver raw or treated water (depending on the alternative) to within close proximity of the City's distribution system, but not full integration into the system. The Plan did not consider any limitations or need for improvements to integrate these supplies into the existing water treatment and distribution system.

Those alternatives that were selected for further evaluation include the following.

- Indirect potable reuse with ASR
- Direct potable reuse
- Brackish groundwater desalination
- New surface water right with ASR
- GBRA Canyon Lake water contract increase

Future phases of the Plan development and implementation could include evaluation of integrating the alternative into the City's current water distribution system. This work would depend on the selected alternative and would consider the optimum location for entry into the City's distribution system and a full analysis of the permitting requirements.

5 Reclaimed Water Alternatives

This section describes the water supply alternatives related to reclaimed water and includes a description of the various types of reuse, or reclaimed, water, and the City's reclaimed water system. Three alternatives are described in this Plan and from these, project costs are estimated for the two recommended alternatives.

5.1 Background

5.1.1 Types of Reclaimed Water

Non-Potable Reuse

Wastewater reuse, alternatively referred to as "reclaimed water," can be classified by use (potable and non-potable) and by how it is handled (direct and indirect). Non-potable

uses may include landscape irrigation, electric generation, industrial cooling, amenity water features, and agriculture.

- Direct Non-Potable Reuse –Treated wastewater is delivered directly from wastewater plant to place of use (also called “flange-to-flange”).
- Indirect Non-Potable Reuse –Treated wastewater is discharged to river, stream, or lake for subsequent diversion downstream (also called “bed and banks”).

Non-potable wastewater reuse quality and system design requirements are regulated by TCEQ by 30 TAC §210. TCEQ allows two types of non-potable reuse as defined by the use of the water and the required water quality:

- Type 1 – Public or food crops generally can come in contact with reuse water, and
- Type 2 – Public or food crops cannot come in contact with reuse water.

The water quality required for Type 1 reuse water is more stringent with lower requirements for oxygen demand (BOD5 or CBOD5), turbidity, and bacteria levels.

Potable Reuse

In addition to non-potable purposes, reclaimed water can also be used to augment potable water supplies. With the recent droughts severely reducing potable supplies, potable reuse projects are being considered as a potential cost effective and safe alternative to meet near term and long term water needs. Potable reuse begins at the WWTP, as it is part of the integrated treatment system for producing potable water supply. Process modifications to enhance the quality of feed water could include flow equalization, improved primary and secondary treatment performance, and nitrogen removal. Disinfection of secondary and tertiary effluent prior to the Advanced Water Treatment Plant (AWTP), should consider potential for disinfection by-products (DBP) formation at the AWTP. The AWTP uses multiple barrier treatment processes, including microfiltration, reverse osmosis (RO) and advanced oxidation and potentially others to achieve anticipated requirements.

Potable reuse has two forms:

- Indirect Potable Reuse (IPR) – highly treated reclaimed water is used to augment potable water supplies using an environmental buffer, such as managed aquifer recharge, surface water discharge or wetlands to provide blending, natural attenuation and residence time as additional barriers before it becomes a raw water supply.
- Direct Potable Reuse (DPR) – highly treated reclaimed water is delivered either directly into the potable water distribution system or the raw water supply entering the water treatment plant, without passing through the natural environment.

If operated properly, water quality from potable reuse projects will exceed current drinking water standards, but there is also significant concern over constituents that are not regulated and do not have established drinking water standards or advisory levels at this time. A growing list of constituents referred to as constituents of emerging concern (CEC) or constituents of concern (COC) have highlighted the need for monitoring

programs to be established in compliance with TCEQ throughout the project, including prior to and during pilot testing, baseline operations and standard operations.

5.1.2 City of Boerne Reclaimed Water System

The City prioritizes the use of reclaimed water and currently utilizes the supply for dust control, streamflow management, and municipal irrigation. The City operates two wastewater treatment plants (WWTP), including the 1.2-MGD Esser Road WWTP, and the newer 1.4-mgd Old San Antonio Road Wastewater Treatment and Recycling Center (WWTRC).

The Esser Road WWTP produces Type 2 reclaimed water, which is currently used for construction dust control and streamflow maintenance. The plant discharges into Currey Creek which flows into Cibolo Creek. The WWTRC produces Type I reclaimed water, which is intended for irrigation supply. The current demand for reclaimed supply is about 493 acft/yr (440,000 gallons per day).

New subdivisions (Ranches at Creekside and Esperanza) planned near the WWTRC will utilize the reclaimed water system for residential irrigation as indicated in Figure 5-1. The 2014 Boerne Reuse Study completed by HDR indicated that total average day demand for expanded reclaimed water system could be 1.85 MGD (2,078 acft/yr) and include a peak day of 2.37 MGD. Table 5-1 includes a summary of existing and future planned reclaimed water demand for non-potable uses. The method used for establishing demand in the 2014 Boerne Reuse Study considered application rates based on gallons/day/acre rather than strictly equivalent dwelling units, which may vary due to lot size. The demands of reclaimed water could vary from those presented in Table 5-1, based on final build out of the developments and the reuse systems in each. This reclaimed demand will replace existing potable water demand for irrigation by automated sprinkler systems in the Ranches at Creekside and Esperanza developments.

Table 5-1. Total Non-potable Demand for the Existing and Planned Reclaimed Water System
(Source: 2014 Boerne Reuse Study, HDR)

Demand	Reclaimed Supply	
	Average Day (gpd)	Peak Day (gpd)
Existing		
Streamflow maintenance ¹	410,000	410,000
Dust Control	10,000	10,000
Subtotal Existing	420,000	420,000
Future Demand		
Esperanza	1,142,000	1,561,000
Ranches at Creekside	273,000	374,000
Subtotal Future	1,415,000	1,935,000
Total	1,835,000	2,355,000
¹ – 2014 Boerne Reuse Study assumed 500,000 gpd. Note: The demands of reclaimed water could vary from those presented, based on final build out of the developments and the reclaimed water systems in each.		

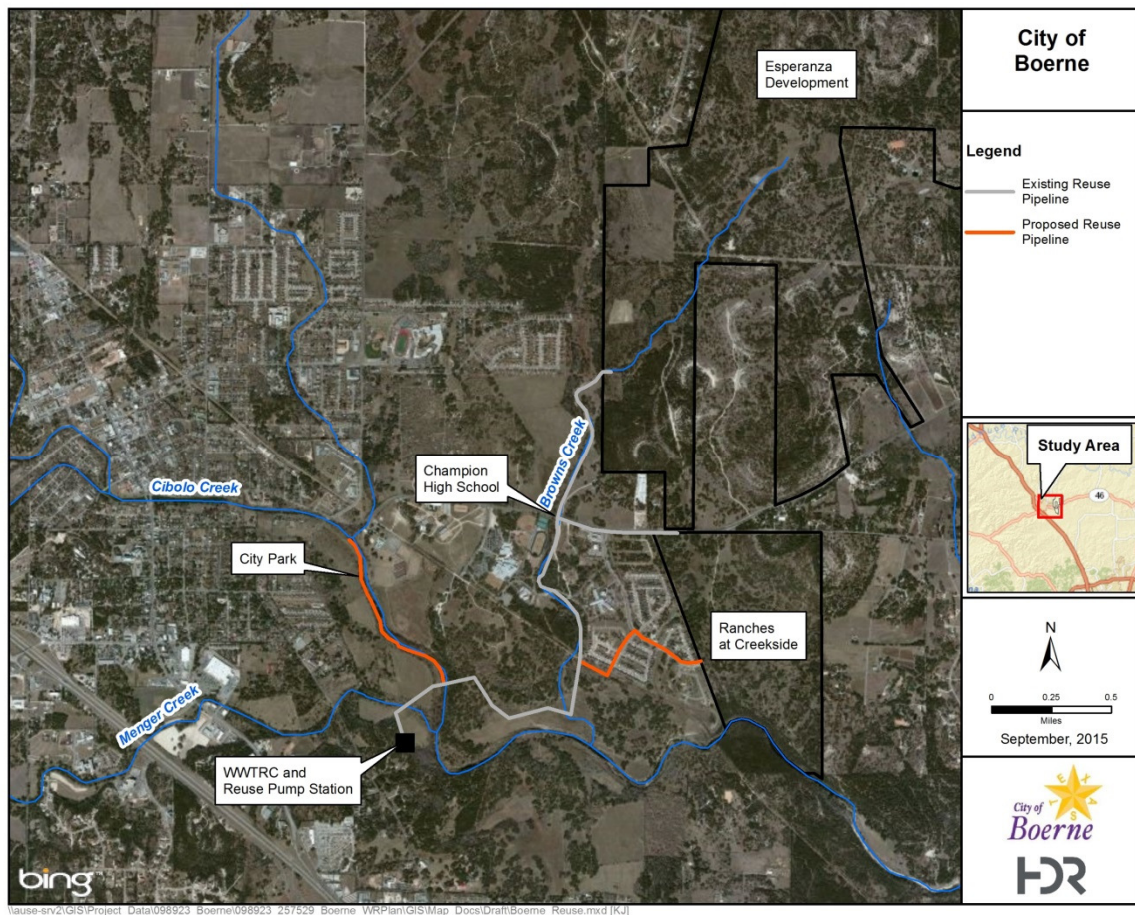


Figure 5-1. Planned Expansion of the Non-Potable Reclaimed Water System

5.1.3 Future Reclaimed Supplies

The availability of reclaimed water supplies is directly related to the projected population and demand as described in Section 2. Table 4-2 includes a summary of the projected reclaimed supplies by decade.

Table 5-2. Projected Reclaimed Supplies

	2020	2030	2040	2050	2060	2070
Population	16,234	24,838	29,542	34,205	38,965	43,637
Water use per capita (gallons)	160	158	157	156	156	156
Wastewater per capita ¹ (gallons)	115	115	115	115	115	115
Wastewater per capita ² (gallons)	83	83	83	83	83	83
Reclaimed Supply ¹ (MGD)	1.867	2.856	3.397	3.934	4.481	5.018
Reclaimed Supply ² (MGD)	1.347	2.062	2.452	2.839	3.234	3.622
Projected Average Non-potable Reuse Demand (MGD)	1.855	1.855	1.855	1.855	1.855	1.855
Available Supply ¹ (MGD)	-	1.001	1.542	2.079	2.626	3.163
Available Supply ² (MGD)	-	0.207	0.597	0.984	1.379	1.767
Notes:						
¹ - based on 115 gpcd as low average residential wastewater flow from City Planning data						
² - based on 83 gpcd for residential flow as noted in the City of Boerne Reuse Plan						

Wastewater per capita is expected to range between 83 gallons per capita per day (gpcd) and 115 gpcd. This represents the amount of indoor water use that would be received by the WWTPs to be treated and made available for other uses. Projected available reclaimed supply before projected non-potable demands is estimated to range between 3.6 MGD and 5.0 MGD in 2070. Non-potable demands are estimated at 1.855 MGD average and include the streamflow maintenance, and irrigation for the existing and planned customers. Net projected available supply for potable reuse alternatives could range between 1.8 MGD (2,000 acft/yr) and 3.2 MGD (3,540 acft/yr) in 2070.

