7 Conjunctive Use

7.1 Lake Granger Augmentation

7.1.1 Description of Option

Rapid population growth and development in Williamson County require additional water supplies throughout the planning period. Much of the increased demand is in the southwestern portion of the county in and adjoining the Cities of Round Rock, Leander and Georgetown. This alternative could add up to 48,949 acft/yr (2,684 from Phase I plus up to 46,265 acft/yr from Phase II[1] in 2070) by augmenting the long-term firm yield of Lake Granger with groundwater pumped from the Trinity Aquifer (Phase I) and the Carrizo-Wilcox Aquifer or another aquifer (Phase II). In the initial phase of the project, water from the Trinity Aquifer in eastern Williamson County would be blended with treated water from the East Williamson County Regional Water Treatment Plant (EWCRWTP). In the second phase of the project, additional groundwater would be developed from the Carrizo-Wilcox Aquifer or another aquifer in areas east of Williamson County, such as Milam, Lee and/or Burleson Counties and be blended with treated Lake Granger water. At this time, specific locations for these supplies have not been identified. For the purposes of this plan, it is assumed that these supplies will come from Milam County.

Facilities for Phases I and II are depicted in Figure 7.1-1 and Figure 7.1-2, respectively. Conceptual designs for the various components of these projects are based on studies performed for the Brazos River Authority in 2005[1], 2009[2] and 2014[3].

As an alternative or complement to using blended Trinity Aquifer and Lake Granger water, the Trinity Aquifer could be used for aquifer storage and recovery (ASR). Treated surface water could be stored in the Trinity Aquifer during times of low demand or high flows and recovered for use at a later date. A Lake Granger ASR project is evaluated in Chapter 8 of Volume II.

7.1.2 Available Yield

Phase I – Conjunctive Use with the Trinity Aquifer

Phase I (Figure 7.1-1) would consist of one or more wells constructed in the Trinity Aquifer in eastern Williamson County, which would be blended with treated water from Lake Granger. Water from the Trinity Aquifer in the Lake Granger area is relatively high in

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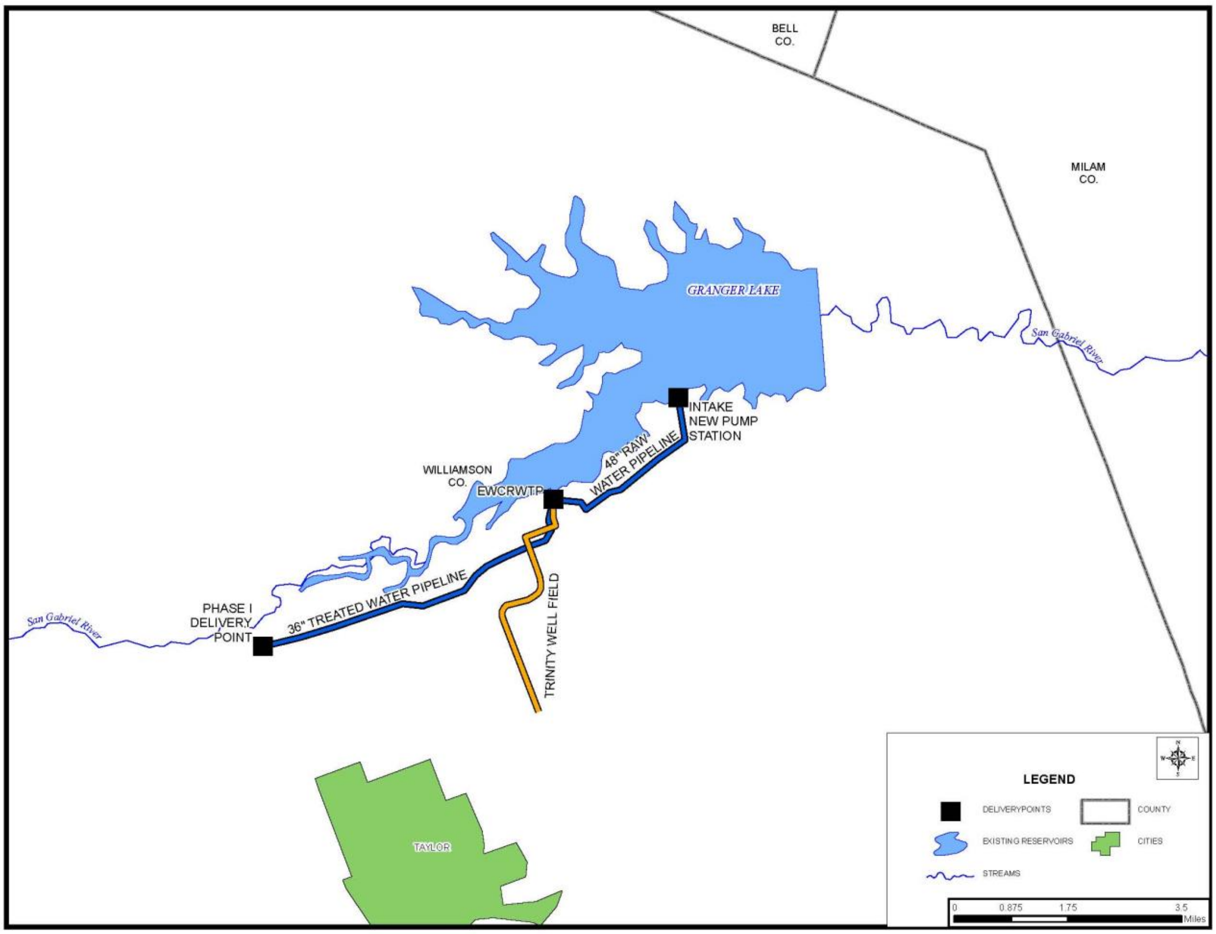
[1] Parsons Brinkerhoff Quade and Douglas, Inc. and Espey Consultants: Williamson County Water Supply Plan Groundwater Procurement, Implementation and Costs, prepared for the Brazos River Authority, July 2005.

[2] R.W. Harden and Associates and Freese and Nichols, Inc.: Assessment of the Use of Trinity Groundwater in Williamson County, Texas, prepared for the Brazos River Authority, July 2009.

[3] R.W. Harden and Associates and Freese and Nichols, Inc.: Results of Test Hole Drilling and Conceptual Design of Permanent Facilities, Trinity Aquifer, Williamson County, prepared for the Brazos River Authority, November 2014.

dissolved solids and a ratio of 3 parts Lake Granger water to 1 part Trinity Aquifer water should meet drinking water standards; however, water from the Trinity Aquifer in Williamson County is fully allocated in Brazos G to meet existing demands and no Managed Available Groundwater (MAG) remains for use by this project. For purposes of preparing costs of the required infrastructure for this analysis, it is assumed that 2,700 acft/yr of supply from the Trinity Aquifer could be made available to Phase I of this project, although the recommended strategy will not include this supply and will not include the Phase 1 infrastructure. Note that the BRA has already constructed a Trinity well as a first step in developing this supply. Assuming sufficient MAG were made available, Phase 1 would supply 2,700 acft/yr in all planning decades.

