4 New Reservoirs

4.1 Brazos River Main Stem Off-Channel Reservoirs

4.1.1 Description of Option

The Brazos River Main Stem Off-Channel Reservoirs (OCR) strategy could potentially provide supply to water user groups downstream of Waco. Fourteen (14) sites along the Brazos River between Lake Waco and Lake Somerville were identified as possible locations for an OCR project. The OCR would impound diversions of unappropriated streamflow pumped from the Brazos River. The locations of the 12 identified sites are shown in Figure 4.1-1. Each site was evaluated based on conservation storage capacity, storage efficiency (in order to minimize losses from evaporation), and potential conflicts.

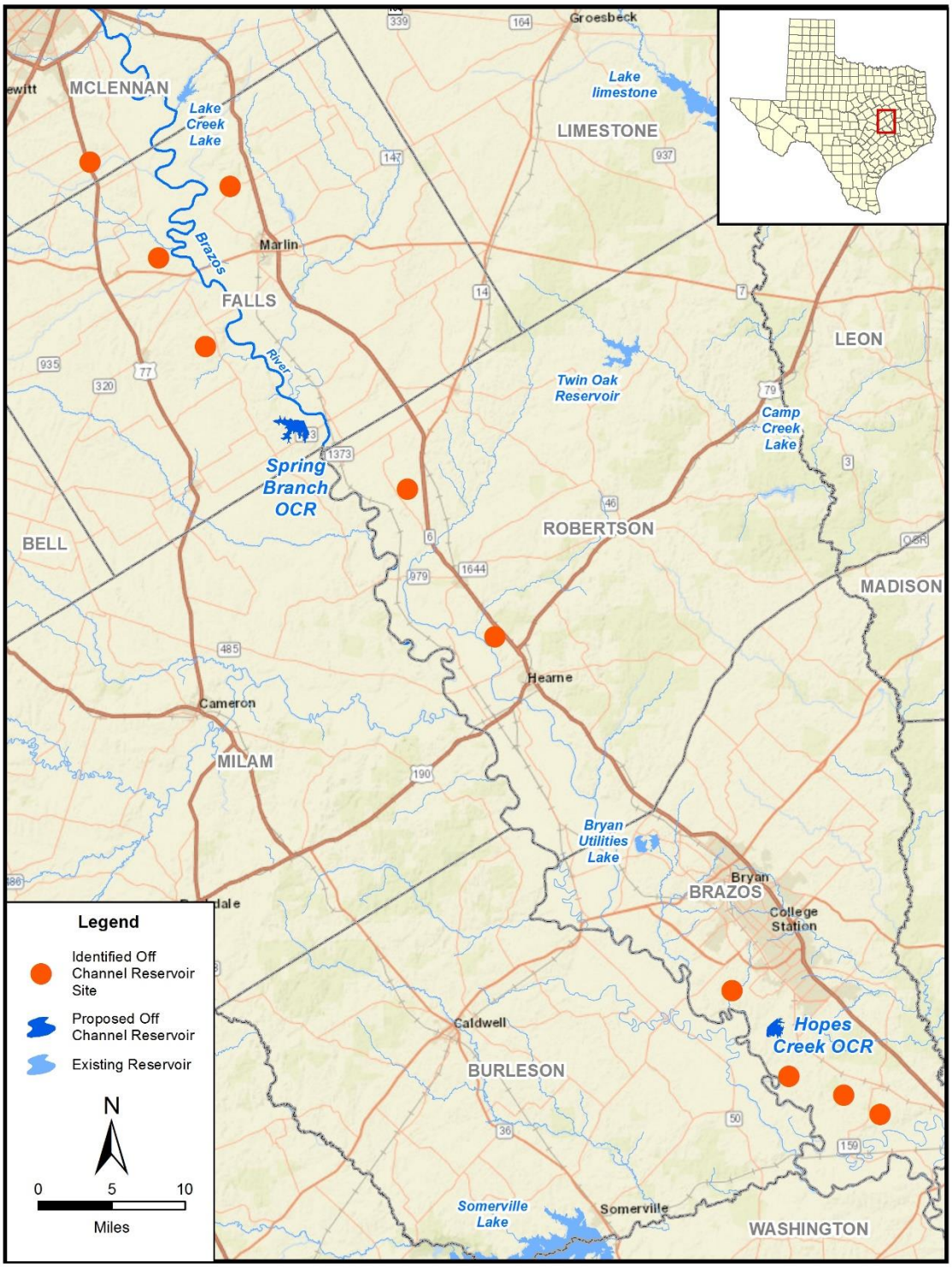
Of the 12 identified sites, the two most favorable sites were selected for yield and cost analyses. The two sites selected are the Spring Branch and Hopes Creek OCR sites. These two sites would divert and store water from the Brazos River and deliver supplies to potential customers in the area. The Spring Branch OCR is located about 12 miles south of Marlin near the Falls County border as shown in Figure 4.1-1. The OCR would provide a conservation storage capacity of 23,715 acft and inundate 1,268 surface acres. The Hopes Creek OCR is located near College Station in Brazos County as shown in Figure 4.1-1. The OCR would provide a conservation storage capacity of 18,618 acft and inundate 664 acres.