Three projects are evaluated in the following sections that would expand the reclaimed system to use this projected supply for indirect or direct potable reuse including:

1. Indirect Potable Reuse to supplement water in Boerne City Lake
2. Indirect Potable Reuse to ASR
3. Direct Potable Reuse

A discussion of each of the alternatives includes expected regulatory and implementation hurdles that would affect timing, cost and feasibility of the project; operational flexibility for uniform and /or peaking capacity; total yield of the project to meet the projected need of the city by 2070. Through coordination with the City, Alternatives 2 and 3 were selected for cost evaluation.

5.2 Indirect Potable Reuse at Boerne City Lake Alternative

5.2.1 Description

One of the alternatives for using the projected remaining reclaimed supply is to augment the raw water supply at Boerne City Lake (BCL). Indirect Potable Reuse (IPR) projects include storage of reuse water in a surface water reservoir or groundwater that provides a physical environmental buffer and lag time that allows operators to identify and respond to situations that may compromise water quality.

Treated effluent from an existing WWTP would go through an advanced water treatment plant (AWTP) using multiple barrier processes to achieve further removal of contaminants. Purified water from the AWTP would be delivered directly to the lake, an engineered storage tank or a wetland through a new transmission system (Figure 5-2). The AWTP would use reverse osmosis (RO) plus other process (microfiltration, advanced oxidation, etc.) to achieve high quality water. The RO process creates reject water (brine) that requires special disposal either through a deep injection well, evaporation ponds or blending with other water for discharge to an impaired water body.

- Indirect potable reuse with ASR
- Direct potable reuse
- Brackish groundwater desalination
- New surface water right with ASR
- GBRA Canyon Lake water contract increase

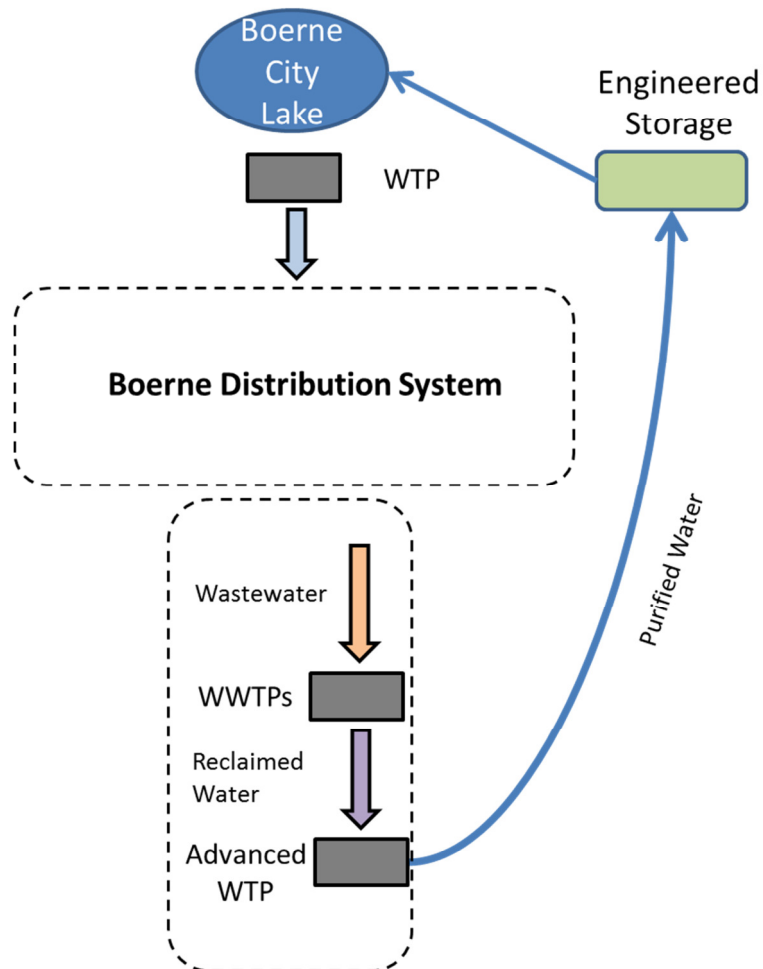


Figure 5-2. Indirect Potable Reuse with Boerne City Lake

5.2.2 Available Yield

Projected available supply for potable reuse alternatives is estimated between 1.8 MGD (2,000 acft/yr) and 3.2 MGD (3,540 acft/yr) in 2070. The RO efficiency rate is estimated at 90% which would reduce the yield of the project by 10%. This 10% is referred to as reject water and would require disposal through deep well injection or some other method. In theory, this IPR supply could be provided to the lake to increase the raw water supply; however, some of the time, the lake would be sufficiently full to curtail adding an additional supply. No study has been conducted to determine how often this would occur. The City has a permitted diversion from BCL of 833 acft/yr. Utilizing Run 3 of the Guadalupe-San Antonio River Basin Water Availability Model (GSAWAM), BCL has a firm yield of 645 acft/yr. The IPR water in this alternative could be used to augment the yield of the lake to the city's permitted amount, but any excess water may either be lost during high inflow periods or limit the capture of some runoff into the lake. Increasing the yield beyond the permitted amount of 833 acft/yr would require an amendment to the City's water rights permit for BCL.

5.2.3 Implementation

Implementation of this water management alternative for the City includes the following issues:

- TCEQ uses a case-by-case regulatory process for potable reuse, which is intended to ensure there is not a single potable reuse system failure. This project requires close coordination with TCEQ to define treatment criteria for expected 5.5 log removal of *Cryptosporidium*, 6 log removal of *Giardia*, 8 log removal of virus after secondary/tertiary WWTP.
- Disposal of reject water from RO process.
- AWTP to be staffed 24/7 by operator with "B" license. Same entity should operate WWTP and the AWTP.
- Source water monitoring for new surface water source per TCEQ Chapter 290.
- Amend existing wastewater discharge permit with TCEQ to add an additional outfall.
- TCEQ may require lake-specific water quality modeling due to discharge into BCL.
- May be required to amend the City's water right for BCL if the diversion exceeds the permitted diversion amount.
- Establish a source control program that limits discharge of toxic contaminants into the wastewater collection system from industries, commercial businesses and residences.
- Monitoring of unregulated constituents to provide data to evaluate the performance of the treatment processes and provide data for public on efficiency and what is being monitored. It is advisable to incorporate water quality performance targets beyond those established by the Safe Drinking Water Act (SDWA).

- Public perception is the main obstacle to continued responsible development of potable reuse.

5.2.4 Operational Flexibility

The IPR at BCL alternative may be able to increase the yield of the lake up to the permitted amount but would not be very effective as a peaking supply since the annual diversion is limited to the permitted amount. Using the lake as storage for this supply would not be as efficient as a system where the purified water is taken directly to the potable distribution system.

5.2.5 Ownership of Water

The city would retain ownership of the reclaimed water, but would need to submit an application for an indirect reuse water right if the supplies are discharged into Boerne City Lake.

5.2.6 Yield for Future Need

This alternative uses reclaimed water, which as a supply, is not adequate to meet all of the projected water needs for the City in 2070.

5.2.7 Engineering and Costing

This alternative was not selected for additional evaluation of costs.

5.3 Indirect Potable Reuse with ASR Alternative

5.3.1 Description

This concept (IPR ASR) is to: (1) provide advanced water treatment to reclaimed water, (2) store the supply in an aquifer with dual-purpose wells (capable of recharge and recovery), and (3) recover the water for summer peaking. For operations, recharge to the aquifer of the reclaimed water would be suspended during recovery operations. The supply of reclaimed water is expected to be rather uniform throughout the year. However, a coordination of reclaimed water between ASR and indirect uses (mostly irrigation) suggests that there would be sufficient reclaimed water for this project during the fall, winter and spring period when irrigation demands are low.

A schematic of the operations is shown in Figure 5-3.

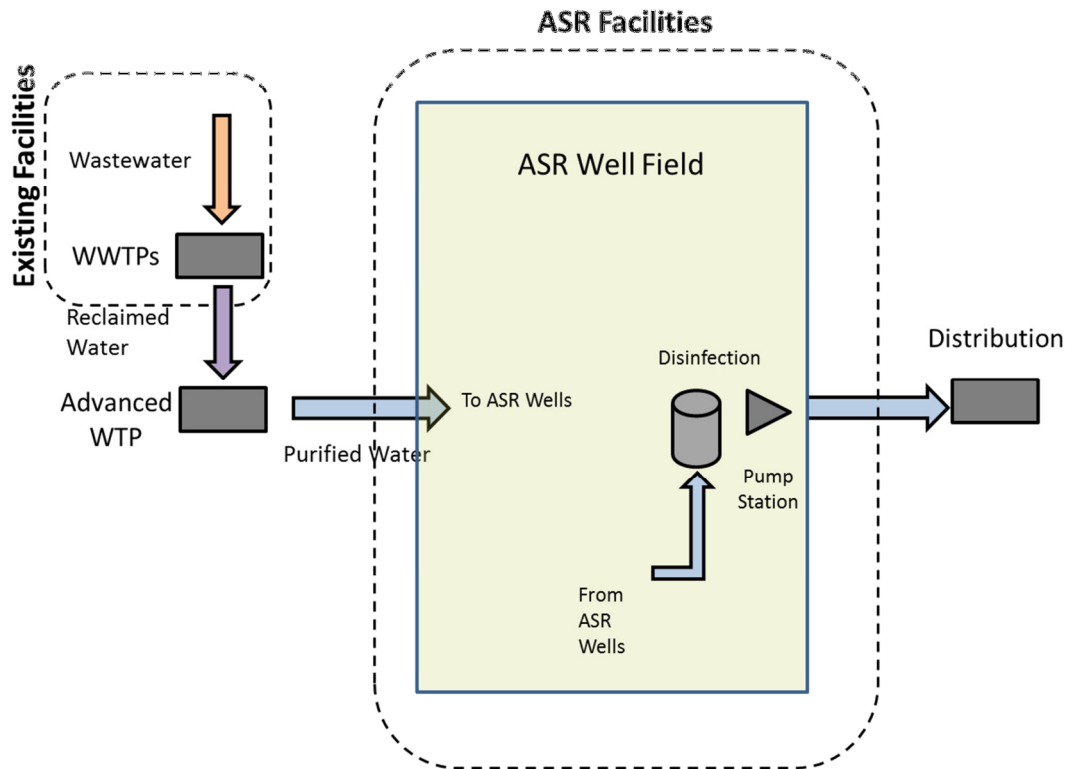


Figure 5-3. Indirect Potable Reuse with ASR

Vicinity of Boerne City Lake

In the vicinity of BCL, the reclaimed water would receive advanced treatment by a new and advanced treatment process at the existing WWTP. New water transmission facilities would deliver the purified water to BCL. An ASR well field in the vicinity of BCL would provide a means of recharging the aquifer and recovering the water. Recovered water would be disinfected and delivered to the existing distribution system at BCL. The recharge operations would occur during non-peaking and non-irrigation season (fall, winter and spring); and recovery would be during the summer. The target aquifer is the Middle Trinity Aquifer (Lower Glen Rose, Hensell Sand and Cow Creek). At this location, the Lower Glen Rose is unsaturated, and groundwater levels fluctuate within the Hensell Sand. With the land surface in the area being about 1,520 ft-msl, and the water table at about 1,160 ft-msl, there is considerable latitude for rises in groundwater levels. Also, with the Lower Glen Rose being unsaturated and Hensell Sand being partly or fully unsaturated much of the time, the storage capacity for a given rise in water levels is much greater in this unconfined section of the aquifer than in a confined section of the Cow Creek.