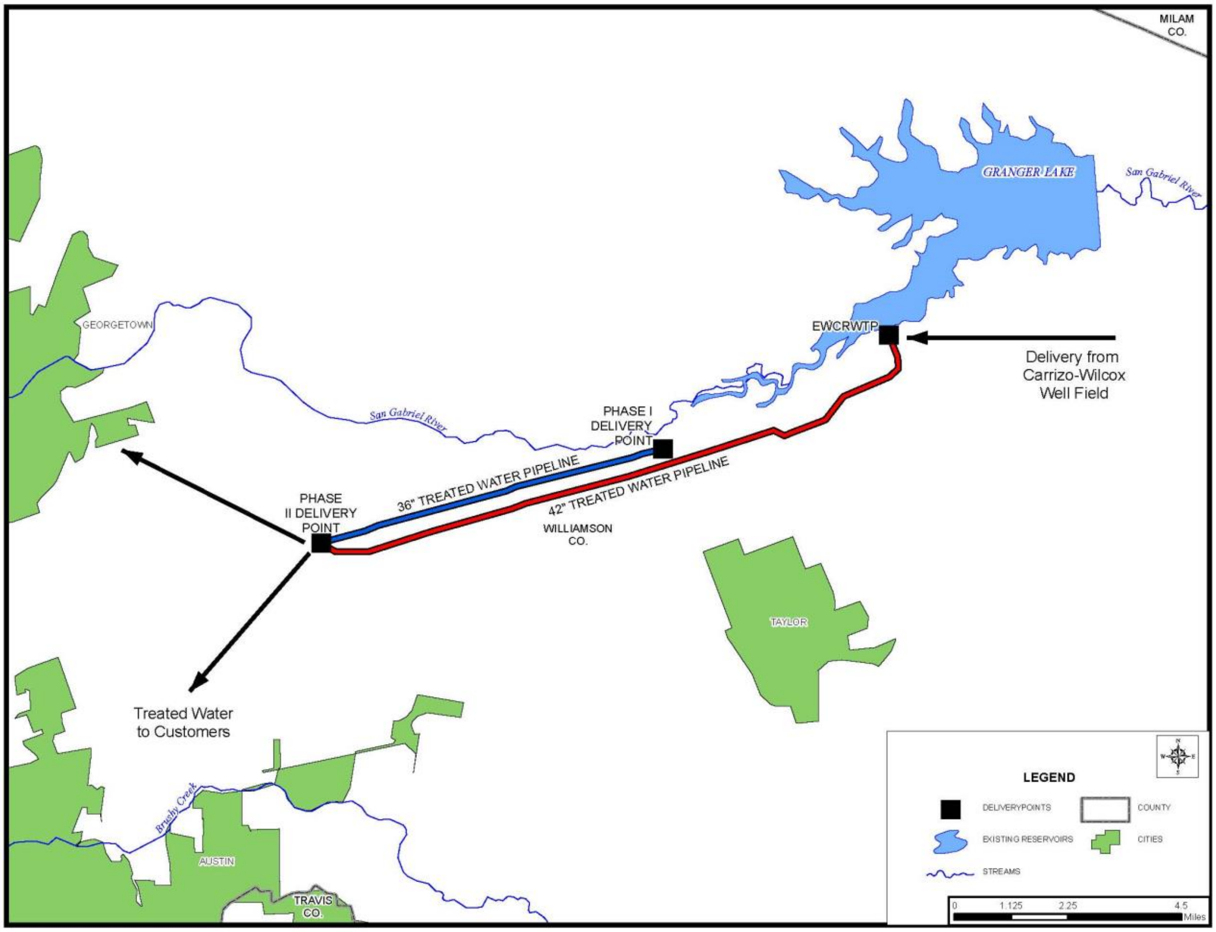
Figure 7.1-1. Phase I – Conjunctive Use with the Trinity Aquifer



Phase II – Conjunctive use with the Carrizo-Wilcox Aquifer

The second phase of the project (Figure 7.1-2) calls for overdrafting Lake Granger during times of high flow, utilizing non-firm surface water authorized by the BRA System Operations Permit. Surface water supplies will be supplemented by water from the Carrizo-Wilcox Aquifer or another aquifer when water from Lake Granger is not available. For purposes of this evaluation, it is assumed that groundwater from Milam County would be utilized.

Figure 7.1-2. Phase II – Conjunctive Use with the Carrizo-Wilcox Aquifer



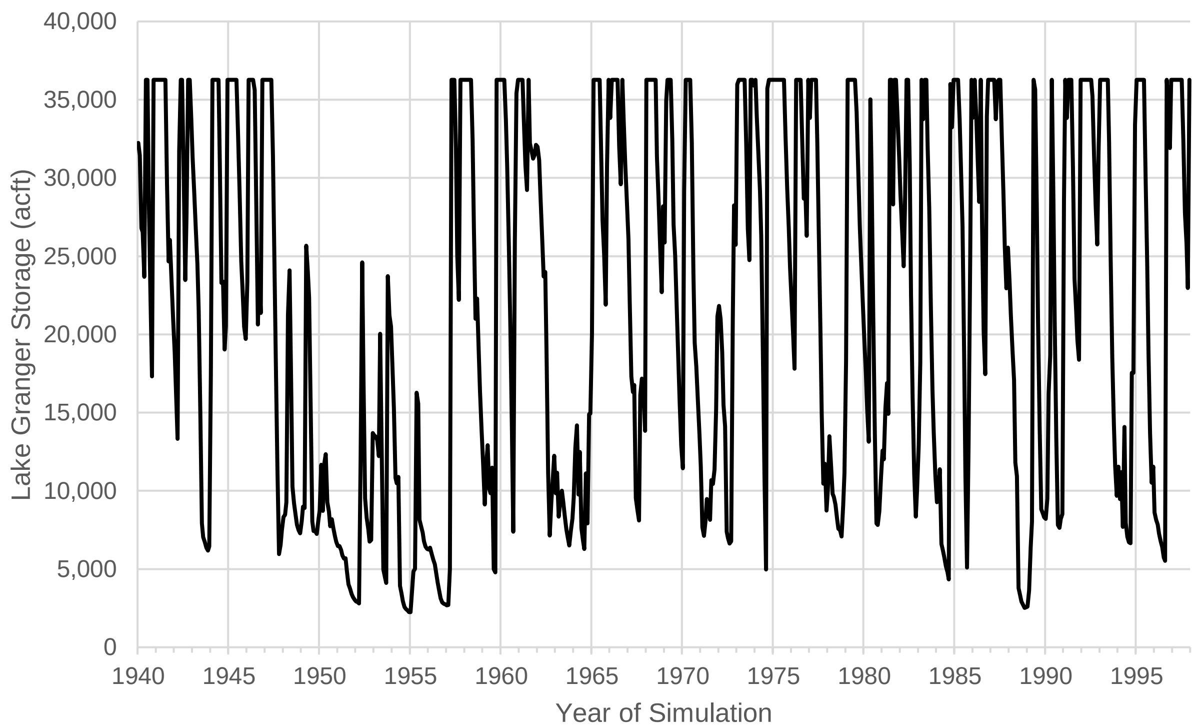
The conjunctive use project would develop a total supply of up to 48,965 acft/yr (2,700 acft/yr from Phase I in 2070 plus up to 46,265 acft/year from Phase II). The 46,265 acft/year supply in Phase II was reported in the 2005 study[4]. A portion of the water from Phase II is used to firm up the 19,840 acft/yr of permitted diversions out of Lake Granger, of which only 11,016 acft/yr are firm in 2070 without the conjunctive use project. EWCRWTP customers and other water utilities who receive supply from Lake Granger are likely candidates for this additional water supply.

