6 Conjunctive Use

6.1 Lake Granger Augmentation

6.1.1 Description of Option

Rapid population growth and development in Williamson County require additional water supplies throughout the planning period. The total need for new supplies in Williamson County is about 19,700 acft/yr in the year 2020, increasing to about 167,200 acft/yr by year 2070. 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 will add 53,361 acft/yr (7,096 from Phase I in 2070 + 46,265 acft/yr from Phase II[1]) by augmenting the long-term firm yield of Lake Granger with groundwater pumped from the Trinity Aquifer and the Carrizo-Wilcox Aquifer. 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 in areas east of Williamson County, in Milam, Lee and Burleson Counties. 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 1 and 2 are depicted in Figure 6.1-1 and Figure 6.1-2, 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]. Two alternatives have been studied previously for the second phase of the project. In the first alternative, referred to as the Comingling Option, Carrizo-Wilcox Aquifer water is first pumped into Lake Granger and comingled with natural runoff in the reservoir. The comingled water is subsequently diverted and all of the water is treated at the EWCRWTP. In the second alternative, referred to here as the Bypass Option, groundwater is blended with treated Lake Granger water rather than comingling the water in the reservoir. Because of concerns about blending groundwater in Lake Granger and the additional cost and treatment capacity associated with treating the blended water, current Brazos River Authority planning assumes that the Bypass Option will be used rather than the Comingling Option. The Comingling Option produces a more consistent water quality to the customers than does the Bypass Option.

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

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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.

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. Pending further study ASR is not included as an option in Phase I at this time.

6.1.2 Available Yield

Using the Brazos G WAM, the firm yield of Lake Granger is projected to decline from a yield of 17,017 acft/yr in the year 2020 to 14,192 acft/yr by 2070. Reservoir sedimentation is depleting conservation storage from its original permitted volume of 65,500 acft to a projected volume at year 2070 of 36,271 acft.

Water from the Trinity Aquifer in the Lake Granger area is relatively high in dissolved solids. Phase I envisions blending Trinity Aquifer water with treated water from the EWCRWTP to reduce dissolved solids concentration. A ratio of 2 parts Lake Granger water to 1 part Trinity Aquifer water should meet drinking water standards. As a result, the amount of water available from the Trinity Aquifer is limited by the yield of Lake Granger. Table 6.1-1 shows the potential supply from the first phase of this project, which ranges from about 8,500 acft/yr of additional supply in 2020 to about 7,100 acft/yr in 2070.

This strategy could potentially be provided supply under the BRA System Operation permit (See Section 7.12), currently pending at the Texas Commission on Environmental Quality. If an entity other than the BRA were to sponsor and pursue this strategy, then an agreement with the BRA would be required to address concerns related to the potential subordination of the System Operation strategy.

Table 6.1-1. Potential Supply from First Phase of Lake Granger Augmentation Project (Values in acft/yr)

Source	2020	2030	2040	2050	2060	2070
Granger Lake Firm Yield	17,017	16,452	15,887	15,322	14,757	14,192
Amount of Trinity Aquifer Groundwater	8,509	8,226	7,944	7,661	7,379	7,096
Total	25,526	24,678	23,831	22,983	22,136	21,288