A review of driller's reports of recently (since 2002) constructed wells in the vicinity of BCL shows few wells, except for a neighborhood on the southwest side of the lake. A review of readily available well records suggests that there are not a significant number, if any, nearby high capacity wells that may divert some of the stored water. However, in the future, drinking water supply wells could be located in the area, which may not be served by the City.

Based on sparse information from high-capacity wells in the area, recharge and recovery rates for extended operations are expected to be about 150 gpm. Normally, the injection rates are about 75 percent of the recovery rates. However, in this setting, the recharge rates are expected to be relatively high because of the overlying unsaturated Lower Glen Rose and part of the Hensell Sand; and, the recovery (pumping) rates are somewhat limited by the available drawdown, which is estimated to be less than 75 ft.

There is always a concern of interaction between surface water features (streams and lakes) and the aquifer, but in the case of BCL, the Upper Glen Rose is nearly impermeable and relatively thick; and, there appears to be a few hundred feet of unsaturated materials between the two. These factors would greatly restrict or prevent stored water in the Trinity from leaking into Cibolo Creek or BCL.

The conceptual design of the well field is to position the wells around the perimeter of the lake, but above the potential flood pool level. Well spacing is proposed to be at 300 ft, which matches Cow Creek Groundwater Conservation District (CCGCD) requirements for a 150 gpm production well. Well depths would be about 550 ft.

A conceptual ASR project with reclaimed water at this location would produce 500 acft/yr and have a peaking factor of 2.0. Operationally, the project would operate for six-month in recharge mode and six-months in recovery mode. With the benefit of the project limited to the six-month recovery period, this project would set the recovery at a rate of 1,000 acft/yr (0.9 million gallons per day (MGD) for six months. The project would require about 5 ASR wells.

Southeast Boerne

In southeast Boerne and in the vicinity of the WWTP, the project concept is the same as the one at BCL, except for the location of the ASR well field. In this case, ASR wells would be located on Boerne-owned property in southeast Boerne and would be screened in the Lower Trinity Aquifer (Sligo and Hosston). In this area, the Lower Trinity Aquifer is substantially separated from the Middle Trinity Aquifer by the Hammett Shale and is rarely used because shallower groundwater supplies can be developed in the Middle Trinity Aquifer, which is the source of water for many wells in this area. Because the quality of the native groundwater in the Lower Trinity Aquifer is largely unknown, the project operations should plan on recovering the same water that was recharged to the aquifer. Because of some recharge water is expected to be lost to blending with native groundwater or drifting, operational plans are to recharge the water over a six month period and to recover water over a four-month period. This allows one to recover about two-thirds of the recharge water.

This alternative would store purified water from an Advanced Water Treatment Plant (AWTP) on a uniform delivery basis in the Trinity Aquifer for additional polishing. The ASR wellfield would be located near the AWTP and the City's production wellfield. The purified water would be recharged into the Trinity Aquifer and recovered during peaking periods. The recovered water would be disinfected and then delivered to the nearest interconnection to the distribution system for blending with other treated potable water.

Well spacing is proposed to be at 300 ft, which matches CCGCD requirements for a 100 gpm production well. Well depths could be up to 900 ft.

A conceptual ASR project with reclaimed water at this location would produce 500 acft/yr and have a peaking factor of 2.0. Operationally, the project would operate for six months in recharge mode and four months in recovery mode. With the benefit of the project limited to the four-month recovery period, a 500 acft/yr project would require the recovery to be at a rate of 1,500 acft/yr (1.4 MGD) for four months. The project would require about 12 wells.

5.3.2 Available Yield

The IPR ASR alternative would provide peaking capacity for the City and reliable supply with projected growth. Projected available supply for potable reuse alternatives is estimated between 1.8 MGD (2,000 acft/yr) and 3.2 MGD (3,540 acft/yr) in 2070 (Table 5-2). Supplies would be available beginning in 2030 to begin recharging the aquifer. The RO efficiency rate is estimated at 90% which would reduce the yield of the project by 10%. This 10% is referred to as reject water and would require disposal through deep well injection or some other method. For evaluation purposes, a 500 acft/yr project would operate under recharge operations for six months out the year, and recovery during 4 months. Recharge into ASR is assumed to occur over six month during the fall, winter and spring (November through April). To recover this same amount in four months the system would be designed at 1.3 mgd. For the ASR alternative, the peaking factor for average annual operations is 3.0.

Depending on groundwater levels, nearby pumping and stored volume, some of the stored supply could be lost to other wells; however, the option assumes recovery operations would pump the same total volume as recharged. This assumption is based on native groundwater being suitable for a public supply. As a result, there may be a blend of native groundwater and stored IPR supplies near the end of the recovery cycle.

5.3.3 Implementation

Implementation of the ASR water management alternative for the City of Boerne includes the following issues:

- Acquiring permits from the CCGCD and from TCEQ for ASR construction, operations and storage of IPR water in the Trinity Aquifer. The city may need to obtain an ASR permit from the CCGCD that allows a recharge credit and a pumping debit.
- Test drilling program to define aquifer characteristics and geochemistry and to select target storage zone.
- Complete physical and chemical analysis of produced water for new groundwater source per TCEQ Chapter 290 and compatibility of treated water and native groundwater and of treated water and aquifer material.
- Detailed groundwater modeling tests are needed to formulate an effective and efficient operations plan.
- Development of a management plan to efficiently use the ASR wells and implementation of SCADA system to operate the recharge and recovery of the wells.

- Potential for drawdown into the screened interval of a well, which can cause aeration and accelerate biologic activity. Periodic redevelopment or rehabilitation may be required if well screens become clogged.
- Operational skills during recharge are needed to maintain positive pressure on the pump or casing during the recharge cycle.
- TCEQ uses a case by case regulatory process for potable reuse, which is intended to ensure there is not a single potable reuse system failure. This project requires close coordination with TCEQ to define treatment criteria for expected 5.5 log removal of Cryptosporidium, 6 log removal of Giardia, 8 log removal of virus after secondary/tertiary WWTP.
- Disposal of reject water from RO process.
- AWTP to be staffed 24/7 by operator with “B” license. Same entity should operate WWTP and the AWTP.
- Establish a source control program that limits discharge of toxic contaminants into the wastewater collection system from industries, commercial businesses and residences.
- Monitoring of unregulated constituents to provide data to evaluate the performance of the treatment processes and provide data for public on efficiency and what is being monitored. It is advisable to incorporate water quality performance targets beyond those established by the SDWA.
- Public perception is the main obstacle to continued responsible development of potable reuse.

5.3.4 Operational Flexibility

The IPR ASR alternative would provide peaking capacity for the City and reliable supply with projected growth.

5.3.5 Ownership of Water

The city would retain ownership of the purified water in the ASR; however, increased residence time in the aquifer could diminish the high quality of the purified water. The City would need to work with the CCGCD to determine an accounting system for the recharge supplies to obtain pumping credits.

5.3.6 Yield for Future Need

This alternative uses reclaimed water, which as a supply, is not adequate to meet all of the projected water needs for the City in 2070.

5.3.7 Engineering and Costing

Major assumptions include:

- The project site is in southeast Boerne.
- A Lower Trinity Aquifer well can produce nearly 100 gpm in the target area.

- Injection rate is estimated at 75 gpm per well in the target area
- The depth to the base of the Lower Trinity Aquifer is about 900 ft.
- The ASR wellfield would be located on city property.
- 3,000 foot injection well at 100 gpm for RO reject disposal.

Major design features include:

- The 1 MGD AWTP would treat the treated wastewater effluent with: (1) Low Pressure Membranes, (2) Reverse Osmosis, and (3) Advanced Oxidation to achieve required water quality before sending the water to the recharge wellfield for an additional buffer.
- Twelve Lower Trinity Aquifer ASR wells with spacing of 300 ft or greater. Two of the wells are considered to be contingency or standby wells.
- A total of 4 monitoring wells for the ASR wellfields.
- The recovered water would be disinfected at the wellfield storage tank and blended with other treated groundwater supplies. Then, the blended water would be pumped into the distribution system.
- Wellfield storage tank and high service pump station
- System would be operated with advanced SCADA.
- A disposal well in a Pre-Cretaceous formation with 1,000 ft of additional piping is used to dispose of the RO concentrate at the AWTP.

A cost summary is provided in Table 5-3. These costs were indexed to September 2013 dollars, consistent with the state-approved regional water planning costing tool. Infrastructure required for the project was estimated using the TWDB unified cost model. As shown, the total cost is estimated to be \$26,625,000. Annual debt service (5.5% for 20 years) is \$2,228,000; and, annual operational cost, including power, is \$1,282,000. This results in a total annual cost of \$3,510,000. The unit cost for 500 acft/yr of treated peaking supply is estimated to be \$7,020 per acre-foot, or \$21.54 per 1,000 gallons. This cost does not include the distribution of the potable water to potential customers.

A major benefit of this alternative is augmenting water supplies during the summer peak season.

Table 5-3. Cost Estimate Summary for Indirect Potable Reuse with ASR southeast of Boerne (September 2013 Prices)

<i>Item</i>	<i>Estimated Costs for Facilities</i>
Transmission Pipeline (8 in dia., 1 miles)	\$341,000
Transmission Pump Station(s) & Storage Tank(s)	\$1,819,000
Well Fields (Wells, Pumps, and Piping)	\$4,926,000
Brine Disposal (Well, Pipeline, Pump Station, Storage Tanks)	\$2,157,000
Disinfection (1 MGD)	\$69,000
Advanced Water Treatment Plant (1 MGD)	\$8,481,000
SCADA and System Integration	\$379,000
TOTAL COST OF FACILITIES	\$18,172,000
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	\$6,342,000
Environmental & Archaeology Studies and Mitigation	\$178,000
Land Acquisition and Surveying (30 acres)	\$191,000
Interest During Construction (4% for 2 years with a 1% ROI)	<u>\$1,742,000</u>
TOTAL COST OF PROJECT	\$26,625,000
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	\$2,228,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	\$70,000
Pump Stations (2.5% of Cost of Facilities)	\$59,000
Disinfection	\$41,000
Advanced Water Treatment Plant	\$1,014,000
Pumping Energy Costs (1092352 kW-hr @ 0.09 \$/kW-hr)	<u>\$98,000</u>
TOTAL ANNUAL COST	\$3,510,000
Available Project Yield (acft/yr)	500
Annual Cost of Water (\$ per acft), based on a Peaking Factor of 2	\$7,020
Annual Cost of Water (\$ per 1,000 gallons), based on a Peaking Factor of 2	\$21.54

5.4 Direct Potable Reuse Alternative

5.4.1 Description

The DPR alternative would provide highly treated and purified reclaimed water directly to the City's distribution system where the new supply would be blended with other potable supplies. Purified reclaimed water could be delivered through a 6-mile pipeline to the Boerne City Lake WTP or alternatively through a 2-mile pipeline to the interconnect with the treated Canyon Lake water supply on the southeast side of the City. The current

preferred option is to deliver to the Canyon Lake interconnect. In the future, other interconnects could be available, which would be identified in further development of the alternative. The DPR alternative would utilize treated reclaimed supplies from the existing WWTPs as source water for the Advanced Water Treatment Plant (AWTP), which would use multiple barrier treatment processes including microfiltration, reverse osmosis and advanced oxidation to achieve anticipated log removal requirements. Purified water from the AWTP would be delivered directly to the Canyon Lake interconnect through a new transmission system to be blended with treated water supply. Distinct from the indirect alternatives, better control and quality of the supply is maintained from the AWTP to the distribution system for the DPR alternative.