[4] Parsons Brinkerhoff Quade and Douglas, Inc. and Espey Consultants: Williamson County Water Supply Plan Groundwater Procurement, Implementation and Costs, prepared for the Brazos River Authority, July 2005.

The TCEQ Brazos WAM (Run 3) was utilized to simulate operations of Lake Granger supplemented with the groundwater pumping. To evaluate this strategy, the WAM was modified to remove Lake Granger from BRA System operations and to simulate projected sediment conditions for Lake Granger in 2070 (all other reservoirs were left at their permitted storages). In the simulation, it was assumed that all of the demand (less the Trinity Aquifer water from Phase I) was taken from Lake Granger until the reservoir was drawn down to 30% of capacity. When the reservoir is 30% full or less, the demand is met by pumping from groundwater. Figure 7.1-3 shows the storage trace for Lake Granger modeled with these assumptions.

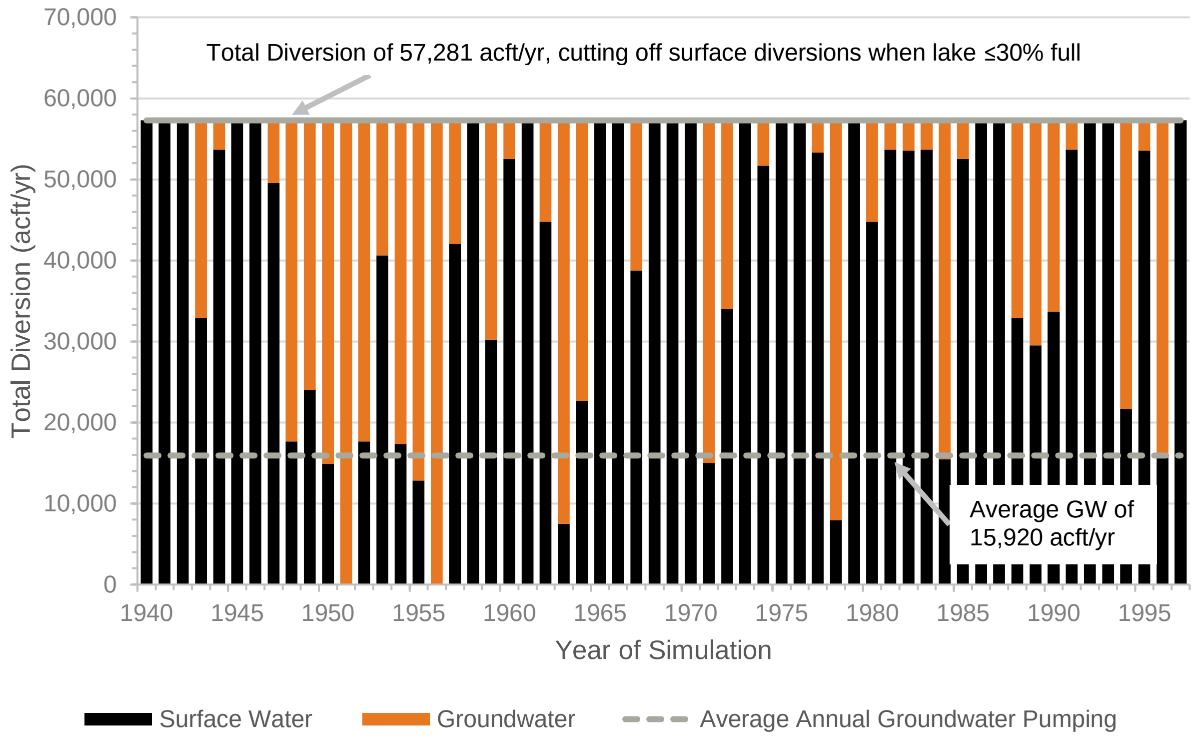
Adding the 8,824 acft/yr used to firm up the permitted (senior) diversions to a new (junior) diversion of 37,441 acft/yr gives a total new project yield of up to 46,265 acft/yr. According to the WAM simulation, this new yield can be achieved with an average annual groundwater pumping of 15,920 acft/yr (Figure 7.1-4). Maximum groundwater pumping in any single year would be equal to the total combined supply of 57,281 acft/yr, as shown in Figure 7.1-4.

Figure 7.1-3. Lake Granger Storage – 2070 Conditions



Note: Storage trace assumes a total diversion of 57,281 acft/yr, of which 19,840 acft/yr is already permitted, and surface water diversions are cutoff if Lake Granger storage drops below 30% of capacity.