4.1.2 Available Yield

Water potentially available for diversion from the Brazos River and subsequent impoundment in the two OCR sites was estimated using the TCEQ Brazos WAM Run 3. The model assumes permitted storages and diversions for all surface water rights in the basin and utilizes a January 1940 through December 1997 hydrologic period of record. Estimates of water availability were derived subject to all diversions and impoundments having to pass streamflows to meet TCEQ environmental flow standards and without causing increased shortages to downstream rights.

Various maximum diversion capacities associated with potential pipeline sizes were evaluated. Results of the analysis indicate that pipeline sizes greater than 60-inch diameter do not provide a yield benefit to either OCR site; therefore, a 60-inch diameter pipeline is assumed to be the optimal size for delivering diversion from the Brazos River. The resulting calculated firm yield of the Spring Branch Creek OCR is 7,200 acft/yr and the firm yield of the Hopes Creek OCR is 6,300 acft/yr.

Figure 4.1-1. Locations of Identified Brazos River Main Stem OCR Sites



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Hopes Creek OCR

Figure 4.1-2 illustrates annual diversions from the Brazos River used to refill storage in Hopes Creek OCR under firm yield operations. On average, 6,825 acft/yr of water would be diverted.

The calculated firm yield of the Hopes Creek OCR is 6,300 acft/yr. Figure 4.1-3 and Figure 4.1-4 illustrates the simulated Hopes Creek OCR storage levels for the 1940 to 1997 historical period, subject to the firm yield of 6,300 acft/yr and assuming delivery of Brazos River diversions via a 60-inch pipeline. Simulated reservoir contents remain above 80 percent capacity about 77 percent of the time and above 50 percent capacity about 94 percent of the time.

Figure 4.1-5 illustrates the change in median streamflow in the Brazos River caused by the project. The Project would not result in any significant changes to median streamflows since diversion from the Brazos River would typically occur during wetter periods when unappropriated flow is available. Figure 4.1-6 illustrates the Brazos River streamflow frequency characteristics with the Hopes Creek OCR in place. This figure shows that diversions from the Brazos River for the project would not significantly reduce streamflow.