The AWTP would use RO as part of the process to achieve high quality water. The RO process creates reject water that requires special disposal either through a deep injection well, evaporation ponds or blending with other water for discharge to impaired water body, as shown in Figure 5-4.

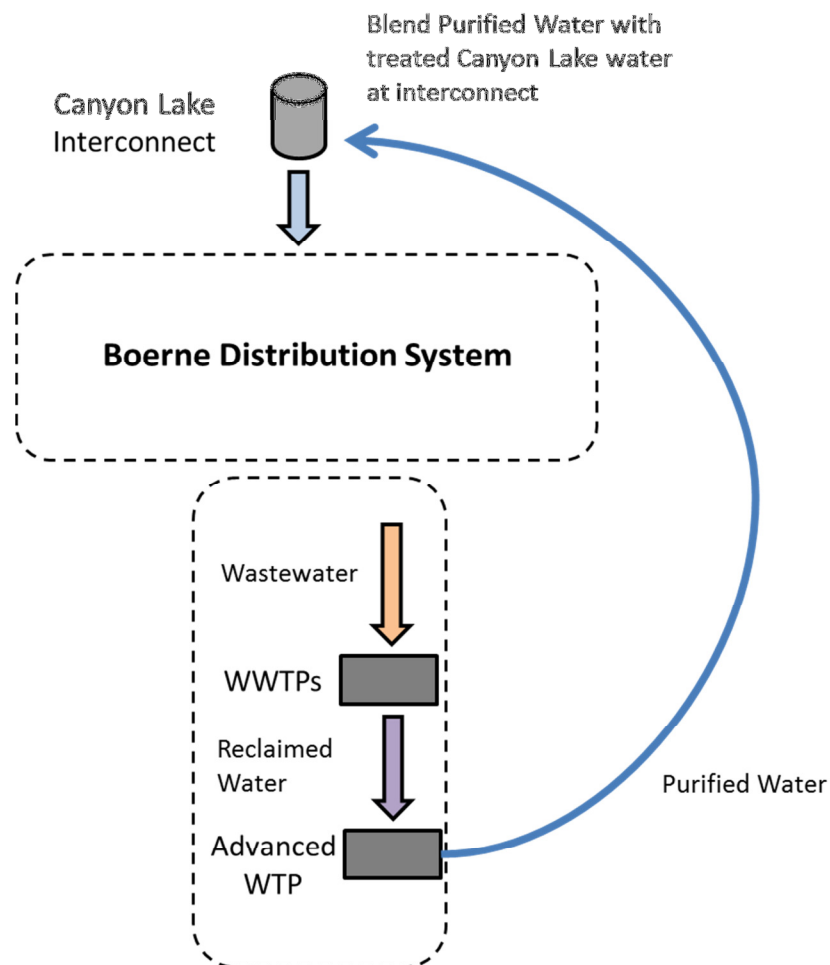


Figure 5-4. Direct Potable Reuse Operation

5.4.2 Available Yield

Projected available supply for potable reuse alternatives is estimated between 1.8 MGD (2,000 acft/yr) and 3.2 MGD (3,540 acft/yr) in 2070 (Table 5-1). This supply would be available at a uniform rate throughout the year. The RO efficiency rate is estimated at 90% which would reduce the yield of the project by 10%. This 10% is referred to as reject water and would require disposal through deep well injection or some other method.

5.4.3 Implementation

Implementation of the DPR alternative for the City of Boerne includes the following issues:

- TCEQ uses a case by case regulatory process for DPR, which is intended to ensure there is not a single DPR system failure. DPR requires close coordination with TCEQ to define treatment criteria for expected 5.5 log removal of Cryptosporidium, 6 log removal of Giardia, 8 log removal of virus after secondary/tertiary WWTP.
- Disposal of reject water from RO process.
- AWTP to be staffed 24/7 by operator with “B” license. Same entity should operate WWTP and the AWTP.
- Establish a source control program that limits discharge of toxic contaminants into the wastewater collection system from industries, commercial businesses and residences.
- Monitoring of unregulated constituents to provide data to evaluate the performance of the treatment processes and provide data for public on efficiency and what is being monitored. It is advisable to incorporate water quality performance targets beyond those established by the SDWA..
- Public perception is the main obstacle to continued responsible development of DPR

5.4.4 Operational Flexibility

The DPR alternative provides a uniform and reliable supply of purified water.

5.4.5 Ownership of Water

Distinct from the indirect alternatives, better control and quality of the supply is maintained from the AWTP to the distribution system for the DPR alternative.

5.4.6 Yield for Future Need

This alternative uses reclaimed water, which as a supply, is not adequate to meet all of the projected water needs for the City in 2070.

5.4.7 Engineering and Costing

Major assumptions include:

- 3,000 foot injection well at 250 gpm for RO reject disposal.
- Purified supply would be blended with treated Canyon Lake supply before introduction to distribution system.

Major design features include:

- The AWTP would treat the treated wastewater effluent with: (1) Low Pressure Membrane, (2) Reverse Osmosis, and (3) Oxidation before sending the water to the WTP as additional buffer and credit toward the required water quality.
- A disposal well in a Pre-Cretaceous Formation with 1,000 ft of additional piping is used to dispose of the RO concentrate at the AWTP.

A cost summary is provided in Table 5-4. These costs were indexed to September 2013 dollars, consistent with the state-approved regional water planning costing tool. Infrastructure required for the project was estimated using the TWDB unified cost model. As shown, the total cost is estimated to be \$37,077,000. Annual debt service (5.5%, 20 years) is \$3,103,000; and, annual operational cost, including power, is \$2,741,000. This results in a total annual cost of \$5,844,000. The unit cost for 3,186 acft/yr of supply at the SWTP is estimated to be \$1,834 per acre-foot, or \$5.63 per 1,000 gallons. This cost does not include the distribution of the potable water.

Table 5-4. Cost Estimate Summary for City of Boerne DPR (September 2013 Prices)

<i>Item</i>	<i>Estimated Costs for Facilities</i>
Pump Stations (3 MGD)	\$1,597,000
Transmission Pipeline (16 in dia., 2 miles)	\$967,000
Disposal Well (Wells, Pumps, and Piping)	\$1,566,000
Brine Storage Tanks	\$598,000
Advanced Water Treatment Plant (3.2 MGD)	\$20,459,000
SCADA and System Integration	\$242,000
TOTAL COST OF FACILITIES	\$25,429,000
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	\$8,850,000
Environmental & Archaeology Studies and Mitigation	\$159,000
Land Acquisition and Surveying (26 acres)	\$213,000
Interest During Construction (4% for 2 years with a 1% ROI)	<u>\$2,426,000</u>
TOTAL COST OF PROJECT	\$37,077,000
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	\$3,103,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	\$32,000
Pump Stations (2.5% of Cost of Facilities)	\$40,000
Advanced Water Treatment Plant	\$2,625,000
Pumping Energy Costs (491391 kW-hr @ 0.09 \$/kW-hr)	\$44,000
TOTAL ANNUAL COST	\$5,844,000
Available Project Yield (acft/yr)	3,186
Annual Cost of Water (\$ per acft), based on a Peaking Factor of 1	\$1,834
Annual Cost of Water (\$ per 1,000 gallons), based on a Peaking Factor of 1	\$5.63

6 Groundwater Supply Alternatives

This section describes the water supply alternatives related to groundwater and includes a description of the hydrogeology of the area. Freshwater and brackish groundwater alternatives are described in this Plan. Project costs are estimated for the brackish groundwater alternative.

6.1 Background

The Trinity Aquifer is the dominate aquifer in the vicinity of Boerne. In addition, an alluvium along major streams may be sufficiently thick and saturated to produce water during normal and wet conditions to supply water to wells. The study area with surface

geology is shown in Figure 6-1 and shows that most of the land surface is the Upper Glen Rose Limestone. Southeast of Boerne and along Cibolo Creek, the Upper Glen Rose has been eroded away, which exposes the Lower Glen Rose at the land surface. Also shown are local occurrences of alluvium. The Trinity Group is overlain by the Fredericksburg Group, which includes the Edwards and associated limestone, and underlain by Pre-Cretaceous rocks¹.