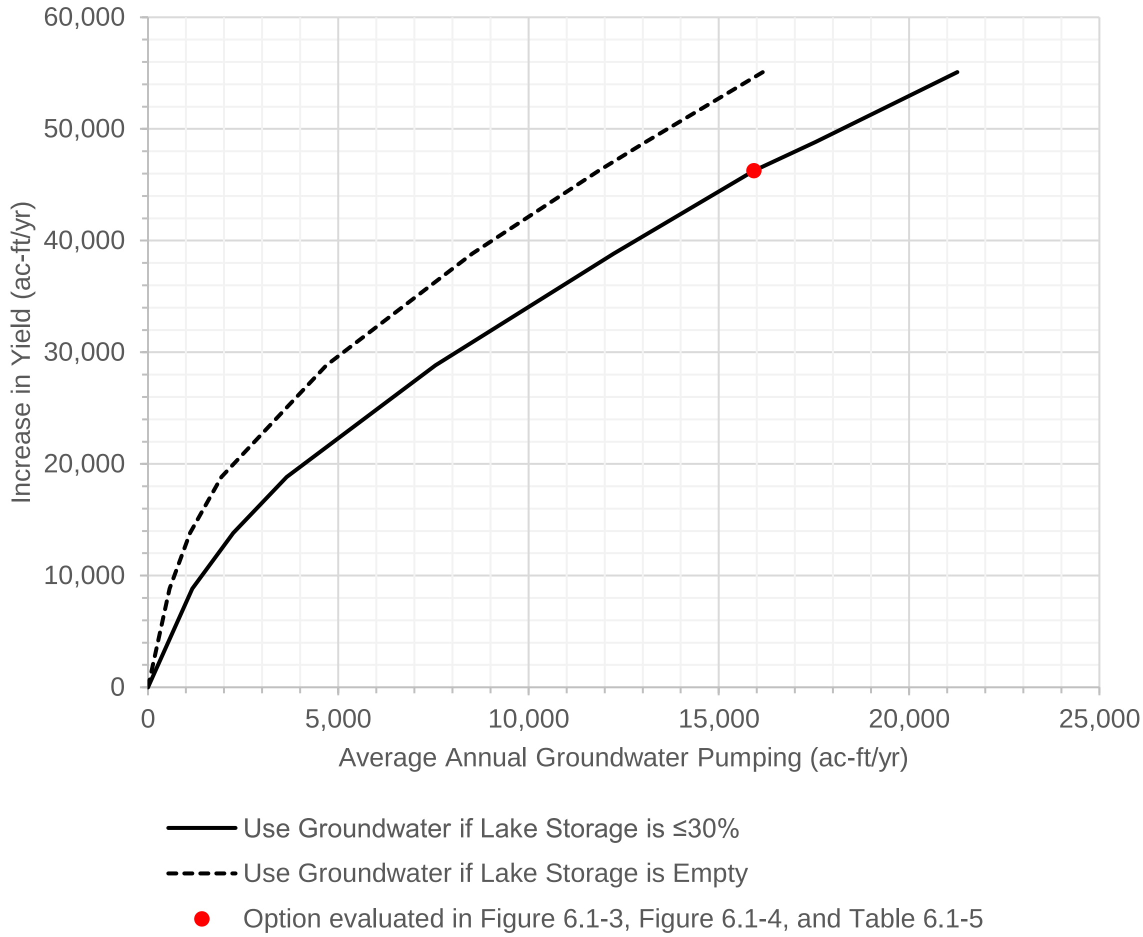
Figure 7.1-4. Distribution of Water Sources for Lake Granger Augmentation – 2070 Conditions



Note: Distribution assumes a total diversion of 57,281 acft/yr, of which 19,840 acft/yr is already permitted but only 11,016 acft/yr is firm in 2070. Surface water diversions are cutoff if Lake Granger storage drops below 30% of capacity.

Average annual pumping from groundwater would be less if the storage in Lake Granger were allowed to drop below 30% before switching to groundwater. Furthermore, the total annual diversion amount could be reduced depending on available groundwater supplies (Figure 7.1-5). Figure 7.1-5 shows how supply from Phase II would vary depending on how the project is operated and how much groundwater is made available. For example, if the reservoir were allowed to go empty the project would generate approximately 9,000 acft/yr of additional yield.

Figure 7.1-5. Relationship between Average Annual Groundwater Pumping and Increase in Yield for Two Operating Policies for Lake Granger Augmentation – 2070 Conditions



The above scenario, as stated, would result in a single maximum groundwater withdrawal of 57,281 acft/yr, which greatly exceeds the MAG remaining after accounting for existing uses. Regional water planning rules do not allow the MAG to be exceeded, even though the average annual groundwater withdrawn from the aquifer would be within the remaining MAG available for this project. Brazos G attempted to develop a MAG Peak Factor for the Carrizo-Wilcox Aquifer in Milam County, but the issue was not supported by the Post Oak Savannah Groundwater Conservation District or Groundwater Management Area 12. Per TWDB requirements, a revised analysis was performed for this conjunctive use project limiting single-year groundwater withdrawals so that the MAG would not be exceeded in any single year. Modeled in this way, the Lake Granger Augmentation project would provide 5,000 acft/yr of new surface water availability in conjunction with 14,168 acft/yr (maximum single year) of groundwater from the Carrizo-Wilcox Aquifer in Milam County. These values for the supply from the project have been entered into the regional water planning database.

7.1.3 Environmental Issues

Environmental impacts could include:

- Possible reduction in flood releases to the San Gabriel River downstream of Lake Granger
- Possible moderate impacts on riparian corridors depending on specific locations of pipelines
- Possible low impacts on instream flows due to slight decrease in groundwater discharges from the Carrizo-Wilcox Aquifer

A summary of environmental issues is presented in Table 7.1-1.

Table 7.1-1. Environmental Issues: Groundwater/Surface Water Conjunctive Use (Lake Granger Augmentation)

Issue	Description
Implementation Measures	Construction of well fields, collection systems, pump stations, pipelines, and expansion of existing water treatment plant
Environmental Water Needs/Instream Flows	Possible impacts on instream flows
Bays and Estuaries	Negligible impact
Fish and Wildlife Habitat	Possible moderate impacts on riparian corridors and upland habitats depending on specific locations of pipelines
Cultural Resources	Possible low impact
Threatened and Endangered Species	Possible low impact
Comments	Assume institutional transfer agreements among water rights owners, suppliers, and users

7.1.4 Engineering and Costing

Facilities for this option are shown in Figure 7.1-1 and Figure 7.1-2, and Table 7.1-2 and Table 7.1-3. For costing purposes, it is assumed that in Phase I potable water supply will be delivered to a point just north of the City of Taylor. In Phase II, delivery would be extended to a point between the Cities of Taylor and Georgetown.

For Phase I, the Trinity Aquifer well field is assumed to require four wells located near the EWCRWTP. Because there is little current use from the Trinity Aquifer in this area, one test well was drilled in 2013 to verify productivity and water quality. Other facilities include a well field collection system, cooling towers, expansions to the EWCRWTP, and a 3.7-mile 36-inch treated water pipeline from EWCRWTP to an existing customer delivery point.

Conceptual designs and construction costs for the various components of these projects are based on studies performed for the Brazos River Authority between 2005 and 2014. The construction costs were updated to September 2018 prices.