* assumes a 2:1 mixing ratio of Granger to Trinity water

Figure 6.1-1. Phase I – Conjunctive Use with Trinity Aquifer

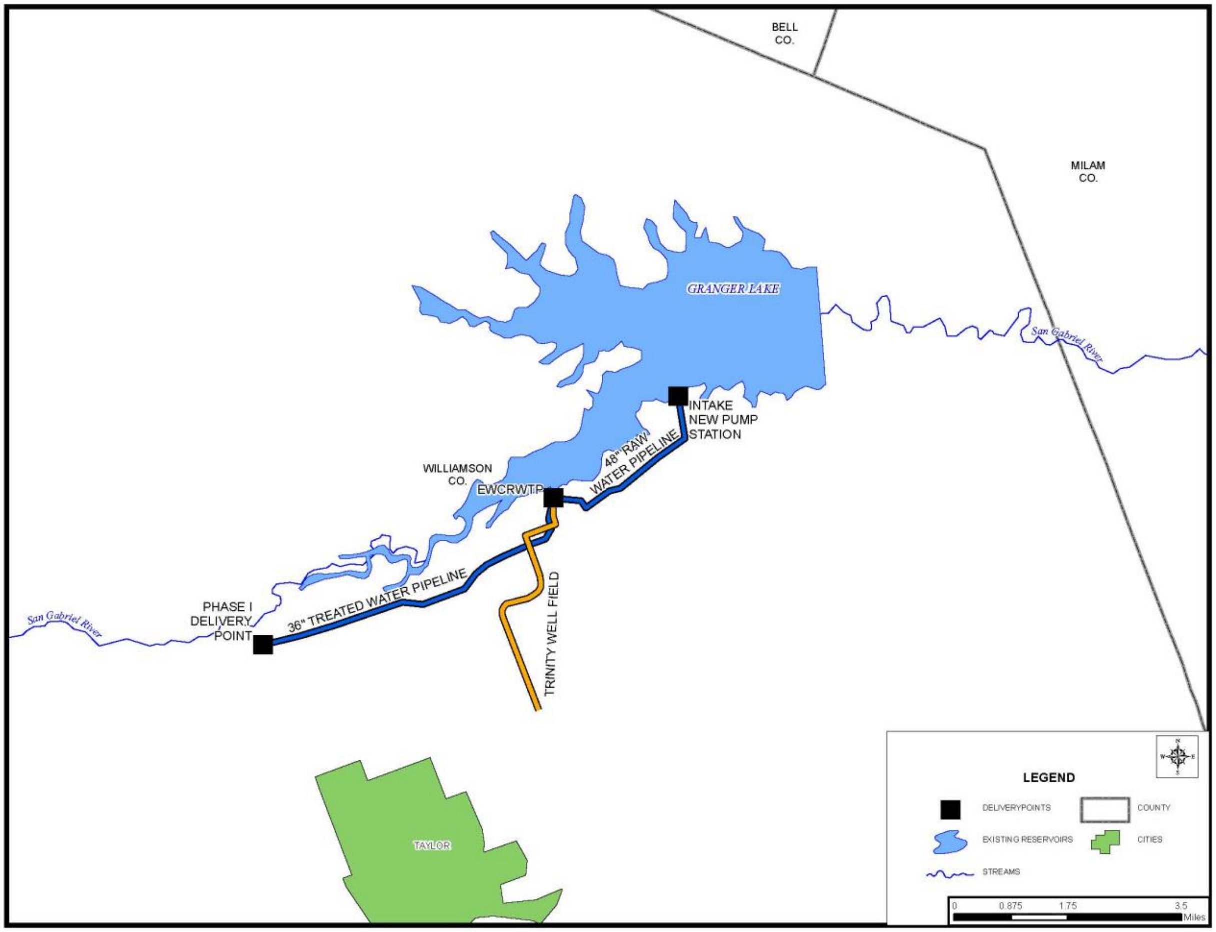
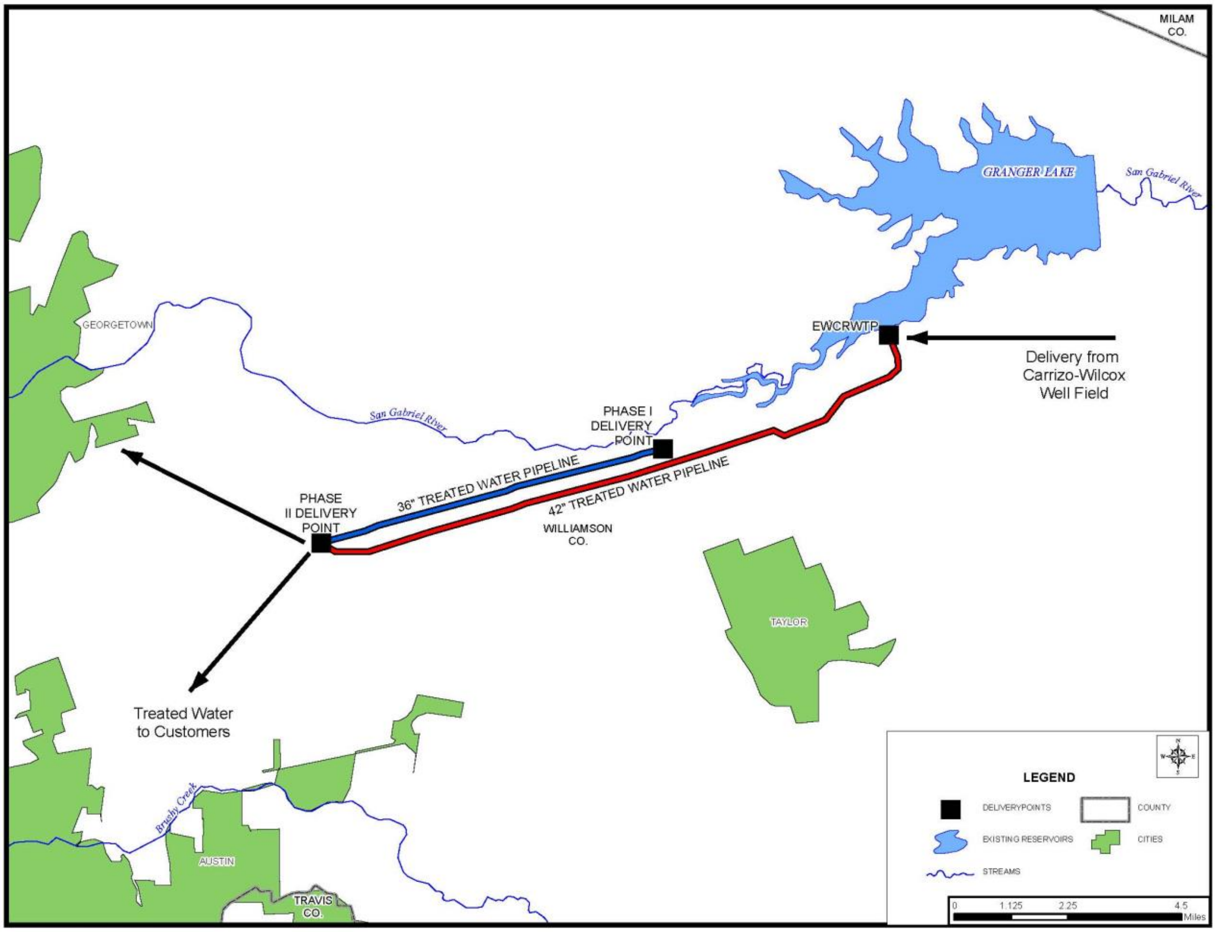


Figure 6.1-2. Phase II – Conjunctive Use with Carrizo-Wilcox Aquifer



The second phase of the project calls for overdrafting Lake Granger during times of high flow, utilizing interruptible surface water from BRA System Operations. Surface water supplies will be supplemented by water from the Carrizo-Wilcox Aquifer when interruptible water from Lake Granger is not available.

The conjunctive use project would develop a total supply of 53,361 acft/yr (7,096 acft/yr from Phase I in 2070 plus 46,265 acft/year from Phase II). 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 14,192 acft/yr are firm in 2070 without the conjunctive use project. EWCRWTP customers and other water utilities in the distribution system are likely candidates for this additional water supply.

The Brazos G WAM was utilized to simulate operations of Lake Granger supplemented with the groundwater pumping. In the WAM, it was assumed that all of the demand (less the Trinity Aquifer water from Phase I) was taken from Lake Granger when the reservoir was full and spilling. When the reservoir is less than full, demands on the reservoir are reduced as the storage declines and the remainder of the demand is met by pumping from the Carrizo-Wilcox Aquifer. Figure 6.1-3 shows the storage trace for Lake Granger modeled with these assumptions. Based on these assumptions, the average pumping from the Carrizo-Wilcox Aquifer is 28,118 acft/yr with a maximum pumping of 51,831 acft/yr (Figure 6.1-4).