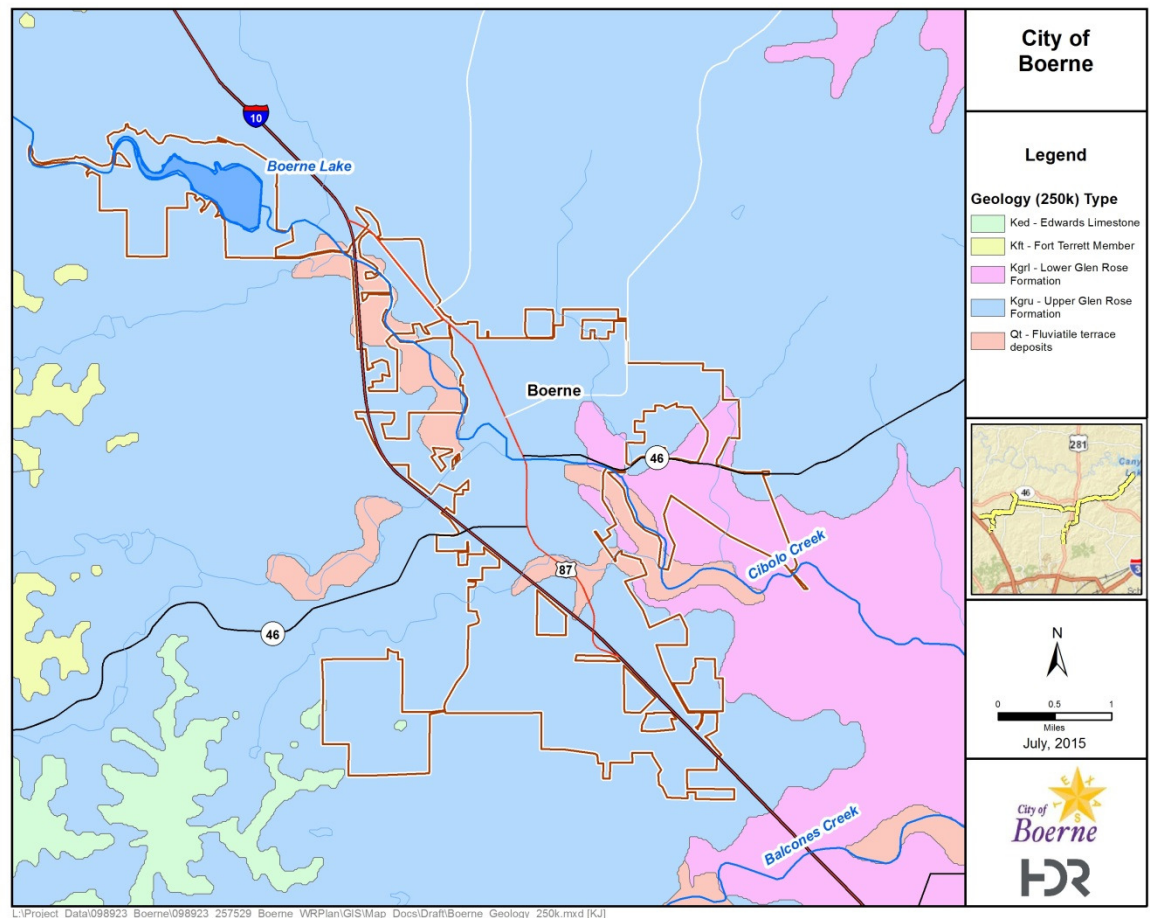


Figure 6-1. Surface Geology

The hydrologic units of the Trinity rocks are divided into the upper, middle and lower Trinity Aquifer. As shown in Table 6-1, the Upper Trinity Aquifer is comprised of the Upper Glen Rose Limestone; the Middle Trinity Aquifer is comprised of the Lower Glen Rose Limestone, Hensell Sand, and Cow Creek Limestone; and the Lower Trinity Aquifer is comprised of the Sligo Limestone and Hosston Sand. The Middle and Lower Trinity Aquifer are separated by the Hammett Shale which functions as a confining bed. A brief description of the stratigraphic units and aquifers is presented in Table 6-1. Figure 6-2 shows a stratigraphic column of at test hole that was drilled by the Texas Water Development Board. This test hole (TWDB Well ID 68-11-718) is located about 0.5 miles northwest of the intersection of Interstate Highway 10 and Texas Highway 46. At this

¹ Ashworth, J.B., 1983, Ground-water availability of the Lower Cretaceous Formations in the Hill Country of South-Central Texas: TWDB Report 273.

location, the Middle Trinity Aquifer is about 420 ft thick and the Lower Trinity Aquifer is 305 ft thick. The most common water-bearing zones for water wells are the Lower Glen Rose, Hensell Sand and Cow Creek. Many of the wells tap more than one water-bearing formation. The water table is usually in the Middle Trinity Aquifer.

Table 6-1. Hydrogeologic Units and Descriptions.

Hydrologic Unit	Stratigraphic Unit	Approximate Thickness near Boerne (ft)	Character of Rocks	Water-Bearing Properties
Upper Trinity Aquifer	Upper Glen Rose	Up to 350	Alternating beds of blue shale, nodular marl, and limestone. Also contains two beds of evaporites	Usually, very small to small quantities of saline water. Much greater well yields and freshwater may occur near karst features
Middle Trinity Aquifer	Lower Glen Rose	250	Limestone grading upward into thin beds of limestone, dolomite, marl and shale. Numerous caves and reefs	Yields small to moderate quantities of fresh to slightly saline water
	Hensell Sand	100	Red to gray clay, silt, sand, conglomerate and thin limestone beds. Grades downward into silty dolomite, marl, shale and shaley limestone	
	Cow Creek	70	Massive limestone, shale, sand and lignite	
Confining Bed	Hammett Shale	60	Dark blue to gray dolomitic shale with thin interbedded layers of limestone and sand	Not known to yield water
Lower Trinity Aquifer	Sligo Limestone	70	Sandy dolomitic limestone	Yields small to large quantities of fresh to slightly saline water
	Hosston Sand	235	Red and white conglomerate, sandstone, claystone, shale, dolomite and limestone	

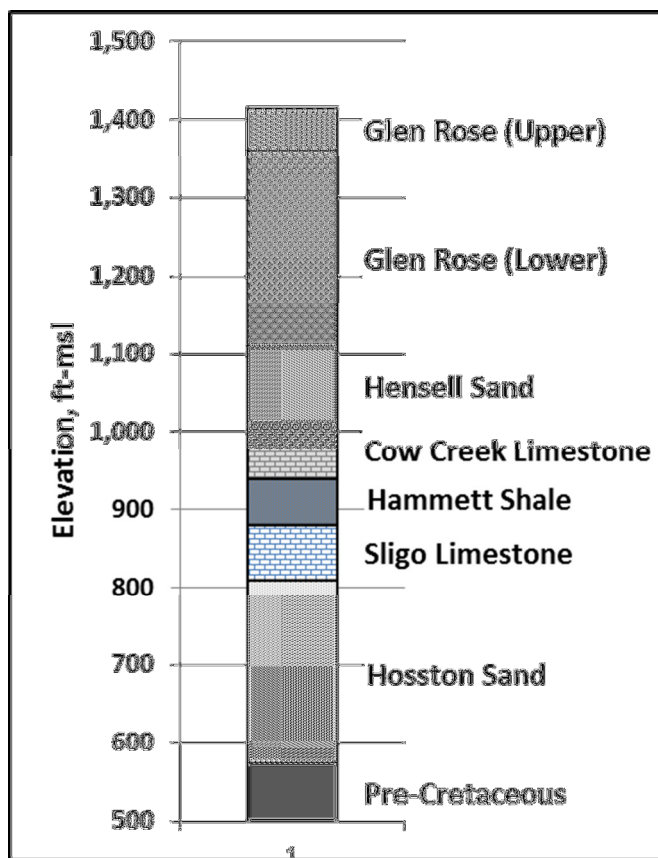


Figure 6-2. Stratigraphic Units in the vicinity of Boerne

Rocks of the Trinity Group dip to the south at about 10 to 15 ft per mi in the western part of the Hill Country and to the east-southeast in the eastern part of the Hill Country. In the vicinity of Boerne, a northeast trending geologic fault near the Kendall-Bexar County line disrupts the regional pattern and causes the rocks to dip to the southwest at about 12 to 15 ft per mi. The Balcones Fault Zone interrupts the regional continuity of the Trinity Group rocks.

Caverns have formed by solution of limestone and evaporites by groundwater movement are common in the Trinity Group, especially in the Glen Rose Limestone. These caverns can extend great distances vertically and laterally and provide major conduits for groundwater flow. Sinkholes are a common occurrence along streambeds flowing over the Glen Rose and Edwards and Associated Limestones and provide a major source of recharge to the aquifer. Karst features (underground conduits, caverns, and caves) are commonly reported to occur in the vicinity of Cibolo Creek east of Boerne. Examples are Cascade Caverns and Cave Without a Name near Boerne, Natural Bridge Caverns near New Braunfels and shallow, relatively high capacity wells in Boerne.

Well yields are reported to vary substantially among the geologic units and laterally within the same unit. A review of drillers report shows that many of the higher capacity wells are completed as open-hole wells across the Lower Glen Rose, Hensell Sand and Cow Creek. Other high capacity wells draw water from the Hensell Sand and/or Cow

Creek. In general, high capacity well yield tend to range between 100 and 250 gallons per minute (gpm). Because of sparse data for high capacity wells and well completions in several geologic formations, a pattern of where the chances are best for a high capacity well is not evident. Some well records show that well sites have been abandoned because of low potential yields.

Regional groundwater levels show a gradient that is consistent with the regional topography of the land surface. They are expected to vary locally around well fields and the karst features in the vicinity of Cibolo Creek. Groundwater level data collected and compiled by the CCGCD for seven monitor wells in the vicinity of Boerne show water levels commonly are at an elevation of about 1,160 ft-msl. Since about 2007, the groundwater levels have fluctuated from about 30 ft on the eastern side of Boerne; and 50-110 ft on the northwest. The groundwater levels show substantial response to high rainfall events and droughts. Absent local high concentrations of pumping, the greater fluctuations indicate lower groundwater availability. For wells on the eastern side, the water levels are above the Hensell Sand, meaning that the Hensell Sand and Cow Creek are fully saturated. For the wells to the north and west, the water levels are in the Hensell Sand, meaning that only the lower part of the Hensell Sand and the Cow Creek will yield water to the well.

In the vicinity of Boerne, the Trinity Aquifer commonly yields freshwater, that is, concentrations of total dissolved solids (TDS) are less than 1,000 milligrams per liter (mg/L). Based on data from water wells in the vicinity of Boerne, the Texas Water Development Board's (TWDB) data base, the median TDS, in mg/L, is 545 for the Upper Glen Rose, 462 for the Lower Glen Rose, 682 for wells open to the Upper Glen Rose, Hensell Sand and Cow Creek, and 740 for the Cow Creek. This suggests that there is a tendency for the water to become slightly more saline with depth. Geophysical logs and some reports indicate that the water in the Sligo and Hosston tends to be slightly saline.

6.2 Cow Creek Groundwater Conservation District

A determination of the CCGCD's accounting of existing permits, of groundwater availability and balance of groundwater for new permits was not made.

For wells in the CCGCD with a production capacity of between 100 and 200 gpm, the spacing from an existing or new well is 300 ft. For 200 to 400 gpm wells, the spacing is 750 ft. The production limits for public water utilities is stated to be one residential connection per four acres of service area. This appears to be most applicable to rural water utilities. Consideration is given to other water supplies.

A cursory review of the CCGCD rules did not find a reference to ASR wells or projects.

6.3 Brackish Groundwater Alternative

6.3.1 Description

This alternative considers increasing the water supply by tapping into brackish groundwater that is not being used by others. This supply could be made available on a continual basis or turned on only during summers and/or drought. Because brackish water exceeds Texas Commission on Environmental Quality's (TCEQ) public drinking

water standards, a conventional brackish groundwater project requires a well field, collection pipelines, desalination water treatment plant, such as reverse osmosis, a means of disposing of the concentrate, and delivery to the distribution system. If the brackish well field was located near Boerne City Lake, there is an opportunity to blend the brackish water with water diverted from BCL for treatment and distribution to customers. This concept eliminates the need for concentrate disposal that often can be a fatal flaw. The exact blending ratios have not been determined because of the lack of readily available data. For conceptual purposes, if the TDS of water in BCL is 500 mg/L, the brackish groundwater is 1,500 mg/L, a target blend is 750 mg/l, the blend would be 1 unit of brackish groundwater for 3 units of water from Boerne City Lake. In other words, a 0.6-MGD supply from BCL could be increased to 0.8 MGD with brackish groundwater. For purposes of this study, the wells will be located on City property around the lake. A schematic illustrating the brackish groundwater project is shown in Figure 6-3.