Figure 4.1-2 Hopes Creek Off-Channel Reservoir Diversions from Brazos River

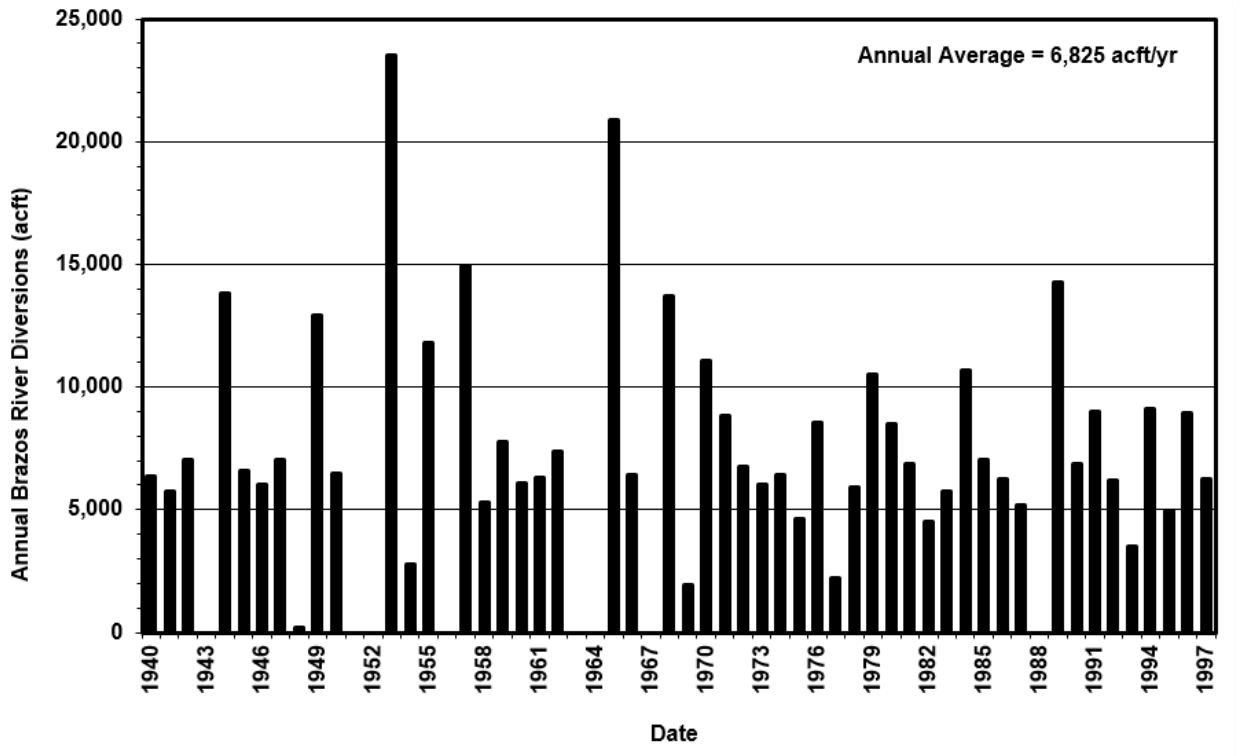


Figure 4.1-3. Hopes Creek Off-Channel Reservoir Storage Trace

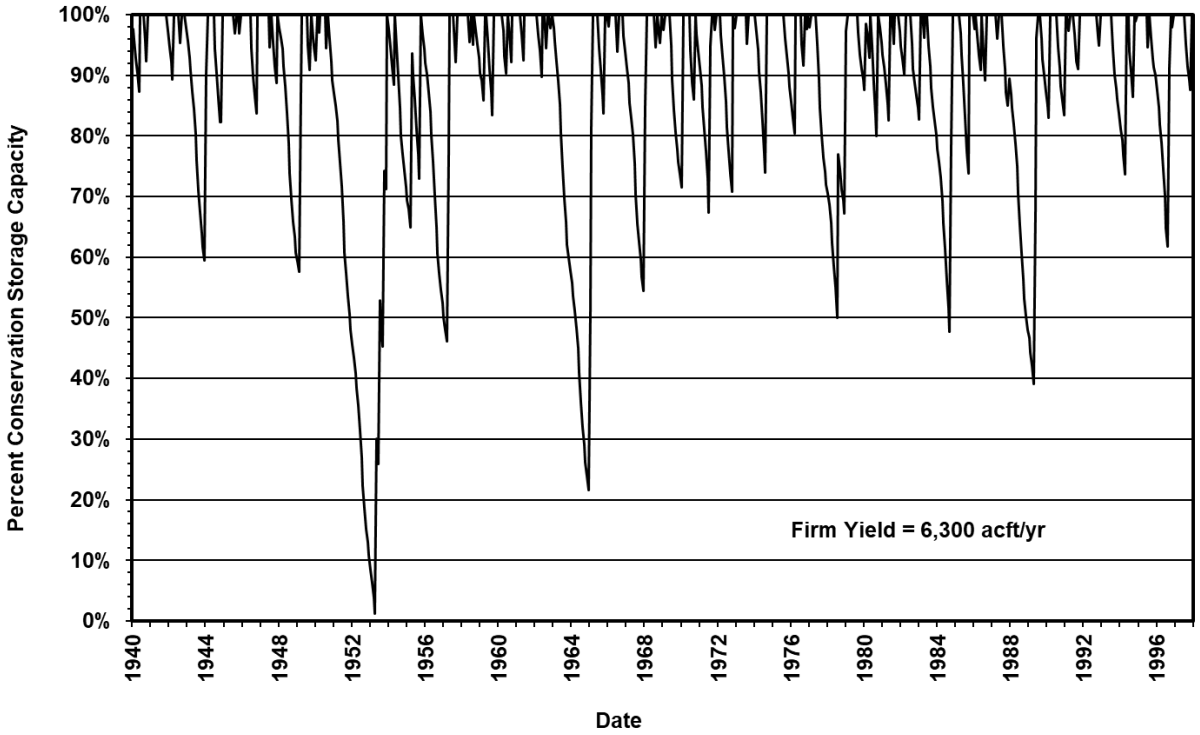