Figure 6.1-3. Lake Granger Storage – 2070 Conditions

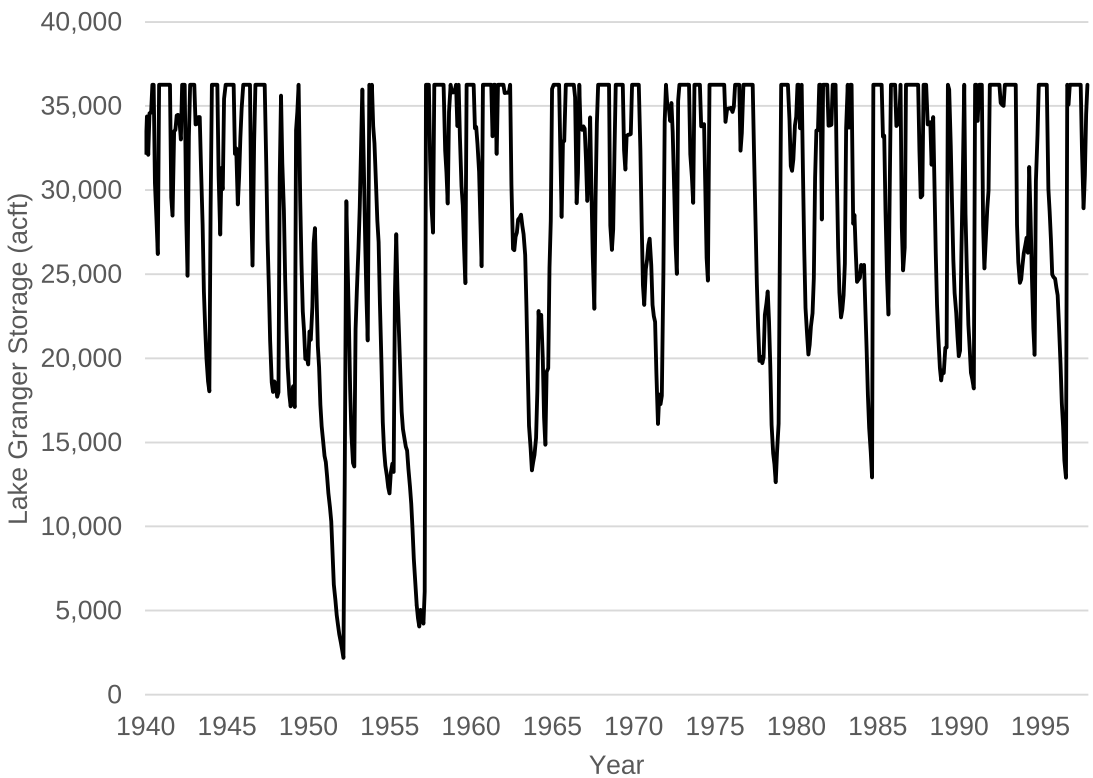
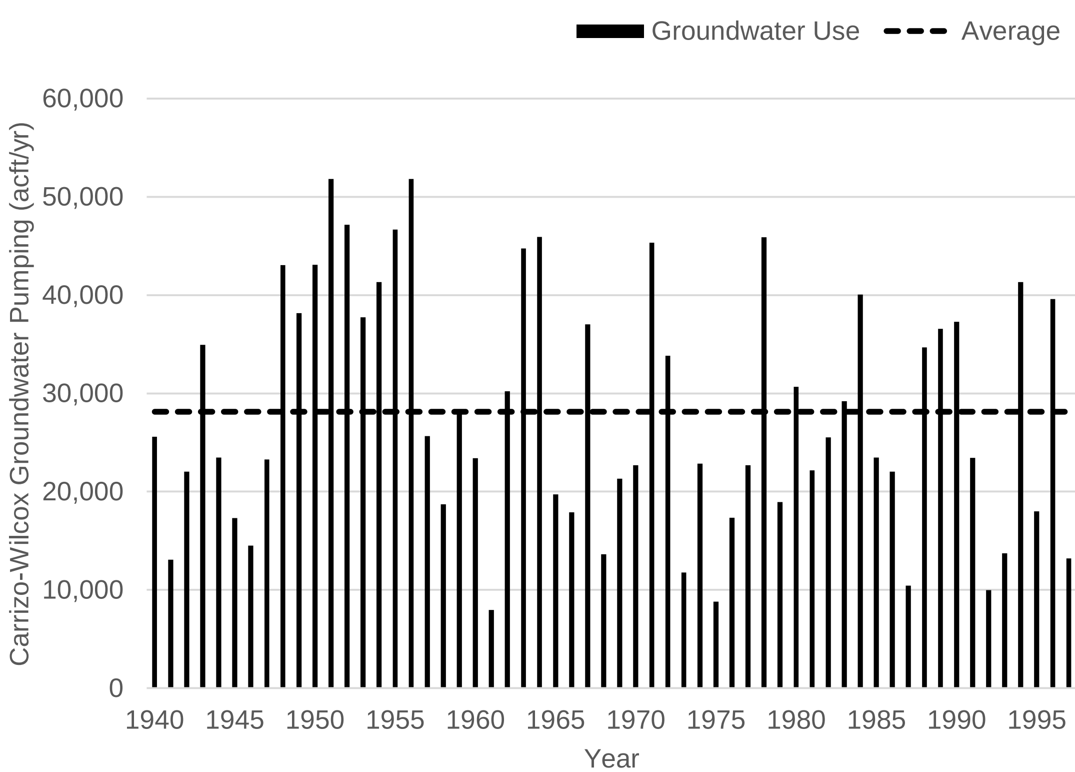


Figure 6.1-4. Annual Carrizo-Wilcox Pumping – 2070 Conditions



A review of groundwater availability for the Trinity Aquifer in Williamson County and the Carrizo-Wilcox Aquifer in Milam County shows that existing demands are equal to are greater than the Modeled Available Groundwater (MAG). Thus, the groundwater supply for the Lake Granger Augmentation Project may not be available as presented.

6.1.3 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 6.1-2.

Table 6.1-2. Environmental Issues: Groundwater/Surface Water Conjunctive Use (Lake Granger Augmentation)

Water Management Option	Groundwater/Surface Water Conjunctive Use
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

6.1.4 Engineering and Costing

Facilities for this option are shown in Figures 6.1-1 and 6.1-2, and Table 6.1-3 and Table 6.1-4. 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. Based on the results, it is concluded that the Trinity Aquifer near the EWCRWTP has greater productivity and a lower concentration of dissolved minerals than projected from the information available in the last plan. Other facilities include a well field collection system, cooling towers (the water will most likely be hot), expansions to the EWCRWTP, and a 3.7-mile 36-inch treated water pipeline from EWCRWTP to an existing customer delivery point. This option also required a larger intake structure in Lake Granger, a new pump station and a 3.8-mile 48-inch raw water pipeline that have already been built by BRA.

Conceptual designs and 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 2013 prices and reformatted to be consistent with Brazos G practices. No evaluation was made to determine consistency of these costs with results from Unified Costing Tool, which is used by all regional planning groups.

The total capital costs for Phase I is $59.4 million as shown in Table 6.1-3. Additional costs for professional services, land acquisition, well mitigation, and interest during construction add $25.7 million for a total project cost of $85.1 million. Annual debt service on this principal amount, calculated on the basis of 5.5 percent interest for 20-year debt is $7.1 million. Operation and maintenance costs for pumping, transmission, and treatment to deliver a total annual supply of 25,526 acft (17,017 acft from Lake Granger in 2020 plus 8,509 acft 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 $7.8 million added to the annual debt service gives a total annual cost for the full project of $14.9 million. For Phase I, the unit cost of water is $584 per acft/yr or $1.79 per 1,000 gallons.