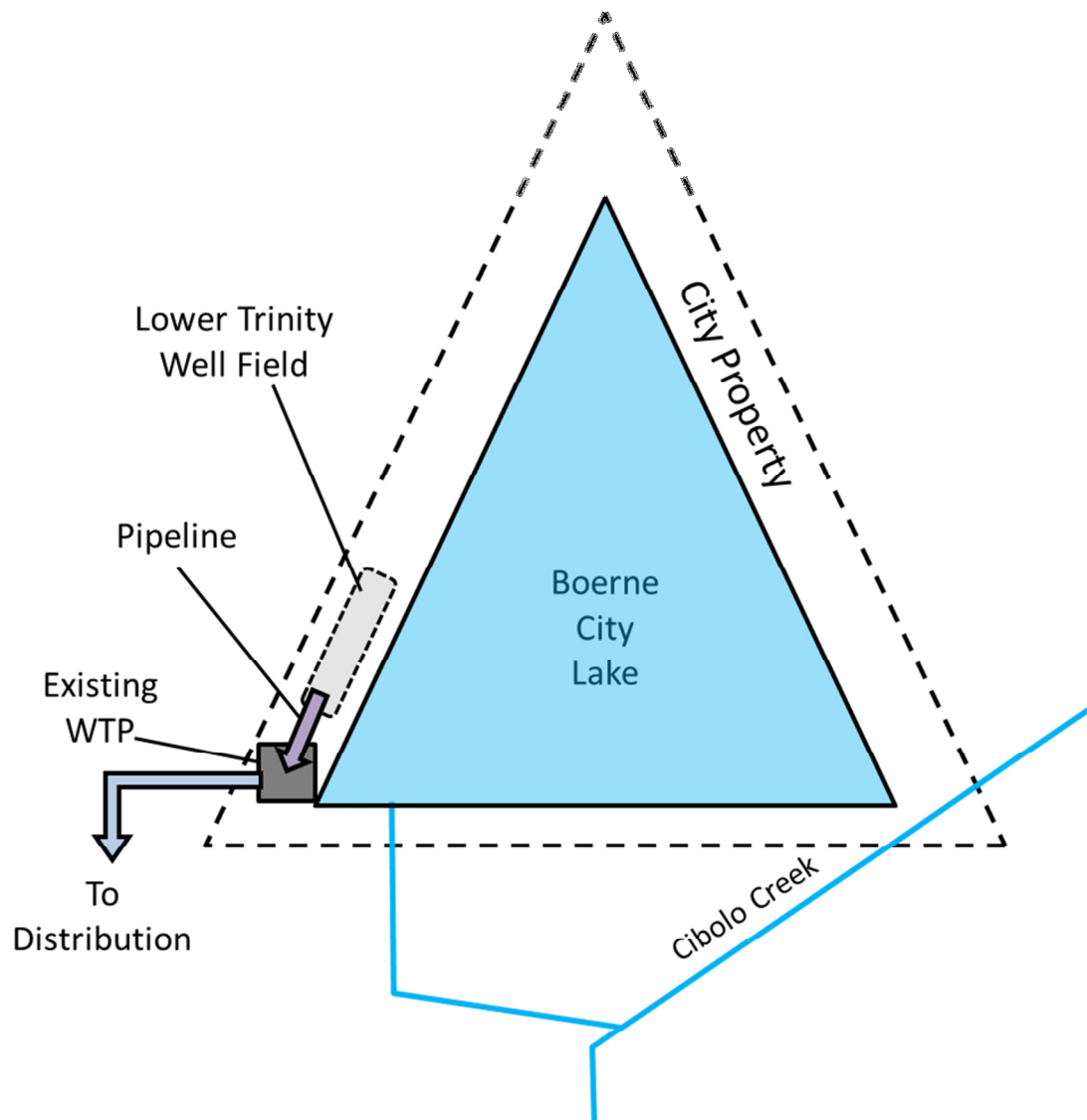


Figure 6-3. Schematic for Brackish Groundwater with Blending from Boerne City Lake Project.

The source of brackish groundwater is assumed to be the Lower Trinity Aquifer (Sligo Limestone and Hosston Sand). This part of the Trinity Aquifer is not tapped or rarely tapped in this area because sufficient groundwater supplies can be obtained from shallower depths (Lower Glen Rose, Hensell Sand, and Cow Creek). Also, the Lower Trinity Aquifer is very significantly isolated from the Middle Trinity Aquifer by the Hammett Shale. Because so few wells are drilled into the Lower Trinity Aquifer in the vicinity of Boerne, its water quality definition is very poor. Based on a few geophysical logs and general statements in reports, the water is expected to be brackish. However, a test drilling program is needed to verify the water quality and aquifer properties.

6.3.2 Implementation

Major issues are expected to include:

- Obtaining approval from TCEQ approval to develop a brackish groundwater supply and blend with a fresher supply.
- Obtaining well and production permits from CCGCD.
- Acceptance of customers for slightly more saline water.
- Uncertainty in the Lower Trinity Aquifer's productivity and water quality will require a test drilling program.

6.3.3 Engineering and Costing

For purposes of this study, a conceptual project assumes a 0.6 MGD supply from Boerne City Lake and a blending ratio of 1:3, the brackish groundwater project would yield 0.2 MGD or up to 224 acft/yr. Average well depth is expected to be about 850 ft and well yields about 100 gpm. The total dissolved solids concentration is estimated to be about 1,500 mg/L. Well spacing is assumed to be 750 ft. A well field of about 2 wells would be required.

Major assumptions include:

- Groundwater in the Lower Trinity Aquifer is a suitable for blending with water from Boerne City Lake.
- Permits can be obtained from CCGCD.
- Water treatment plant can be modified to accommodate disinfection of brackish groundwater and blending with treated lake water.

A cost summary is provided in Table 6-2. These costs were indexed to September 2013 dollars, consistent with the state-approved regional water planning costing tool. Infrastructure required for the project was estimated using the TWDB unified cost model. As shown, the total cost is estimated to be \$1,151,000. Annual debt service (5.5%, 20 years) is \$96,000; and, annual operational cost, including power, is \$20,000. This results in a total annual cost of \$130,000. The unit cost for a long-term average supply of 224 acft/yr of supply at the BCL is estimated to be \$580 per acre-foot, or \$1.78 per 1,000 gallons. This cost does not include any improvements to the distribution system.

Table 6-2. Cost Estimate Summary for brackish groundwater alternative (September 2013 Prices)

<i>Item</i>	<i>Estimated Costs for Facilities</i>
Well Fields (Wells, Pumps, Piping, and Disinfection)	\$642,000
SCADA and System Integration	\$70,000
TOTAL COST OF FACILITIES	\$736,000
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	\$257,000
Environmental & Archaeology Studies and Mitigation	\$138,000
Interest During Construction (4% for 0.5 years with a 1% ROI)	<u>\$20,000</u>
TOTAL COST OF PROJECT	\$1,151,000
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	\$96,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	\$7,000
Pumping Energy Costs (139983 kW-hr @ 0.09 \$/kW-hr)	\$13,000
TOTAL ANNUAL COST	\$130,000
Available Project Yield (acft/yr)	224
Annual Cost of Water (\$ per acft), based on a Peaking Factor of 3	\$580
Annual Cost of Water (\$ per 1,000 gallons), based on a Peaking Factor of 3	\$1.78

6.4 Fresh Groundwater Well Alternative

The conventional alternative for Boerne and others has been to add new Trinity Aquifer wells to the water system. This alternative is relatively inexpensive, largely because the source water is fresh, needs only disinfection, and can be pumped directly into the distribution system. As the area has grown and many new wells have been installed, suitable high capacity well sites have become rather limited.

For purposes of this plan, the Trinity Aquifer well alternative is sited on the southeast side of Boerne and either on or near Boerne City Park or one of the high schools in the area. The well would be about 400 ft deep and produce an estimated 100 to 200 gpm. Disinfection to the raw water would occur at the well head. The treated water would be injected directly into the distribution system. The new well would produce about 0.30 MGD of peaking capacity.

6.4.1 Implementation

Major issue expected to be:

- Acceptance for additional groundwater production by neighbors, City officials and CCGCD.

6.4.2 Engineering and Costing

Although this alternative was not selected by the City for full development of a cost estimate, for comparison purposes to the other alternatives, costs associated with developing a new fresh water public-supply well were estimated from the TWDB regional water planning costing tool. For a 175-gpm, 300-ft well, the cost would equal approximately \$240,000. For a 175-gpm, 500-ft well, the cost would equal approximately \$300,000. Assumptions in these estimates include complete installation of the well and pump to include drilling services, materials, pump and control equipment, valves, testing, security fencing, and a small access road. The costs do not include those for a building, surface piping connecting to a transmission/collector pipeline, or power connection costs.

Assuming a peaking factor of 2.0, a 175-gpm well would operate at 87.5 gpm and produce 141 acft/yr per well.

7 Surface Water Alternatives

7.1 Background

This section describes the water supply alternatives related to surface water. Three alternatives are described in this Plan and from these, project costs are estimated for the two recommended alternatives.

7.2 Firm Yield Increase of Boerne City Lake Alternative

Boerne City Lake is permitted for up to 833 acft/yr of water supply. However, recent analyses from the Region L Planning Group indicate that the firm yield is less than the permit. Utilizing Run 3 of the Guadalupe-San Antonio River Basin Water Availability Model (GSAWAM), BCL has a firm yield of 645 acft/yr. A variety of factors limit the firm supply from a reservoir, including sedimentation, evaporative losses, limited inflows, environmental flows, and pass-throughs of inflows for downstream senior water rights.

This surface water alternative specifically investigates whether pass-throughs of inflows for senior water rights in the GSAWAM modeling is a limiting factor for the BCL firm yield. Because of BCL's unique location above the Edwards Aquifer outcrop, many of these calls in reality could be considered futile calls. This is due to the fact that water passed by BCL would not likely affect flows below the Edwards Aquifer outcrop due to the high recharge rate.

If Boerne could demonstrate that the firm supply was limited in the models only and any calls from downstream senior water rights would be futile, the City could potentially petition TCEQ for increased diversions from BCL.

7.2.1 Available Yield

In order to simulate the Futile Call option for BCL, the GSAWAM was modified such that the Upper Cibolo Creek watershed was effectively cut-off from the rest of the river basin. By doing so, only the physical dimensions of BCL, the local evaporative loss, and the inflows would affect the firm yield calculation.

Through this process, the firm yield of BCL was calculated as 645 acft/yr – the same as the previous Region L work. Therefore, the limiting factor is not calls from downstream senior water rights, but rather another local factor.

7.3 Surface Water with ASR Alternative

Two ASR projects are being considered that use surface water as the supply. One is a new surface water right, and the other is a contract expansion with GBRA for treated water from Canyon Lake.

For purposes of this study, ASR projects can be operated in a short-term perceptive for summer peaking or long-term for drought proofing. For summer peaking, treated water would be stored in an aquifer during the fall, winter and spring and recovered during the summer. For droughts, stored water would be accumulated over several years and then recovered during extended drought conditions. As one would expect, the amount of storage for summer peaking operations is much less than for extended drought contingencies. At this time, it is understood that the emphasis should be placed on summer peaking operations.

A consideration in ASR projects is an accounting of the water. If the water is being stored in an aquifer where the native groundwater is brackish, then the operations would need to be designed so that the recover water is the same water that was recharged earlier. However, if the native water is potable, then an accounting procedure with the CCGCD is suggested so that an ASR account would receive credit for recharge water and debit for recovered water. In this case, one would not have to be concerned of other wells diverting the stored water for their use.