Figure 4.1-4. Hopes Creek Off-Channel Reservoir Storage Frequency

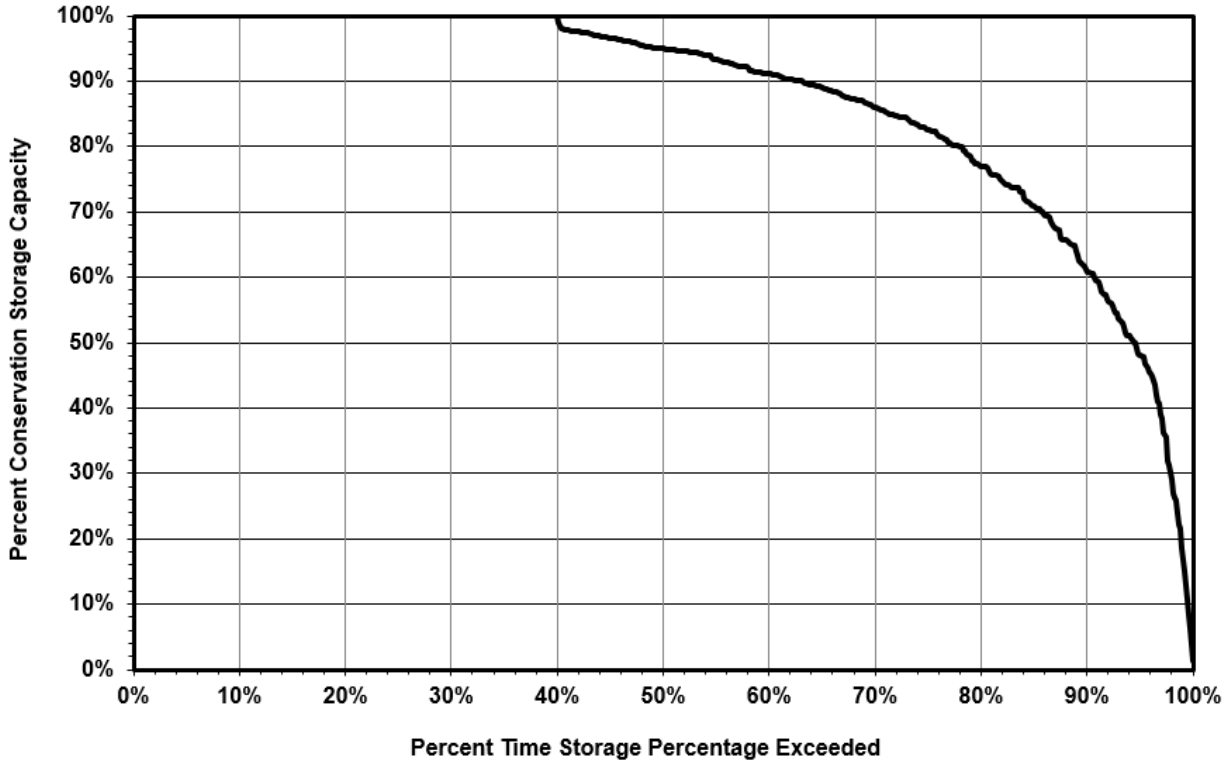


Figure 4.1-5. Monthly Median Streamflow Comparisons for the Brazos River with and without Diversions for Hopes Creek Off-Channel Reservoir