Phase II will provide 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 in Milam County, although all or part of the required well field may be located in Burleson, Lee or other counties to the east of Williamson County. Carrizo-Wilcox groundwater will 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 will 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 Chisholm Trail Special Utility District, Georgetown or Round Rock would need to build treated water pipelines to the delivery point.

The Phase II total capital cost is $360.6 million as shown in Table 6.1-4. Additional costs for professional services, land acquisition, well mitigation, and interest during construction add $276.5 million for a total project cost of $637.1 million. Annual debt service on this principal amount is $53.3 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 $21.2 million added to the annual debt service gives a total annual cost for the full project of $74.5 million. For Phase II, the unit cost of water is $1,611 per acft/yr or $4.94 per 1,000 gallons. Compensation to BRA may be required if this strategy were developed by another entity other than BRA to compensate for any subordination of the System Operations strategy.

Table 6.1-3. Cost Estimate Summary for Phase I of Lake Granger Augmentation

Item	Estimated Costs for Facilities
Trinity Aquifer Well Field (4 wells)	$24,369,000
EWCRWTP Expansions (12.5 MGD)	$28,670,000
Treated water pipeline (36 in. dia., 3.7 miles)	$4,453,000
Transmission Pump Station(s)	$1,925,000
TOTAL COST OF FACILITIES	**$59,417,000**
Engineering, Legal Costs and Contingencies	$20,573,000
Environmental & Archaeology Studies and Mitigation	$713,000
Land Acquisition and Surveying (37 acres)	$219,000
Interest During Construction (1.5 years)	$4,248,000
TOTAL COST OF PROJECT	**$85,170,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$7,127,000
Operation and Maintenance	$5,050,000
Pumping Energy Costs (13233294 kW-hr @ 0.09 $/kW-hr)	$1,191,000
Purchase of Water (25,526 acft/yr @ $60.50/acft)	$1,544,000
TOTAL ANNUAL COST	**$14,912,000**
Available Project Yield (acft/yr)	**25,526**
Annual Cost of Water ($ per acft)	**$584**
Annual Cost of Water ($ per 1,000 gallons)	**$1.79**

Table 6.1-4. Cost Estimate Summary for Phase II of Lake Granger Augmentation

Item	Estimated Costs for Facilities
Carrizo-Wilcox Well Field (30 wells)	$33,848,000
Pipeline from Well Field to EWCRWTP (36 & 48 in. dia. each 44 miles)	$128,311,000
Blending Facility	$9,993,000
EWCRWTP Expansions (83 MGD)	$83,485,000
Treated water pipeline from delivery to customers (various dia., 68 miles)	$68,617,000
Transmission Pump Stations	$33,895,000
Treated water storage	$2,417,000
TOTAL COST OF FACILITIES	**$360,566,000**
Engineering, Legal Costs and Contingencies	$116,765,000
Environmental & Archaeology Studies and Mitigation	$4,322,000
Land and/or Groundwater Rights Acquisition	$100,000,000
Land Acquisition and Surveying	$4,371,000
Interest During Construction (3 years)	$51,033,000
TOTAL COST OF PROJECT	**$637,057,000**
ANNUAL COST	
Debt Service for Infrastructure (5.5 percent, 20 years)	$53,309,000
Operation and Maintenance	$10,990,000
Pumping Energy Costs (@ 0.09 $/kW-hr)	$5,725,000
Annual Cost to Purchase Water (Assumed $60.50 per acft)	$2,799,000
Annual Groundwater Permitting Cost (Assumed $60.50 per acft)	$1,701,000
TOTAL ANNUAL COST	**$74,524,000**
Available Project Yield (acft/yr)	**46,265**
Annual Cost of Water ($ per acft)	**$1,611**
Annual Cost of Water ($ per 1,000 gallons)	**$4.94**

6.1.5 Implementation Issues

Early significant activity toward implementation of this startegy has been accomplished by the Brazos River Authority via its ownership of Lake Granger water supply, application for a systems operation permit, ownership of the existing water treatment plant on Lake Granger, 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. However, for purposes of regional planning, both Phase 1 and 2 projects overdraft the groundwater supply, which is inconsistent with required procedures as implemented by the TWDB.

This water supply option has been compared to the plan development criteria, as shown in Table 6.1-5.

Potential Regulatory Requirements:

- Requirements for permits to use surface water and groundwater, as well as for pipeline construction, will require permits as follow:
- Local groundwater district pumping permits as needed.
- TCEQ water rights permit (pending) for BRA System Operations (Phase II)
- 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

Table 6.1-5. 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	• No. Groundwater availability does not consider MAG as other Options do
F. Requirements for Interbasin Transfers	• Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	• None