The total capital costs for Phase I is $68.6 million as shown in Table 7.1-2. Additional costs for professional services, land acquisition, well mitigation, and interest during construction add $28.1 million for a total project cost of $96.7 million. Annual debt service on this principal amount, calculated on the basis of 3.5 percent interest for 20-year amortization is $6.8 million. Operation and maintenance costs for pumping, transmission, and treatment to deliver a total annual supply of 13,716 acft (11,016 acft/yr from Lake Granger in 2070 plus 2,700 acft/ry from the Trinity Aquifer), as well as groundwater leasing and surface water purchase contracts must be accounted for to arrive at a unit cost of produced water. These additional costs of $4.5 million added to the annual debt service gives a total annual cost for the full project of $11.2 million. For Phase I, the unit cost of water is $819per acft/yr or $2.51 per 1,000 gallons during debt service, assuming the 2,700 acft/yr supply could be made available.

Phase II could provide up to an additional 46,265 acft/yr of supply. The location of the well field for Phase II has not been identified. For the purposes of this study, it is assumed that the well field will be located approximately 44 miles away from the EWCRWTP, located in Milam County. All or part of the required well field may be located in Milam, Burleson, Lee or other counties to the east of Williamson County, and groundwater supplies could originate from either of the Williamson County Groundwater Supply Options (North or South), from the Alcoa Property Supplies (Carrizo-Wilcox Aquifer in Milam County), or a combination of these sources. Groundwater would be gathered by a well-field collection system and transported by parallel 36-inch and 48-inch pipelines (built in phases) to a blending facility near the EWCRWTP. An additional 42-inch treated water pipeline would be built from the blending facility to the Phase I delivery point. Two parallel 38-inch and 42-inch pipelines (also built in phases) would deliver the water to a new customer delivery point between the cities of Taylor and Georgetown. Customers such as Georgetown, Round Rock or County-Other users would need to build treated water pipelines to the delivery point. Costs for Phase II are included here for the infrastructure size needed to develop the entire supply anticipated by the project sponsor. Unit costs and annual costs for water are shown assuming the smaller supply eligible under regional water planning rules.

The Phase II total capital cost is $496.7 million as shown in Table 7.1-3. Additional costs for professional services, land acquisition, well mitigation, and interest during construction add $348.9 million for a total project cost of $845.6 million. Annual debt service on this principal amount is $51.1 million. Annual costs for the new supply of 46,265 acft/yr, as well as groundwater leasing, regulatory groundwater withdrawal fees, and surface water purchase contracts must be accounted for to arrive at a unit cost of produced water. These additional costs of $24.4 million added to the annual debt service gives a total annual cost for the full project of $75.5 million. For Phase II, the unit cost of water is $1,631 per acft/yr or $5.01 per 1,000 gallons under the full supply. Under the reduced supply eligible under regional water planning rules, the unit cost of water is $3,937 per acft/yr or $12.08 per 1,000 gallons. Compensation to BRA may be required if this strategy were developed by an entity other than BRA to compensate for any subordination or use of the System Operations Permit.

Table 7.1-2. Cost Estimate Summary for Phase I of Lake Granger Augmentation (note that Phase 1 is not included in the 2021 Brazos G Plan as a recommended strategy. Costs are shown here to illustrate the project should MAG values change in the future.)

Item	Estimated Costs for Facilities
Trinity Aquifer Well Field (4 wells)	$27,579,000
EWCRWTP Expansions (12.5 MGD)	$33,526,000
Treated water pipeline (36 in. dia., 3.7 miles)	$5,208,000
Transmission Pump Station(s)	$2,250,000
TOTAL COST OF FACILITIES	**$68,563,000**
Engineering, Legal Costs and Contingencies	$23,737,000
Environmental & Archaeology Studies and Mitigation	$302,000
Land Acquisition and Surveying (36 acres)	$252,000
Interest During Construction (1.5 years)	$3,831,000
TOTAL COST OF PROJECT	**$96,685,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$6,803,000
Operation and Maintenance	$2,327,000
Pumping Energy Costs)	$1,059,000
Purchase of Water (13,716 acft/yr @ $76.50/acft)	$1,049,000
TOTAL ANNUAL COST	**$11,238,000**
Available Project Yield (acft/yr)	**13,716**
Annual Cost of Water ($ per acft)	**$819**
Annual Cost of Water ($ per 1,000 gallons)	**$2.51**

Table 7.1-3. Cost Estimate Summary for Phase II of Lake Granger Augmentation

Item	Estimated Costs for Facilities
Well Field (30 wells)	$39,455,000
Pipeline from Well Field to EWCRWTP (36 & 48 in. dia. each 44 miles)	$132,111,000
Blending Facility	$11,648,000
EWCRWTP Expansions (83 MGD)	$108,352,000
Treated water pipeline from delivery to customers (various dia., 68 miles)	$77,342,000
Transmission Pump Stations & Storage Tanks	$125,275,000
Storage Tanks (Other Than at Booster Pump Stations)	$2,488,000
TOTAL COST OF FACILITIES	**$496,671,000**
Engineering, Legal Costs and Contingencies	$163,362,000
Environmental & Archaeology Studies and Mitigation	$4,435,000
Land and/or Groundwater Rights Acquisition	$120,000,000
Land Acquisition and Surveying	$5,799,000
Interest During Construction (3 years)	$55,297,000
TOTAL COST OF PROJECT	**$845,564,000**
ANNUAL COST	
Debt Service for Infrastructure (3.5 percent, 20 years)	$51,051,000
Operation and Maintenance	$14,449,000
Pumping Energy Costs	$5,089,000
Annual Cost to Purchase Water (46,265 acft/yr at assumed $76.50 per acft)	$3,655,000
Annual Groundwater Permitting Cost (15,920 acft/yr at assumed $76.50 per acft)	$1,218,000
TOTAL ANNUAL COST	**$75,462,000**
Available Project Yield (acft/yr)	**19,168**
Annual Cost of Water ($ per acft)	**$3,937**
Annual Cost of Water ($ per 1,000 gallons)	**$12.08**

7.1.5 Implementation Issues

Early significant activity toward implementation of this strategy has been accomplished by the Brazos River Authority via its ownership of Lake Granger water supply, obtaining the System Operation Permit, ownership of the existing water treatment plant on Lake Granger, construction of a test well into the Trinity Aquifer, and pursuit of nearby groundwater supplies. Developing a suitable approach to the evaluated level of groundwater pumping requires additional cooperative agreements with local groundwater districts and landowners.