7.3.1 New Surface Water Right

Description

The ASR with a new Surface Water Right project stores surplus surface water in an aquifer during normal and high flow conditions. A new surface water right would be junior to all other water rights in the Guadalupe River Basin. As a result, it is considered to be very unreliable. Ideally, one must divert the water to storage at high rates when the water is available, store the water for an extended period of time, and recover the water at low rates during droughts.

The project concept is to: (1) seek a new surface water right, (2) capture the water during normal and high flow conditions, (3) store this water in the Middle Trinity Aquifer, and (4) recover the water during the summer peaking season. The diversion facilities would be immediately downstream of Boerne City Lake and would deliver the water to the existing surface water treatment plant. After conventional treatment, water would be recharged to the Middle Trinity Aquifer. When needed, the water would be recovered, piped to the existing WTP for disinfection and delivered to the existing distribution system. Figure 7-1 presents a schematic of this project.

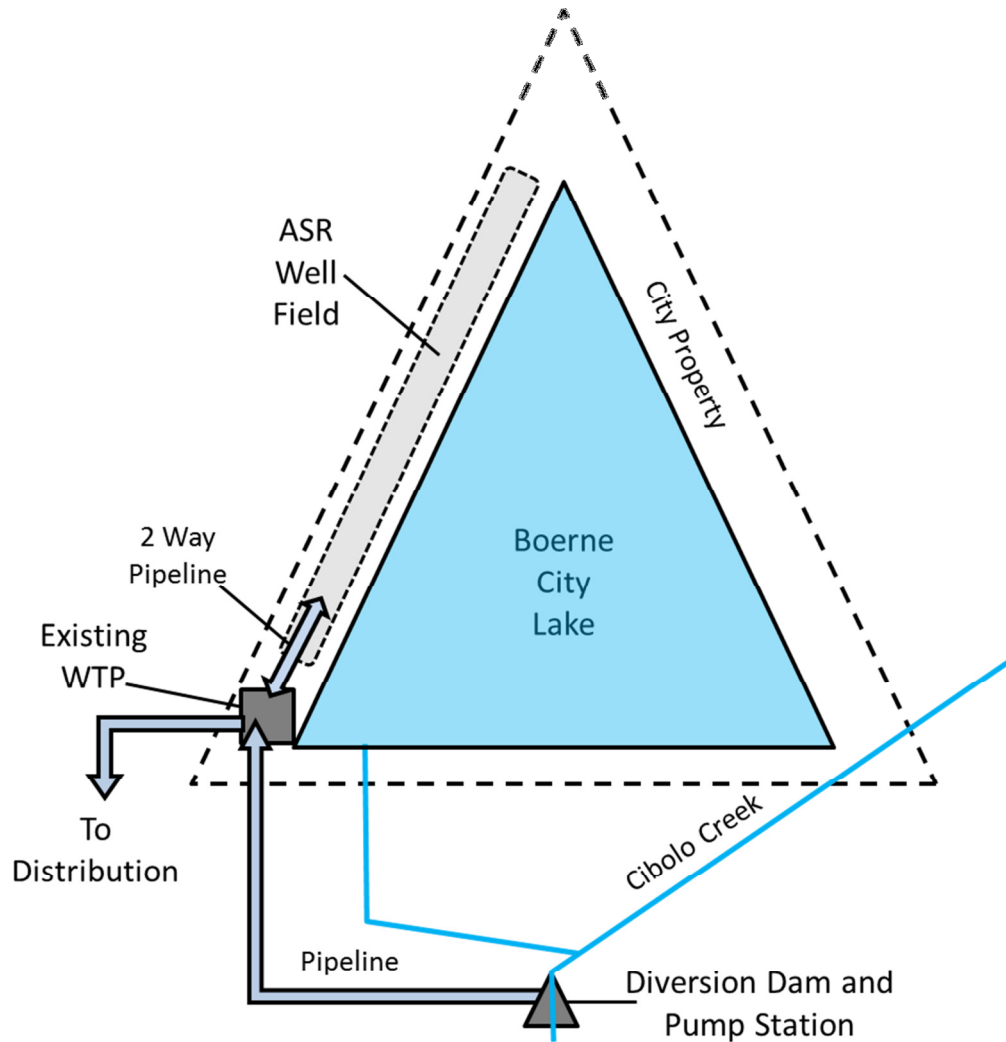


Figure 7-1. Schematic for ASR with new Surface Water Right Project.

Very preliminary plans are to operate the diversion, raw water treatment and recharge for eight (8) months during the fall, winter and spring. As needed, water treatment will be with unused capacity of the existing WTP or by a WTP expansion. Recovery would be during four months when the demands are high. The increase in supply for Boerne is assumed to be equal to the amount of surface water that could be captured from a new surface water right.

The target aquifer is the Middle Trinity Aquifer. At this location, the Lower Glen Rose is unsaturated, and groundwater levels range within the Hensell Sand. With the land surface in the area being about 1,520 ft-msl, and the water table at about 1,160 ft-msl, there is considerable latitude for rises in groundwater levels. Also, with the Lower Glen Rose being unsaturated and Hensell Sand being partly or fully unsaturated much of the time, the storage capacity for a given rise in water levels is much greater in this unconfined section of the aquifer than in a confined section of the Cow Creek. Also, a well field in the immediate vicinity of Boerne City Lake provides a rather large tract of land that is controlled by the City and greatly reduces the potential losses of water to

others wells. However, in the future, drinking water supply wells could be located in the area, which may not be served by the City. If this alternative is further developed, a current evaluation of the location of water supply wells in the area would be completed.

Available Yield

For purposes of this study, a conceptual project would produce 500 acft/yr with a peaking factor of 2.0. Because of the reliability factor, a surface water right of approximately 1,320 acft/yr would need to be obtained with a maximum diversion of 110 acft/mo, which is set to a well field capacity. The yield of 500 acft/yr is approximately equal to the average long-term supply of the project with these assumptions.

Based on a preliminary surface water availability modeling study, the frequency of the water supply ranges from zero to 110 acft/mo. Figure 7-2 illustrates the percent of the surface water right that would be available for the project on and the 8-month recharge window. As shown, for a repeat of hydrologic conditions from 1934-1989, the full supply would be available for about 10 of the 56 years, and no supply would be available for about 15 years. On a long-term average about 56 percent of the supply would be available. If there was a reoccurrence of the 1950s drought, no water would be available for diversion in 9 out of 10 years. It is important to note that these estimates of surface water availability do not account for new environmental flow requirements and are expected to be somewhat lower when a detailed analysis is preformed.

With the benefit of the project limited to the four-month recovery period, a 500 acft/yr project would require the recovery to be at a rate of 1,500 acft/yr (1.4 MGD) over four months. The project would require about 12 wells.

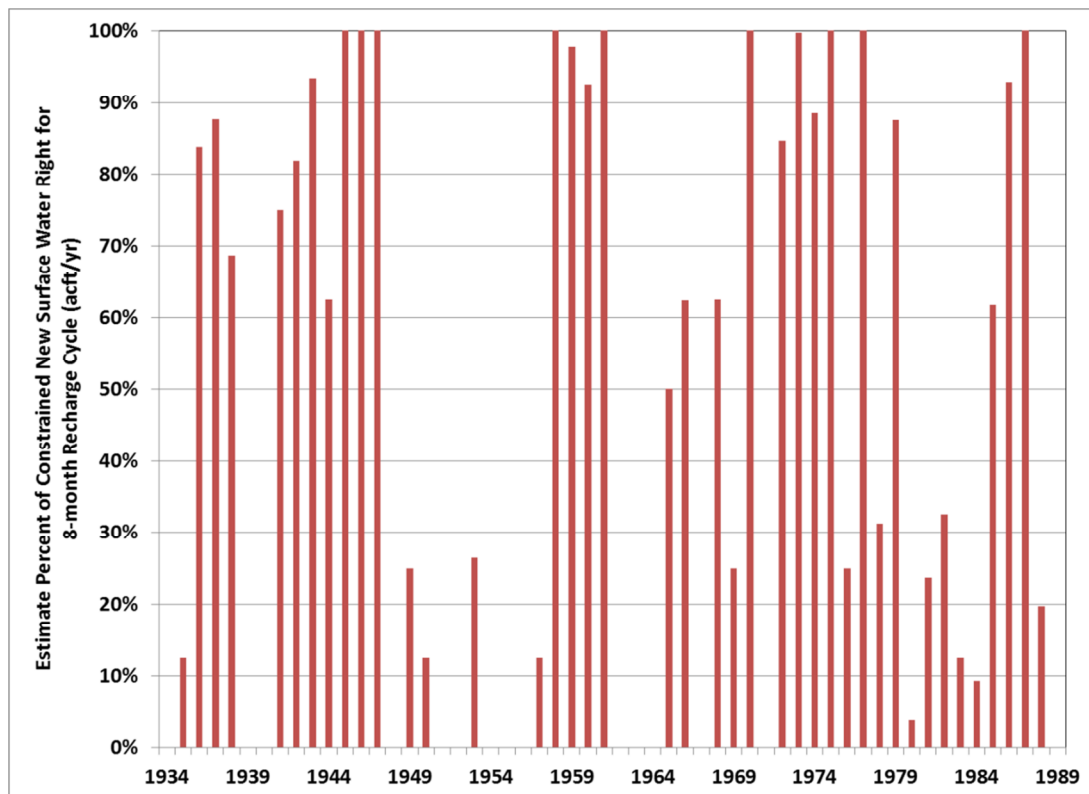


Figure 7-2. Approximate supply from new surface water right immediately downstream of Boerne City Lake Dam.

Implementation Issues

Some of the major issues of ASR with a surface water right may include:

- Obtaining a new surface water right.
- Requirements for TCEQ approval for ASR system.
- There are no written CCGCD rules for ASR.
- Other than at Kerrville, there is no experience on the performance of the aquifer to recharge and recover in the Trinity Aquifer. As a result, an in-depth study that would include test drilling must be undertaken.

Engineering and Costing

Major assumptions include:

- A surface water right for about 1,320 acft/yr is obtained from TCEQ.
- Permits can be obtained from CCGCD.
- The diversion and ASR recharge would occur over an 8-month period during the fall, spring, and summer, and recovery would occur over a 4-month period.

- The Middle Trinity Aquifer is suitable for recharge and long-term storage of treated surface water.
- Existing water treatment plant capacity is available for treatment during the recharge cycle.
- Geochemistry of the aquifer and native groundwater is suitable for an ASR project with treated surface water.
- Preliminary water right availability analyses are reasonably correct.

A cost summary is provided in Table 7-1. These costs were indexed to September 2013 dollars. Infrastructure required for the project was estimated using the TWDB unified cost model. As shown, the total cost is estimated to be \$7,975,000. Annual debt service (5.5%, 20 years) is \$667,000; and, annual operational cost, including power, is \$142,000. This results in a total annual cost of \$881,000. The unit cost for a long-term average supply of 500 acft/yr of supply at BCL is estimated to be \$1,762 per acre-foot, or \$5.41 per 1,000 gallons. This cost does not include any improvements to the distribution system.