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6.2 Oak Creek Reservoir

6.2.2 Description of Option

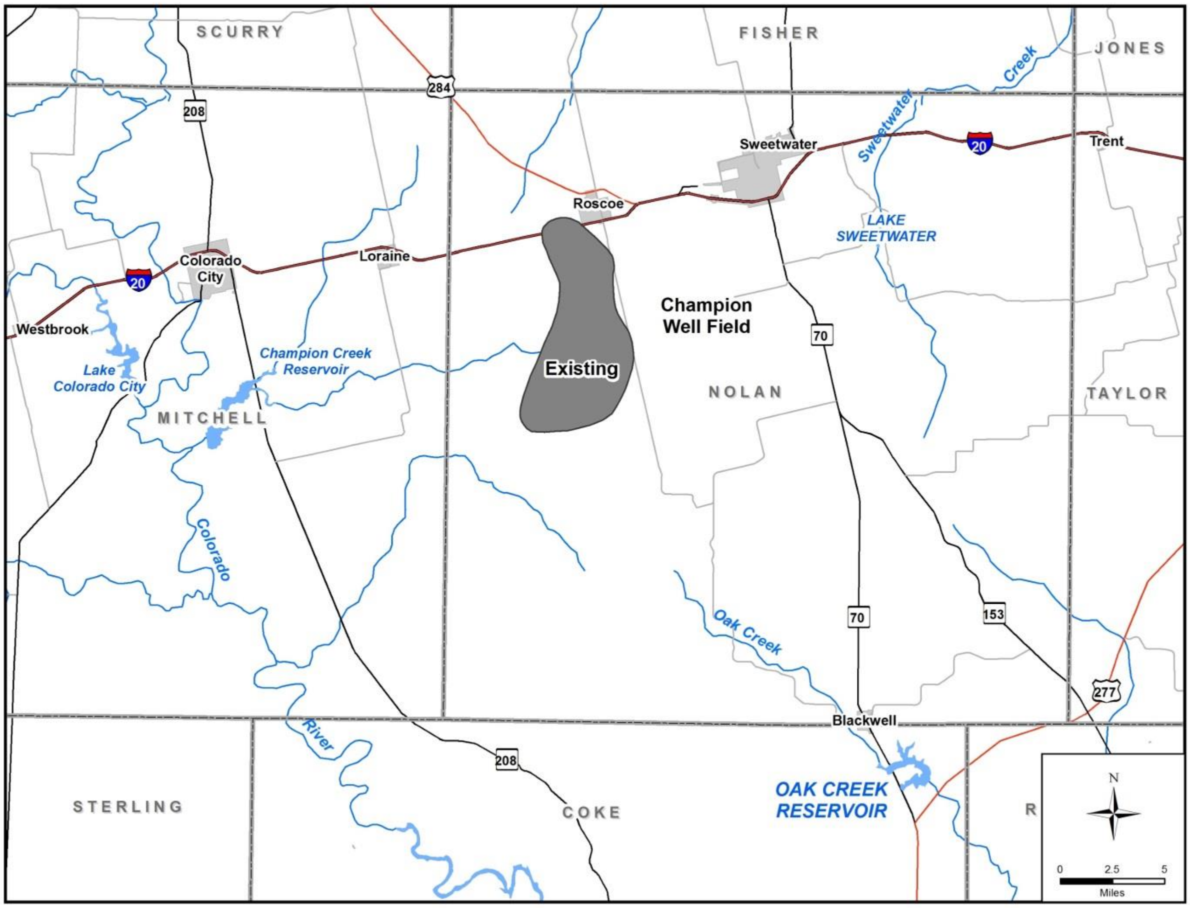
The City of Sweetwater (Sweetwater) utilizes water supplies from the Oak Creek Reservoir in Coke County and the Champion Well Field in Nolan County. The wells are in the Dockum Aquifer. Prior to the drought beginning in 1998, the primary water supply was Oak Creek Reservoir and supplemental supplies 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 about 35 new wells in the Champion Well Field on an emergency basis. During the later 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.

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). 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 long term average of groundwater use must remain within the MAG even though it may 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 6.2-1.

Figure 6.2-1. Existing Champion Well field and Oak Creek Reservoir Locations



L:\Project_Data\00044_BrazosG\GIS\Map_Docs\General\Champion_Well_Field.mxd

6.2.3 Available Yield

The Champion Well field has a capacity of 4,142 acft/yr after the 2014 expansion. However, the availability to Sweetwater has been limited by MAG restrictions to 2,535 acft/yr. An analysis of Sweetwater's demands and water supply contracts shows the peak demand during the planning period is 4,116 acft/yr in 2070. While Champion well field has sufficient capacity to meet annual demands, it is limited by available groundwater. The city also utilizes water supplies from the Oak Creek Reservoir and can purchase yield through subordination agreements, however, they cannot rely on this supply during times of drought.

At least three Water Availability Model (WAM) simulations have been made for the Oak Creek basin by consultants for Region F. They are known as the Basin WAM, Run 3, and Mini-WAM. The first two simulations have a daily time step and end in 1998, thus they miss recent periods of drought. The Mini-WAM has monthly time intervals and ends in 2014. A result comparison of the Mini-WAM for Oak Creek Reservoir with historical results showed a reasonable match. For these reasons, the data from the Mini-WAM were used in this conjunctive use analysis.

A study was conducted to balance the use of groundwater and surface water to limit depletion of available groundwater. Three strategies were used to meet the maximum need of 4,116 acft per year during the planning period without exceeding the long term MAG of 2,535 acft/yr and assuming subordination of downstream rights to Oak Creek Reservoir. The water level in Oak Creek Reservoir was used to determine the proportion of supply coming from each source. Strategy 1 relied on Oak Creek Reservoir as a primary source and utilized Champion Well Field only when needed to supplement supply. This involved the utilization of ground water when the reservoir dropped to 25% capacity. Figure 6.2-2 shows the temporal distribution of annual diversions and annual pumpage to meet 2070 demands. This figure shows that, the worst drought condition for this conjunctive water management strategy since 1940 would have been for 2010-2014 conditions.

While Strategy 1 is a plausible operation scenario for the conjunctive use of Oak Creek and Champion well field, the aggressive utilization of surface water prevents Oak Creek from full recovery after periods of drought. Figure 6.2-3 shows the storage trace for Oak Creek assuming Strategy 1 was utilized under 2070 demands and 1940-2014 hydrologic conditions. The long term groundwater average use for Strategy 1 is 1,201 acft/yr, which is significantly less than the available supply for Sweetwater despite over drafting the MAG 18 of the 74 years.

Figure 6.2-2. Strategy 1 Distribution of Water Sources for Sweetwater for 2070 Demands with 1940-2014 Hydrologic Conditions