For this project to be eligible for certain types of state funding under the full supply it can develop, the MAG will need to be increased for the Trinity Aquifer in Williamson County (for Phase 1), and a MAG Peak factor likely will need to be adopted for the Carrizo-Wilcox Aquifer in Milam, Burleson and/or Lee Counties (for Phase 2) to allow the full supply to be developed within regional water planning rules.

This water supply option has been compared to the plan development criteria, as shown in Table 7.1-4.

Potential Regulatory Requirements:

Requirements for permits to use surface water and groundwater, as well as for pipeline construction, will require permits as follows:

- Local groundwater district pumping permits as needed;
- Prior to implementation, the BRA Water Management Plan that is a part of the System Operation Permit will need to be updated to address non-firm appropriations;
- U.S. Army Corps of Engineers Section 404 permits for pipeline stream crossings, discharges of fill into wetlands and waters of the U.S. for construction, and other activities;
- NPDES Stormwater Pollution Prevention Plans;
- TP&WD Sand, Shell, Gravel, and Marl permit for construction in state-owned stream beds; and
- Aquatic Resource Relocation Plan (ARRP) and a relocation permit may be required from TPWD if a dewatering event is required during construction.

Table 7.1-4. Comparison of Lake Granger Augmentation to Plan Development Criteria

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet needs
2. Reliability	2. Uncertain, dependent on acquiring groundwater
3. Cost	3. Reasonable (moderate to high)
B. Environmental factors	
1. Environmental Water Needs	1. Low impact
2. Habitat	2. Low to moderate impact
3. Cultural Resources	3. Low impact
4. Bays and Estuaries	4. Low impact
5. Threatened and Endangered Species	5. Low impact
6. Wetlands	6. Low impact
C. Impact on Other State Water Resources	• No apparent negative impacts on state water resources; no effect on navigation
D. Threats to Agriculture and Natural Resources	• Low to None
E. Equitable Comparison of Strategies Deemed Feasible	• Option is considered to meet municipal and ‘County-Other’ shortages
F. Requirements for Interbasin Transfers	• Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	• None

7.2 Oak Creek Reservoir

7.2.1 Description of Option

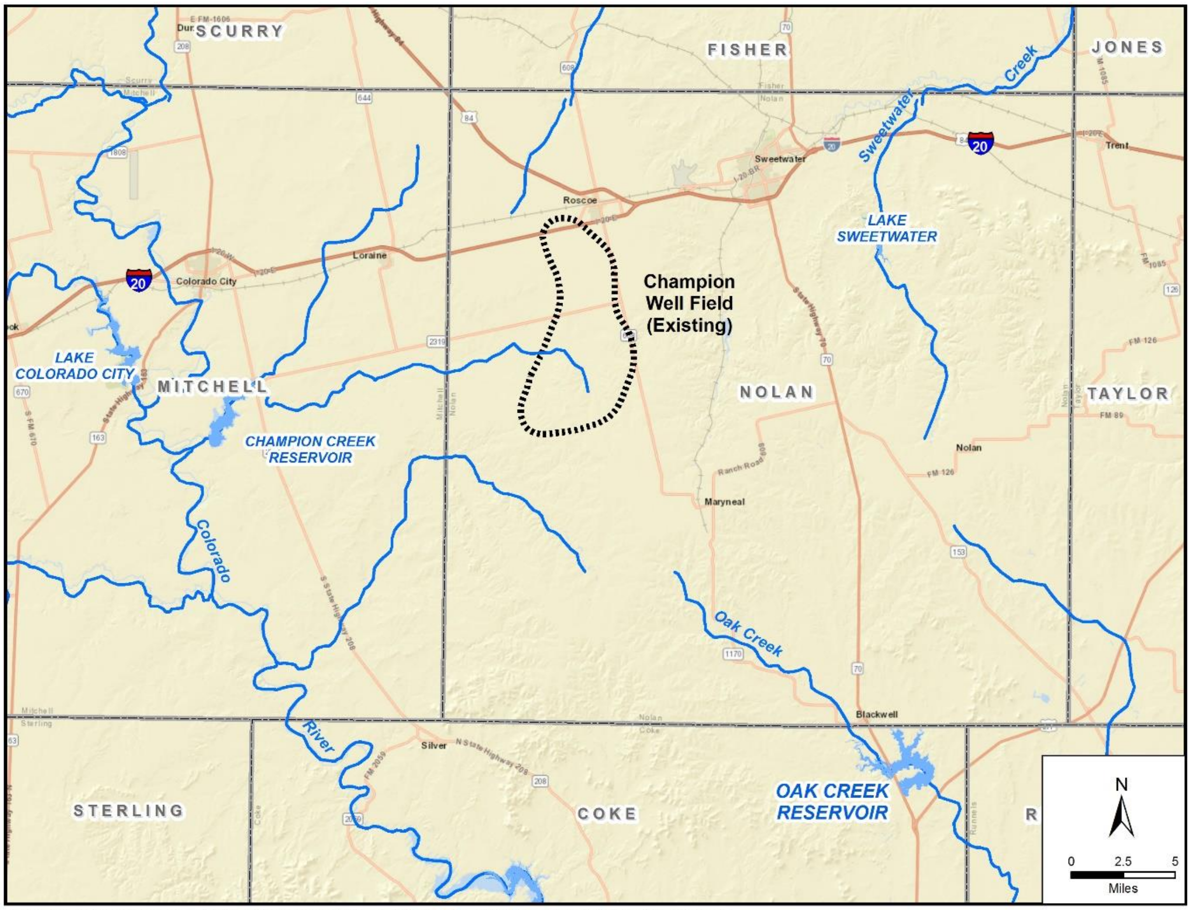
The City of Sweetwater (Sweetwater) utilizes water supplies from the Oak Creek Reservoir in Coke County and the Champion Well Field in Nolan County. The wells are in the Dockum Aquifer. Prior to the drought beginning in 1998, the primary water supply was Oak Creek Reservoir and supplemental supplies from Lake Sweetwater, Lake Trammel and about eight wells in the Champion Well Field. Because of the 1998-2007 drought, the water supplies from the lakes diminished and finally disappeared. As a result, the City installed 35 new wells in the Champion Well Field on an emergency basis. During the latter part of the drought, groundwater from the Champion Well Field was the sole source of supply. Six more wells were added in the summer of 2014, bringing the current well capacity for Sweetwater to a total of 4,142 acft/yr, which would exceed the MAG for the Dockum Aquifer in Nolan County when considered with other existing uses, such as irrigation.

To assess the long-term groundwater supplies from the Champion Well Field and in the general vicinity, a study was conducted for the Brazos G Regional Water Planning Group by HDR, Inc. (HDR) prior to the 2016 Brazos G Plan. This study was partly funded by Sweetwater and consisted of: (1) developing a local groundwater model for western Nolan and eastern Mitchell Counties, (2) evaluating four potential groundwater pumping scenarios in the vicinity of the Champion Well Field with the groundwater model, and (3) evaluating the performance of wells in the Champion Well Field.