Table 7-1. Cost estimate summary for ASR with new surface water right (September 2013 Prices)

<i>Item</i>	<i>Estimated Costs for Facilities</i>
Intake Pump Station	\$1,037,000
Transmission Pipeline (6 in dia.)	\$101,000
Well Fields (Wells, Pumps, and Piping)	\$3,550,000
SCADA and System Integration	\$214,000
TOTAL COST OF FACILITIES	\$5,664,000
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	\$1,977,000
Environmental & Archaeology Studies and Mitigation	\$196,000
Interest During Construction (4% for 0.5 years with a 1% ROI)	<u>\$138,000</u>
TOTAL COST OF PROJECT	\$7,975,000
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	\$667,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	\$37,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	\$43,000
Advanced Water Treatment Plant	\$0
Pumping Energy Costs (691092 kW-hr @ 0.09 \$/kW-hr)	\$62,000
TOTAL ANNUAL COST	\$881,000
Available Project Yield (acft/yr) (See Note)	500
Annual Cost of Water (\$ per acft), based on a Peaking Factor of 3	\$1,762
Annual Cost of Water (\$ per 1,000 gallons), based on a Peaking Factor of 3	\$5.41
* NOTE: The project yield is not firm and depends on availability of a water right. In wet years, 880 acft would be available. In dry years, no water would be available.	

7.4 Expanded GBRA Contract with ASR Alternative

It is understood that: (1) Boerne's water supply contract with GBRA for water from Canyon Lake can be increased: and (2) the water is delivered at a uniform rate. A means of fully utilizing water throughout the year from the existing or expanded contract is to store excess water that would occur during the fall, winter and spring in an ASR system and to recover the water during the summer for peaking demands. This project would increase peaking capacity and provide a means of fully utilizing the base-loaded supply. The proposed operations assume GBRA would provide treated water to Boerne's distribution system. The water would be delivered during the non-peaking season by the existing distribution system to new ASR wells, which would be near the existing distribution system. Candidate sites are school property and parks throughout the City.

Because of the short-term operations on a seasonal cycle where the recharge and recovery is essentially equal, the wells can be closely spaced. Also, location of wells within the City minimizes the potential of water losses to nearby production wells.

The ASR wells would be about 400 ft deep and have a pumping capacity of about 200 gpm and a recharge capacity of about 175 gpm. The wells would be operated in recharge mode about six months and in recovery mode about six months each year. This conceptual project assumes a contract increase of 1,000 acft/yr. This operational plan would increase the summer peaking capacity by 0.89 MGD directly from the contracted supply plus 1.33 MGD from ASR, which results in an increase of 2.22 MGD.

Implementation Issues

Some of the major issues of this alternative may include:

- Increase in contracted water from GBRA and existing water treatment capacity.
- Requirements for TCEQ approval for ASR system.
- There are no written CCGCD rules for ASR, much less for the use of reclaimed water. Thus, some difficulty in permitting should be expected.
- Other than at Kerrville, there is no experience on the performance of the aquifer to recharge and recover in the Trinity Aquifer. As a result, an in-depth study that would include test drilling must be undertaken before a substantial investment in Advanced WTP, pipelines, pump stations and ASR wells is made.

8 Regional Alternatives

Water supply from sources involving purchase of water from another entity or one not necessarily within direct control of the City was considered. Examples of these entities could include the San Antonio Water System (SAWS) or the Guadalupe-Blanco River Authority (GBRA). In addition, an alternative that does not currently exist could become available in the future. As updates of this Plan are completed, evaluation of current options also will be completed.

One regional alternative was selected by the City for planning level cost estimation in this Plan: increase of the GBRA Canyon Lake contract. This alternative is described in further detail below.

8.1 GBRA Canyon Lake Contract Increase Alternative

8.1.1 Description

The City of Boerne currently purchases up to 3,611 acft/yr of treated water from the GBRA out of the Western Canyon Pipeline. Current capacity in the Western Canyon system is fully allocated. However, the GBRA has a planned expansion of the system to be complete by 2050. One alternative for the City is to purchase additional water from GBRA in 2050 and beyond. This supply is considered a long-term water supply and would not be able to be utilized as a peaking resource.

8.1.2 Firm Yield

The Western Canyon system consists of withdrawals from Canyon Lake, treatment, and distribution through a pipeline primarily serving Comal and Kendall Counties. The Western Canyon system is currently sized to deliver up to 11 MGD. Through a water treatment plant expansion and additional pumps, the system can increase supply to 16 MGD.

The City of Boerne could acquire part or all of the additional 5 MGD (about 5,000 acft/yr) of treated water from GBRA for long-term water supply, not available for peaking, beginning in 2050, at a unit cost of \$344/acft/yr, based on the 2016 SCTRWP cost estimate for this supply.

9 Summary and Recommendations

The City of Boerne is experiencing rapid population growth. However, current water supplies from a GBRA contract for Canyon Lake water and limited groundwater and surface water rights causes planning for future water supplies to be necessary. This planning is intended to support the City's commitment in meeting the communities' water supply needs and improving reliability.

Currently, the City obtains its water from surface and groundwater sources. Surface water is withdrawn from Boerne City Lake and treated at a City owned and operated surface water treatment plant at the lake. Other surface water supplies include purchase of treated surface water from Canyon Lake through a contract with the Guadalupe-Blanco River Authority (GBRA). Groundwater is withdrawn from the Trinity Aquifer from nine wells in and near the City. Additionally, the City is continuing to build upon its existing investments in that its reclaimed water is currently being used for irrigation and dust control purposes.

The scope of this project is to: (1) evaluate future water supply demands and needs of its customers through 2070, (2) prepare and describe a list of potentially feasible alternatives from diversified water sources and operational strategies, (3) evaluate selected alternatives by preparing cost estimates and implementation issues, and (4) consider projects that would improve reliability of water supplies.

In the current 2016 SCTRWP, the first water supply need of 650 acft/yr occurs in 2050, and using City of Boerne supply and demand information, the first water supply need of 315 acft/yr occurs in 2040. However, at this time, it is understood that the emphasis for new water supply should be placed on summer peaking operations.

The list of alternatives considered in this Plan, for both new water supply and to satisfy peaking needs, include the following.

Reclaimed Water

- Direct non-potable reuse
- Indirect potable reuse to supplement water in Boerne City Lake
- Indirect potable reuse with aquifer storage and recovery (ASR)

- Direct potable reuse

Groundwater

- Brackish groundwater desalination
- Fresh groundwater supplies

Surface Water

- Increased firm yield of Boerne City Lake
- New surface water right with ASR
- GBRA Canyon Lake water contract increase with ASR

Regional

- GBRA Canyon Lake water contract increase

9.2 Cost Estimate Summary

Through communication with City staff, cost estimates of five alternatives were completed in this study. Recommended alternatives are evaluated at the planning level. In this study, a planning level evaluation includes estimation of the firm water supply of the alternative and a cost estimate to deliver raw or treated water (depending on the alternative) to within close proximity of the City's distribution system, but not full integration into the system.

Future phases of the Plan could include evaluation of integrating the alternative into the City's current water distribution system once it is determined where the proposed water will enter the City's distribution system and a full analysis of the permitting requirements.

Those alternatives that were selected through communication with the City's staff for further evaluation include the following.

- Indirect potable reuse with ASR
- Direct potable reuse
- Brackish groundwater desalination
- New surface water right with ASR
- GBRA Canyon Lake water contract increase

Costs associated with each of these alternatives vary in the method of analysis. Several of the alternatives can provide a long-term supply, while others are meant to alleviate the peaking needs of the City. The reader is referred to the descriptions of each alternative for further details. Below are brief summaries of the costs of each recommended alternative, as well as the estimated cost of a fresh groundwater well. This latter option was not considered a selected alternative in discussions with City staff. However, it is presented for comparison purposes, as a new fresh groundwater well is considered to be the most cost effective alternative.

Indirect potable reuse with ASR

- Available Project Yield (acft/yr): 500
- Annual Cost of Water (\$ per acft), based on a Peaking Factor of 2: \$7,020
- Annual Cost of Water (\$ per 1,000 gal), based on a Peaking Factor of 2: \$21.54

Direct potable reuse

- Available Project Yield (acft/yr): 3,186
- Annual Cost of Water (\$ per acft), based on a Peaking Factor of 1: \$1,834
- Annual Cost of Water (\$ per 1,000 gal), based on a Peaking Factor of 1: \$5.63

Brackish groundwater desalination

- Available Project Yield (acft/yr): 224
- Annual Cost of Water (\$ per acft), based on a Peaking Factor of 1: \$580
- Annual Cost of Water (\$ per 1,000 gal), based on a Peaking Factor of 1: \$1.78

New surface water right with ASR

- Available Project Yield (acft/yr): 500
- Annual Cost of Water (\$ per acft), based on a Peaking Factor of 3: \$1,762
- Annual Cost of Water (\$ per 1,000 gal), based on a Peaking Factor of 3: \$5.41

It is important to note that the yield of this project is not firm and depends on availability of a water right. In wet years, 880 acft would be available. In dry years, no water would be available.

GBRA Canyon Lake water contract increase

- Available Project Yield (acft/yr): 5,000
- Annual Cost of Water (\$ per acft), based on a Peaking Factor of 1: \$344
- Annual Cost of Water (\$ per 1,000 gal), based on a Peaking Factor of 1: \$1.06

The City could acquire part or all of the additional 5 MGD (~5,000 acft/yr) of treated water from GBRA beginning in 2050. The water is not intended for peaking use.

Fresh Groundwater Well

For comparison purposes, costs associated with developing a new freshwater public-supply well were estimated from the TWDB regional water planning costing tool. For a 175-gpm, 300-ft well, the cost would equal approximately \$240,000. For a 175-gpm, 500-ft well, the cost would equal approximately \$300,000. Assumptions in these estimates include complete installation of the well and pump to include drilling services, materials, pump and control equipment, valves, testing, security fencing, and a small access road. The costs do not include those for a building, surface piping connecting to a transmission/collector pipeline, or power connection costs.

Assuming a peaking factor of 2.0, a 175-gpm well would operate at 87.5 gpm and produce 141 acft/yr per well. Unit costs were not developed for this alternative, as it was not a selected alternative of the City's.

9.3 Recommendations

Recommended future work to advance the planning for future water supply needs includes the following items.

- Evaluation of integrating alternatives into the City's current water distribution system once it is determined where the proposed water will enter the City's distribution system.
- Evaluation of integrating the alternatives to accommodate future demands in high growth areas.
- Update the yield of Boerne City Lake. Currently, the modeled yield of BCL is 645 acft/yr. However, with a new topographic survey, which are typically completed by the TWDB, and subsequent updates to the surface water availability model, a more accurate yield can be determined, leading to more informed water supply decisions.
- Evaluation of the reliability of existing supplies from Boerne City Lake and fresh groundwater.
- Test drilling to determine the quality and potential well yield from Lower Trinity Aquifer water wells.
- Test drilling and technical analyses with the possibility of local scale groundwater modeling for potential ASR projects.
- Evaluation of alternatives for disposal of reject water from advanced water treatment plant and desalination projects.

Regulatory and Regional Considerations

- Comprehensive analysis of TCEQ and CCGCD permitting and regulatory requirements for individual alternatives.
- Coordination with CCGCD on the reliability of local, fresh groundwater supplies, availability of brackish groundwater, and permitting and operation of ASR.
- Coordination with the South Central Texas Region L Water Planning Group.