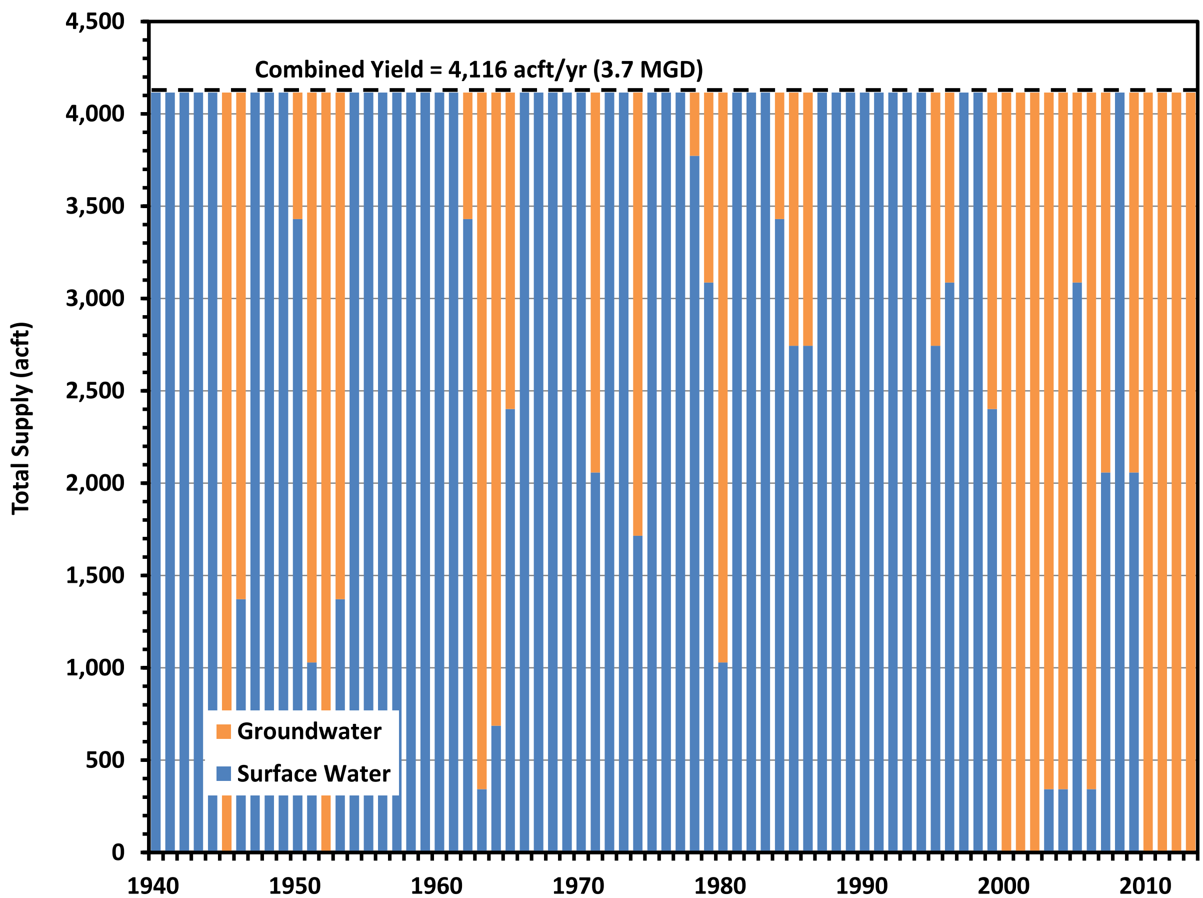
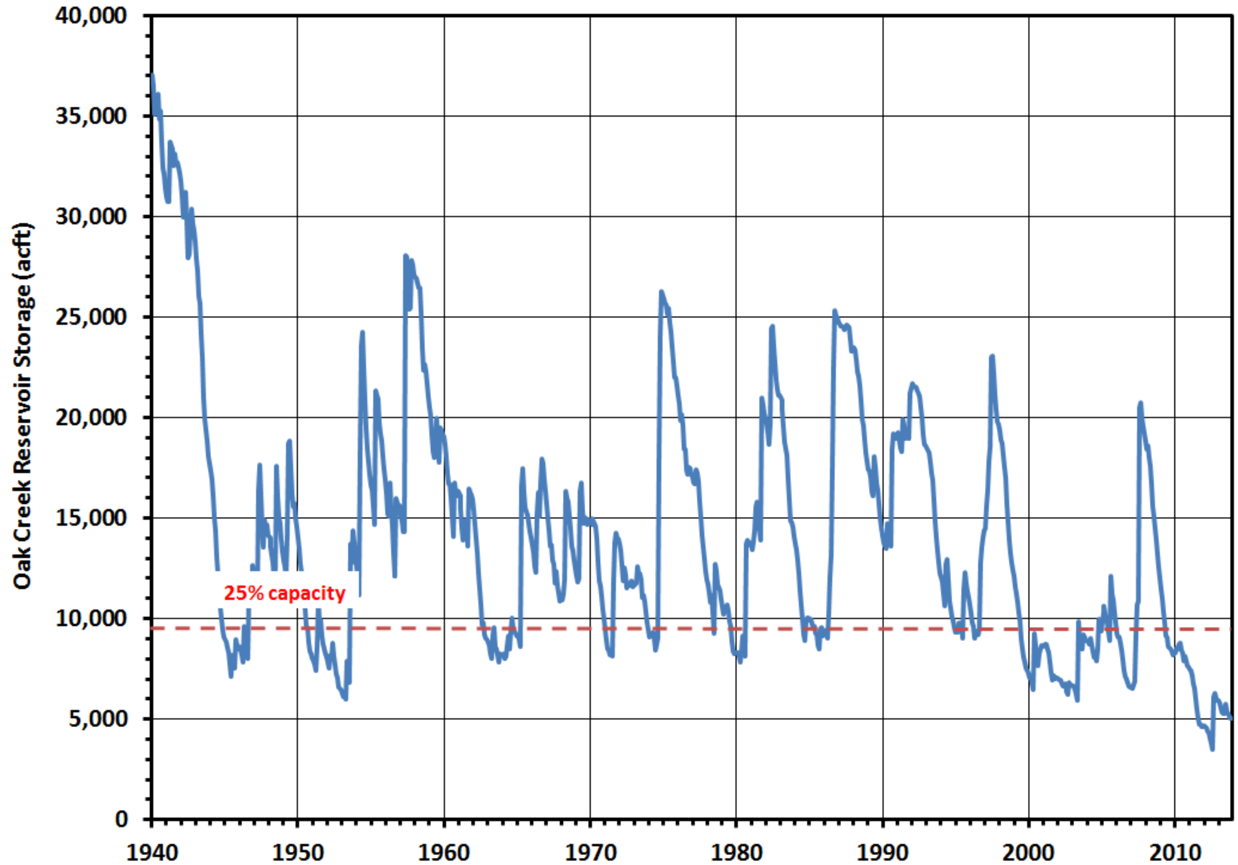


Figure 6.2-3. Strategy 1 Storage Trace for Oak Creek with 2070 Demands and 1940-2014 Hydrologic Conditions



Strategy 2 attempts to maximize the use of Champion Well Field while keeping the long term groundwater use at or below the MAG limit. In this scenario, Oak Creek was used as the sole source of supply only when the reservoir was at 57% or above. Figure 6.2-4 shows the temporal distribution of annual diversions and annual pumpage to meet 2070 demands. The long term average groundwater use for this strategy is 2,531 acft/yr which is still less than the MAG of 2,535 acft/yr despite overdrafting 41 of the 74 years. The storage trace (Figure 6.2-4) for Oak Creek Reservoir under this strategy shows that the reservoir can recover when groundwater is used more frequently.