Studies of Oak Creek Reservoir by Water Planning Groups in Region F and K have concluded that there is no firm yield for Sweetwater when considering existing senior downstream surface water rights. These studies have noted the feasibility of subordinating downstream rights from Oak Creek Reservoir in the Colorado River Basin to increase local supplies.

The conjunctive management concept for Sweetwater is to use Oak Creek Reservoir and Champion Well Field as parallel supplies. Both the reservoir and the well field will contribute on an average month, but either may be over-drafted when the other supply is low. The maximum annual use of groundwater from the Dockum must remain within the MAG and cannot be surpassed in any given year. This strategy will not involve any new facilities but will be composed of an operational strategy to balance supplies. The locations of Champion Well Field, Oak Creek Reservoir and Sweetwater are shown in Figure 7.2-1.

Figure 7.2-1. Existing Champion Well field and Oak Creek Reservoir Locations



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7.2.2 Available Yield

The Champion Well field has a production capacity of 4,142 acft/yr after the 2014 expansion. However, for regional water planning purposes, the supply availability to Sweetwater is limited to 2,329 acft/yr, consisting of supplies from both the Brazos Basin and Colorado Basin portions of the Dockum Aquifer in Nolan County. An analysis of Sweetwater's demands and water supply contracts shows the maximum demand during the planning period is greater than the City's supply availability. Sweetwater also utilizes water supplies from the Oak Creek Reservoir; however, the reservoir is not a reliable drought supply and has no firm yield without subordination agreements with downstream senior water right holders.

A preliminary analysis was conducted to determine the potential yield increase from operating the City's well field and Oak Creek Reservoir in conjunction to meet demands, with the requisite subordination agreements in place. The analysis balances the use of groundwater and surface water to maximize supplies from the two sources without exceeding the long-term groundwater supply of 2,329 acft/yr. With the proposed subordination agreement assumed in place, conjunctive operation of Oak Creek Reservoir and the Champion Well Field can create an additional yield increase of 1,500 acft/yr without overdrafting the MAG volumes for the Dockum Aquifer in Nolan County.

In the analysis, Oak Creek Reservoir is operated as the primary supply source and is overdrafted during wet periods and underutilized during drought periods. The Champion Well Field is operated as a backup supply source to supplement supplies from the reservoir during drought periods. The storage level in Oak Creek Reservoir was used to determine the commencement of groundwater supplies to supplement surface water supplies. Groundwater supplies commence when reservoir storage levels drop below 40 percent of the storage capacity provides the maximum firm yield of 3,829 acft/yr.

Figure 7.2-2 shows the temporal distribution of annual diversions and annual pumpage to meet the conjunctive use firm yield of 3,829 acft/yr and assumes groundwater supplies commence when storage levels drop below 40% of capacity in the reservoir. The long-term average groundwater use for this strategy is 1,188 acft/yr.

Figure 7.2-2. Simulated Annual Distribution of Water Sources for Conjunctive Use Operations

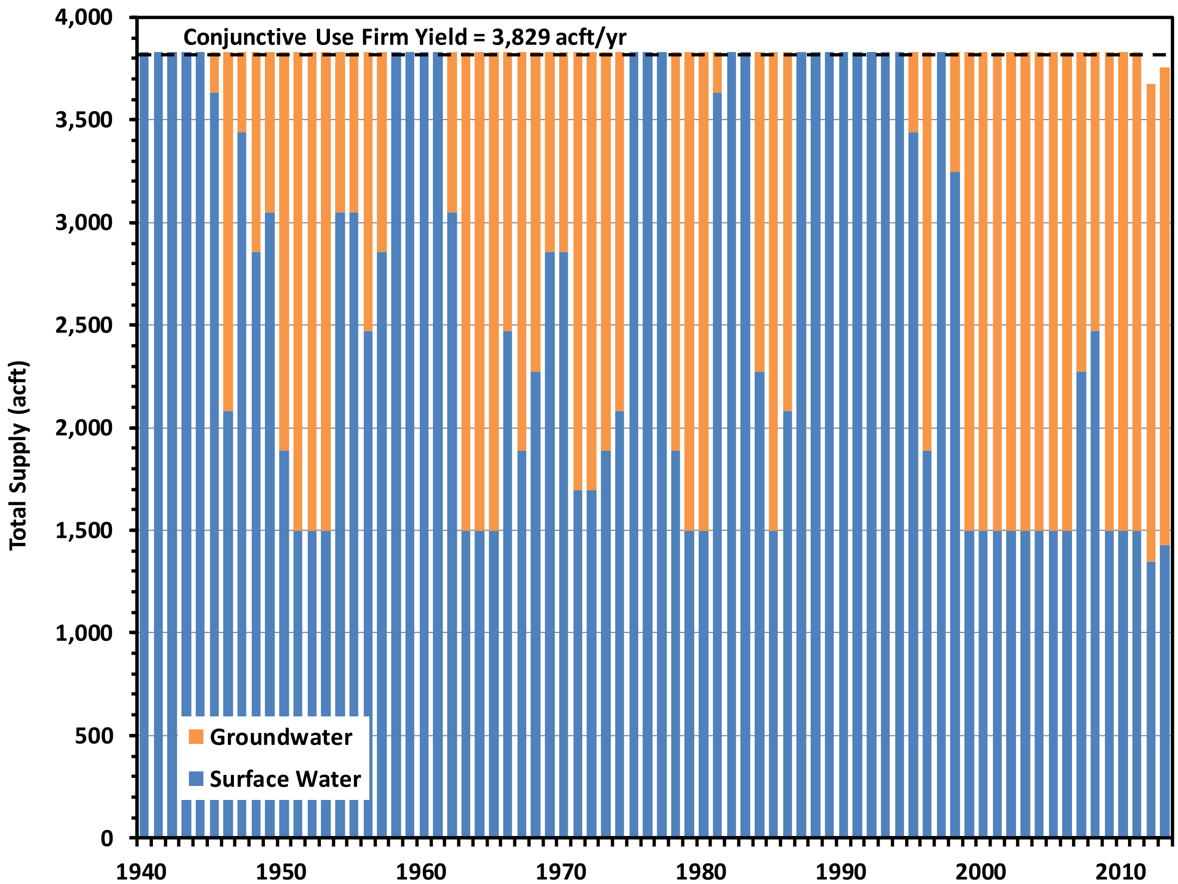


Figure 7.2-2 shows the temporal distribution of annual diversions and annual pumpage to meet the conjunctive use firm yield of 3,829 acft/yr and assumes groundwater supplies commence when storage levels drop below 40% of capacity in the reservoir. The long-term average groundwater use for this strategy is 1,188 acft/yr.