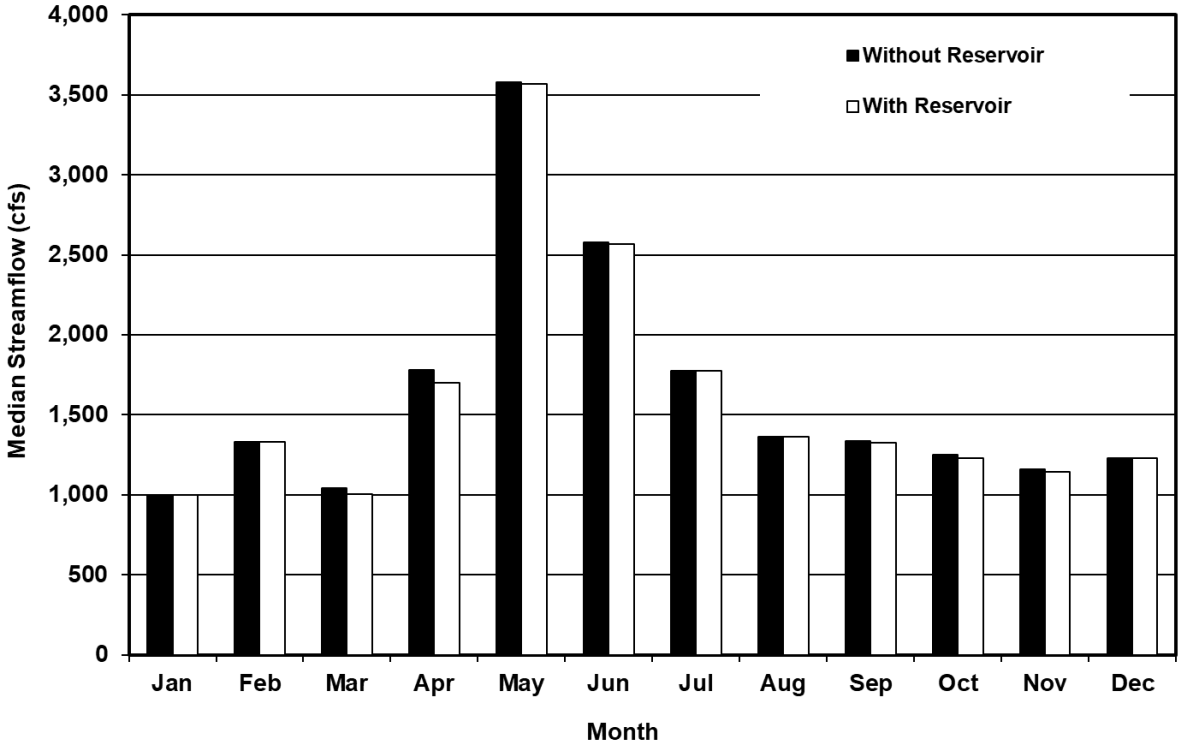
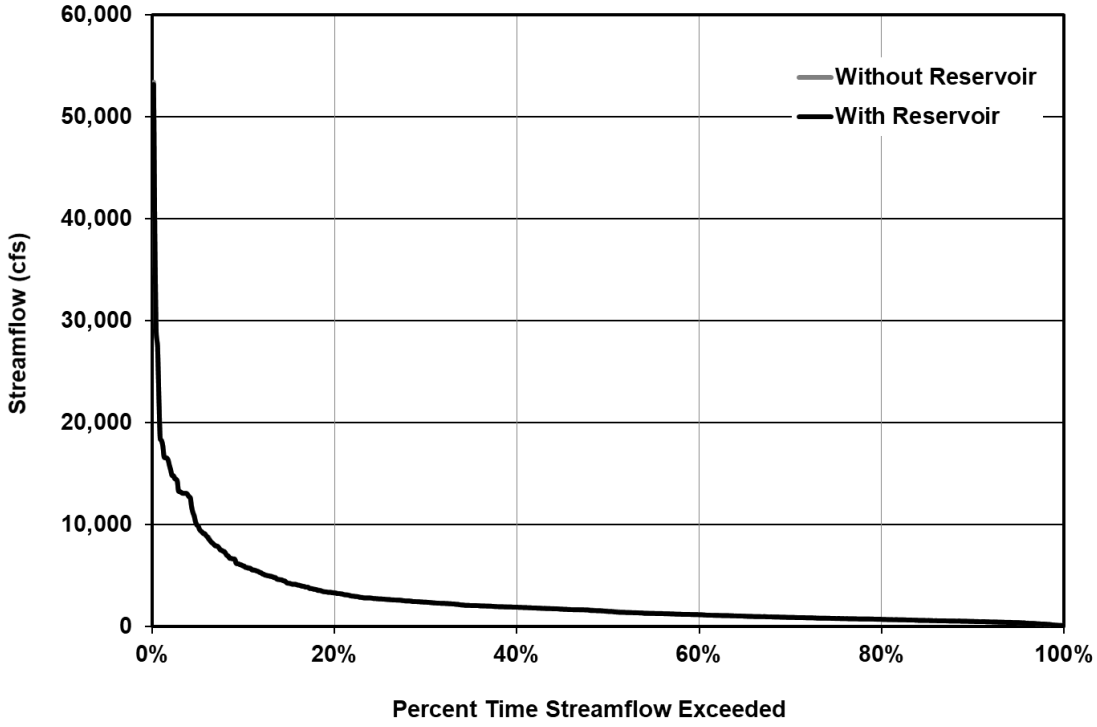