Figure 6.2-4. Strategy 2 Distribution of Water Sources for Sweetwater for 2070 Demands with 1940-2014 Hydrologic Conditions

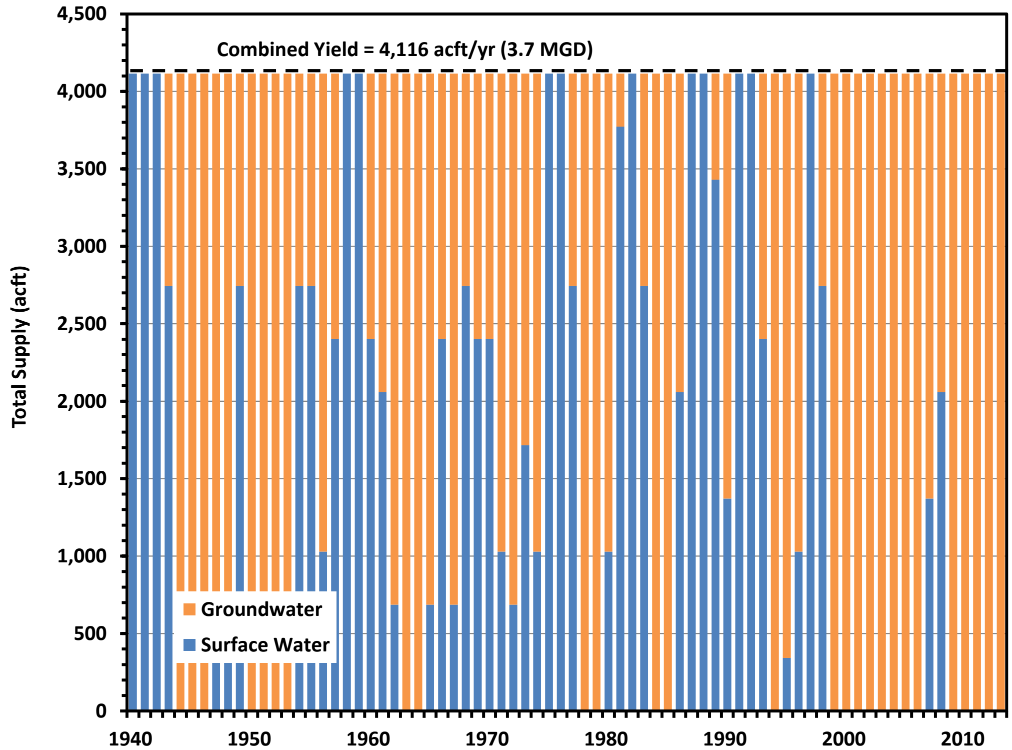
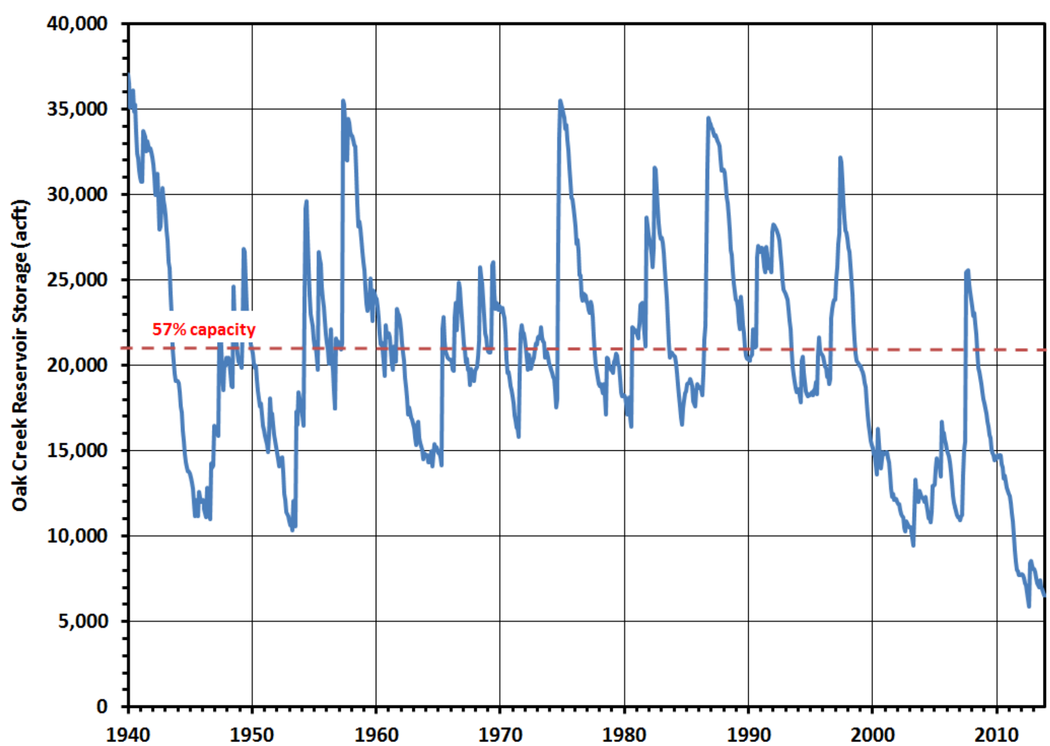


Figure 6.2-5. Strategy 2 Storage Trace for Oak Creek with 2070 Demands and 1940-2014 Hydrologic Conditions



The first two strategies show that while the needs can be met with either source set as a primary supply, relying too heavily on surface water can keep the reservoir from recovering and relying too heavily on groundwater will cause overdrafting of the MAG an undesirable number of years. A third strategy was considered that attempted to keep the long term averages of groundwater use and surface water use roughly equivalent. For this strategy, about 50% of the supply came from Oak Creek Reservoir and about 50% came from Groundwater for non-drought conditions. If in any given month, the reservoir dropped below 25% full, then groundwater was used as a sole source. Otherwise, the supply is a blend of the two sources. Figure 6.2-6 shows the temporal distribution of annual diversions and annual pumpage to meet 2070 demands. The long term average groundwater use for this strategy is 2,046 acft/yr which is still less than the MAG of 2,535 acft/yr and the MAG was only overdrafted 12 out of 74 years. The storage trace (Figure 6.2-7) for Oak Creek Reservoir under this strategy shows that while the reservoir does not fully recover, it remains at a higher level than in Strategy 1.