Figure 7.2-2Figure 7.2-3 shows the resulting storage trace for Oak Creek Reservoir under the conjunctive use firm yield demand of 3,829 acft/yr and Figure 7.2-4 provides the resulting storage frequency. The figures show that storage in the reservoir remains less than half full in the simulation for about 75 percent of the time due to the overdrafting of surface water supplies to maximize the conjunctive use yield. The storage trace figure also shows that storage levels were reduced to near zero during the drought conditions occurring the last two decades of the simulation.

Figure 7.2-3. Oak Creek Reservoir Simulated Storage under Conjunctive Use Operations

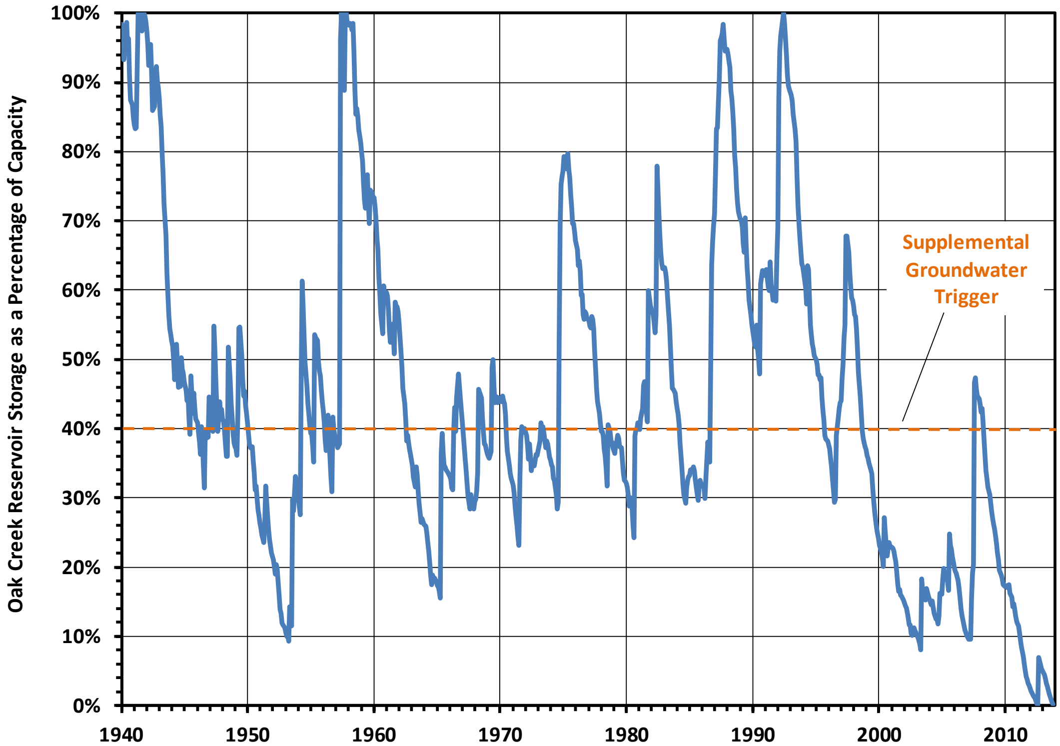
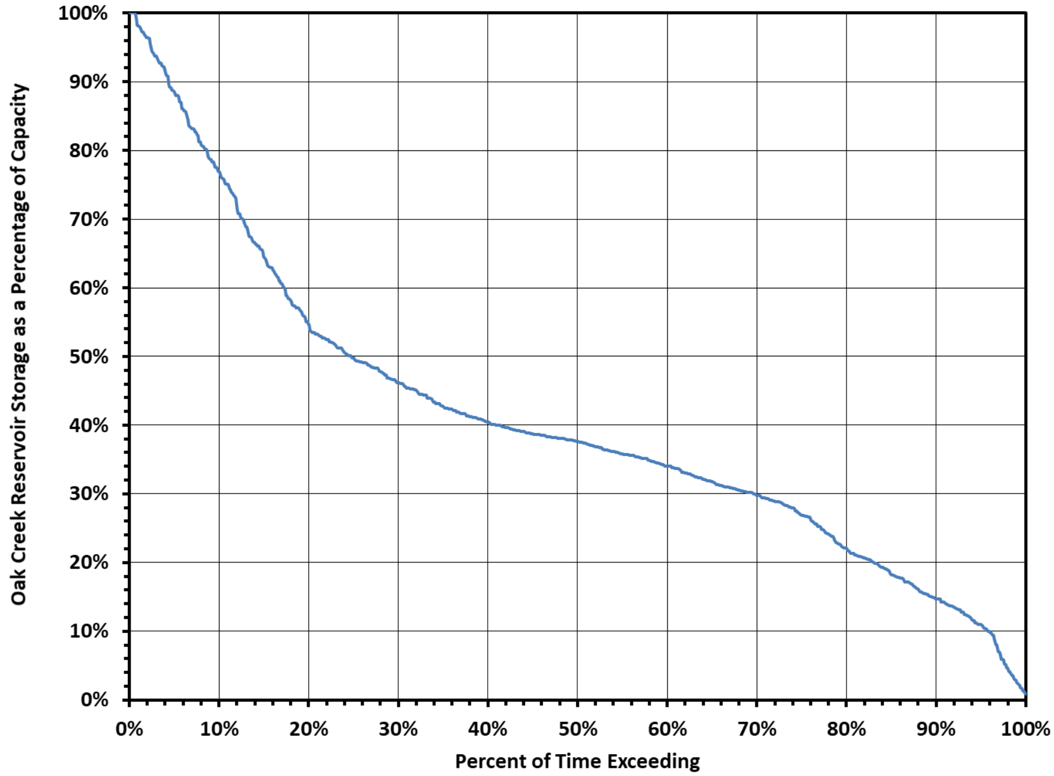


Figure 7.2-4. Oak Creek Reservoir Simulated Storage Frequency under Conjunctive Use Operations



7.2.3 Environmental Issues

There are no new environmental impacts associated with this strategy. No wells, pipelines or other infrastructure is required for this strategy.

7.2.4 Engineering and Costing

No wells, pipelines or other infrastructure is required for this strategy. As a result, there are no costs associated with this strategy.

7.2.5 Implementation Issues

Development of this water management strategy requires the subordination of the senior water rights that are downstream of Oak Creek Reservoir. This issue is discussed in the 2021 Region F Regional Water Plan.

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