Figure 6.2-6. Strategy 3 Distribution of Water Sources for Sweetwater for 2070 Demands with 1940-2014 Hydrologic Conditions

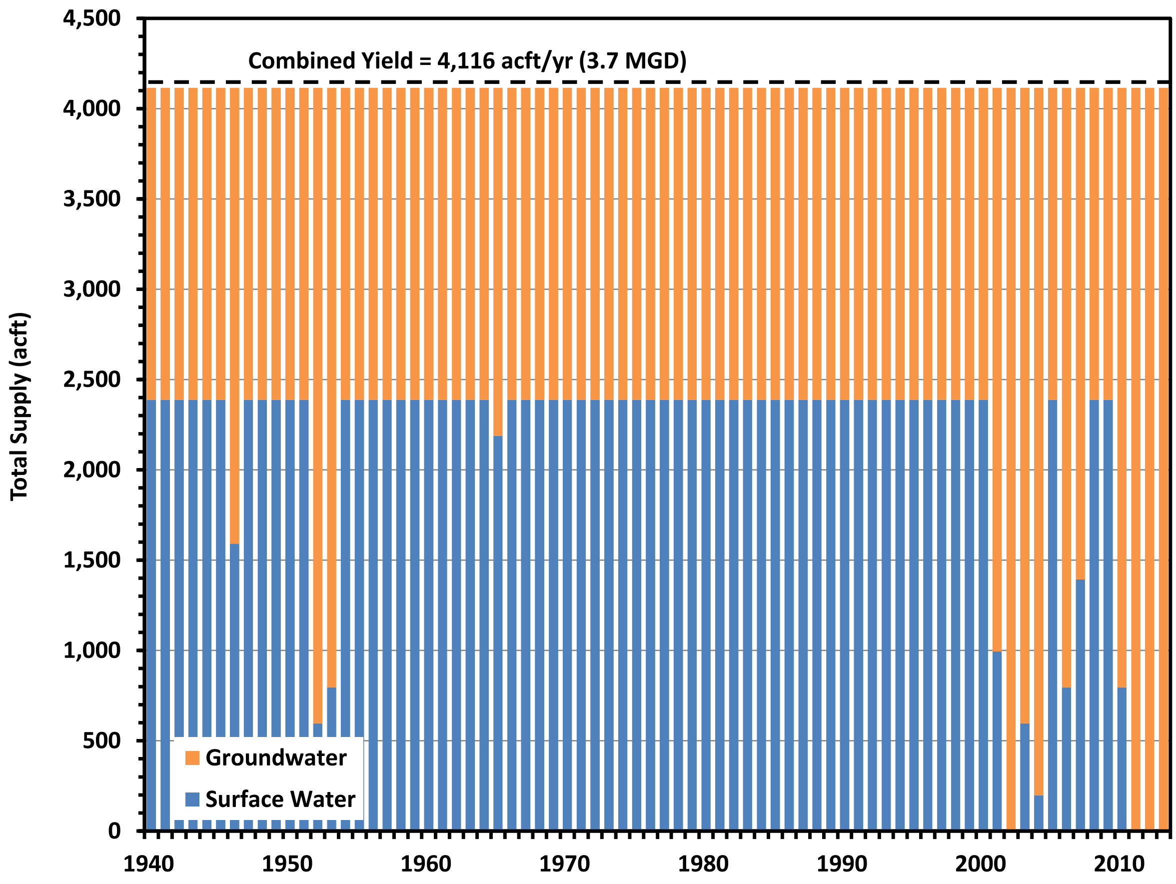
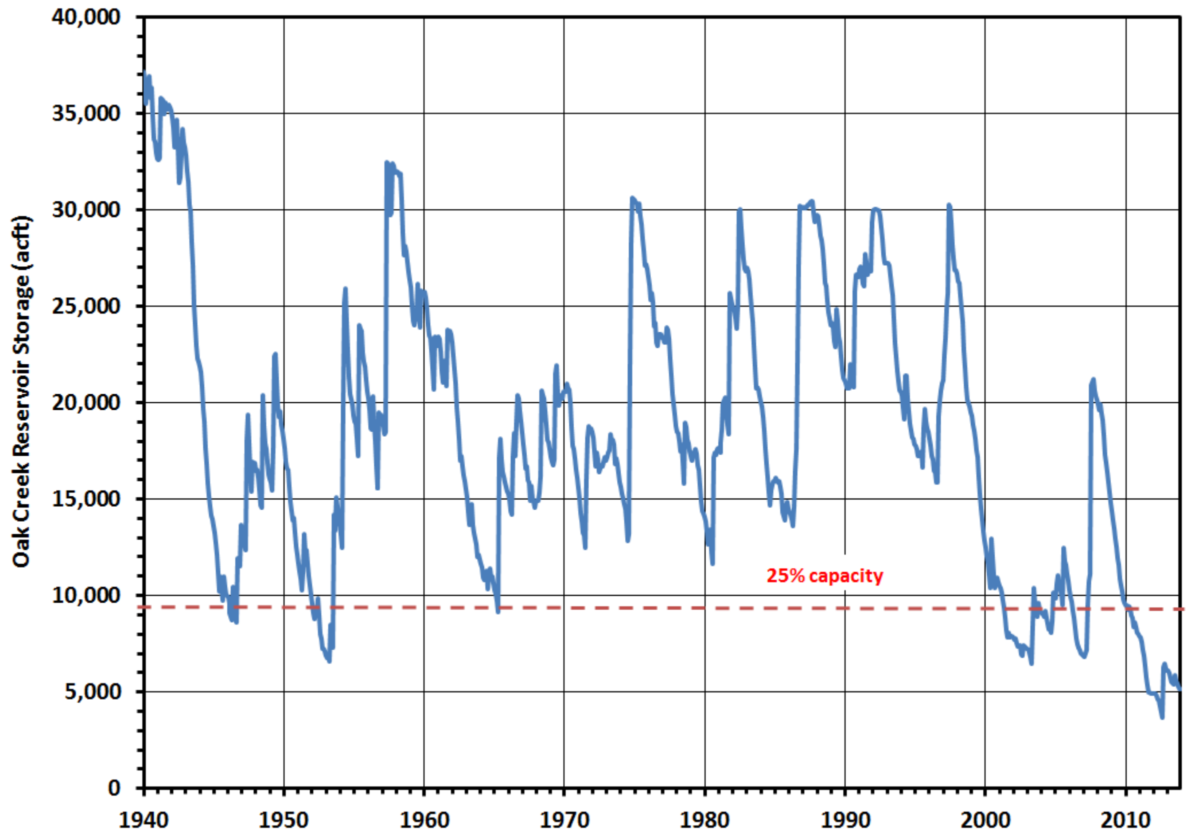


Figure 6.2-7. Strategy 3 Storage Trace for Oak Creek with 2070 Demands and 1940-2014 Hydrologic Conditions



6.2.4 Environmental Issues

There will be no new environmental impacts associated with this strategy. No wells, pipelines or other infrastructure will be built for this strategy.

Implementation Issues

Development of this water management strategy requires the subordination of the senior water rights that are downstream of Oak Creek Reservoir.

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