Figure 4.1-6. Streamflow Frequency Comparisons for the Brazos River with and without Diversions for Hopes Creek Off-Channel Reservoir



Spring Branch OCR

Figure 4.1-7 illustrates annual diversions from the Brazos River used to refill storage in Spring Branch OCR under firm yield operations. On average, 8,723 acft/yr of water would be diverted.

Figure 4.1-8 and Figure 4.1-9 illustrates the simulated Spring Branch OCR storage levels for the 1940 to 1997 historical period, subject to the firm yield of 7,200 acft/yr and assuming delivery of Brazos River diversions via a 60-inch pipeline. Simulated reservoir storage remains above 80 percent capacity about 72 percent of the time and above 50 percent capacity about 90 percent of the time.

Figure 4.1-10 illustrates the change in streamflows in the Brazos River caused by the project. Similar to Hopes Creek OCR diversion, diversions for the Spring Branch OCR would not result in significant decreases in streamflow in the Brazos River. Figure 4.1-11 illustrates the Brazos River streamflow frequency characteristics with the Spring Branch OCR in place.

Figure 4.1-7. Spring Branch Off-Channel Reservoir Diversions

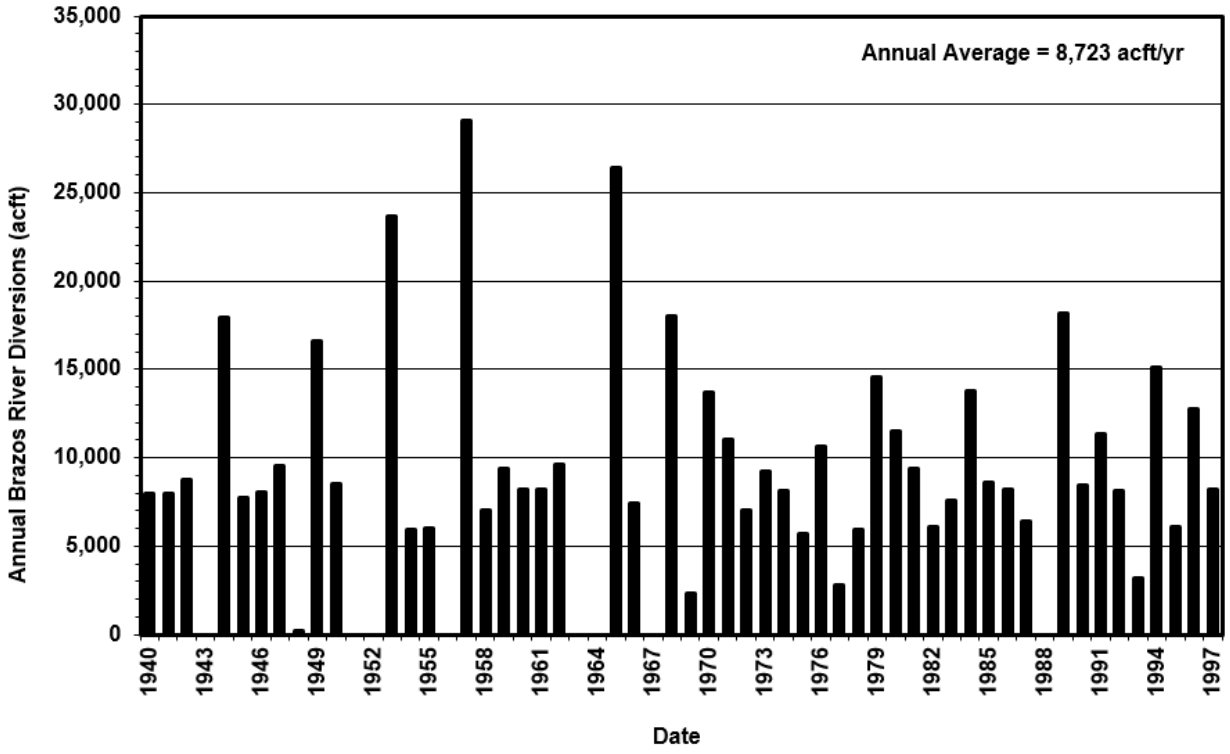


Figure 4.1-8 Spring Branch Off-Channel Reservoir Storage Trace

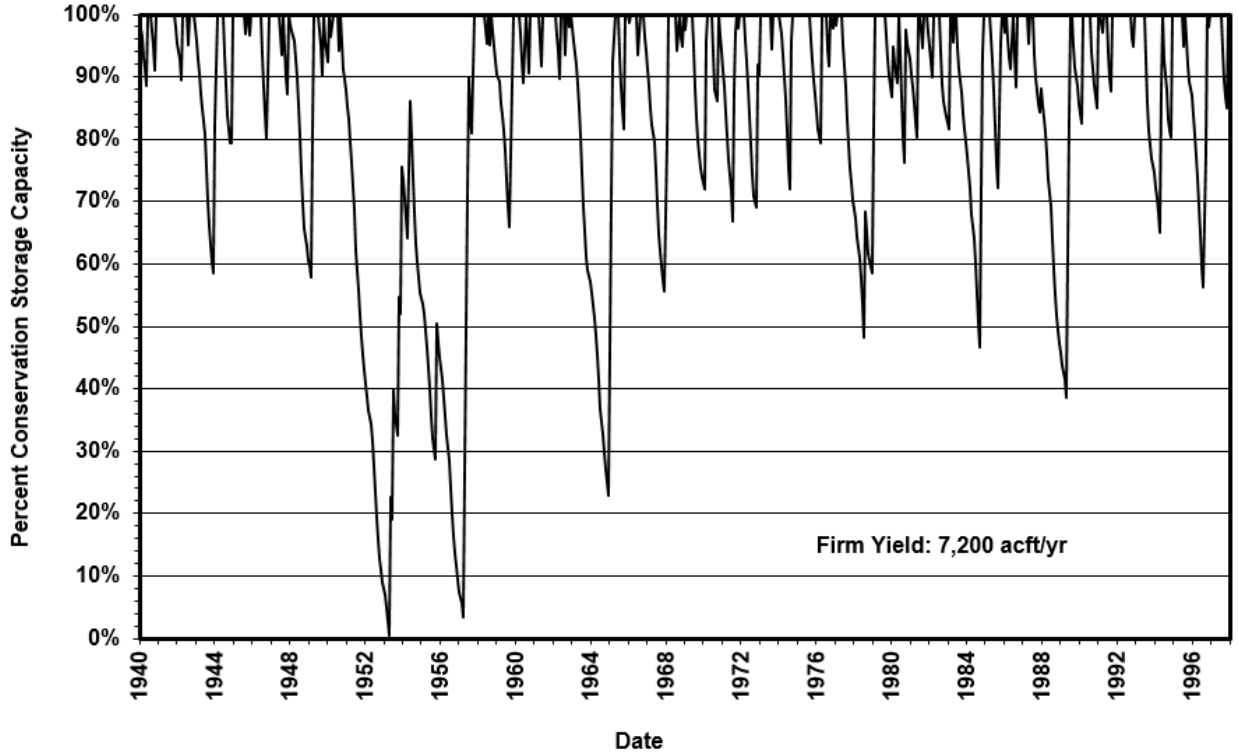


Figure 4.1-9 Spring Branch Off-Channel Reservoir Storage Frequency at Firm Yield

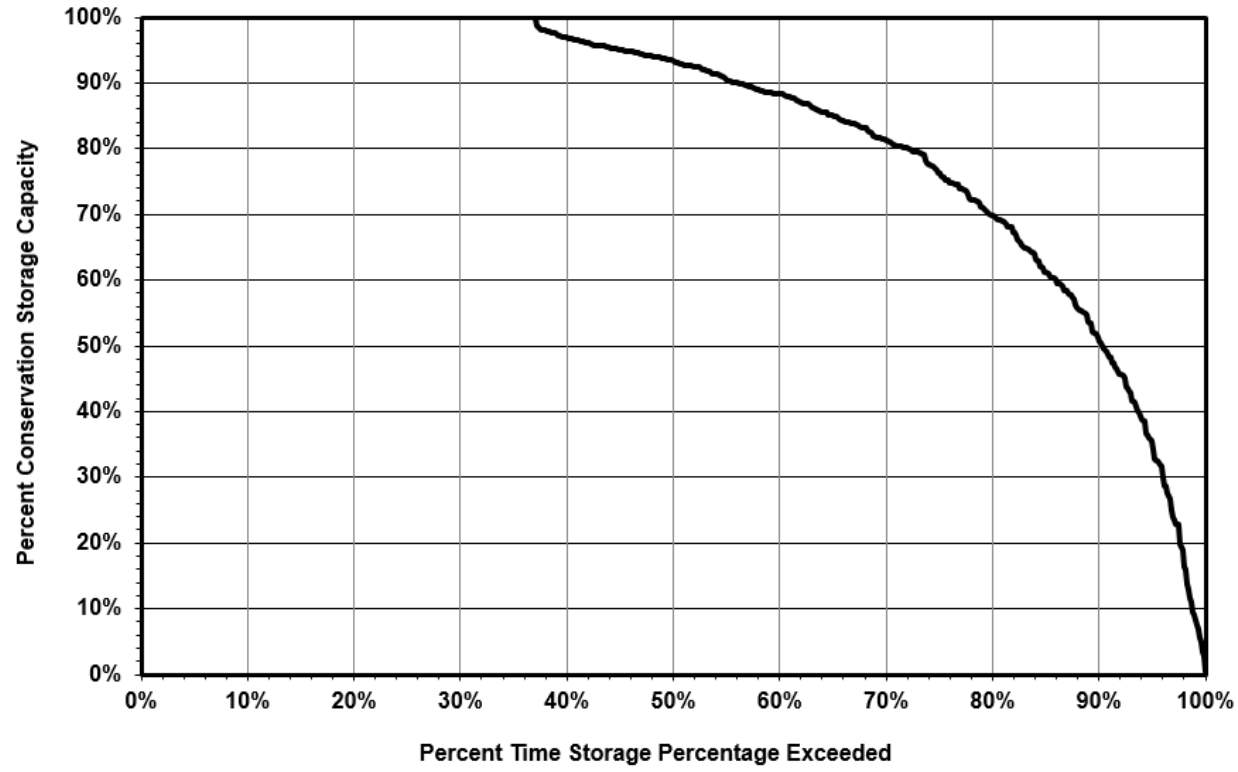


Figure 4.1-10 Monthly Median Streamflow Comparisons for the Brazos River with and without Diversions for Spring Branch Off-Channel Reservoir

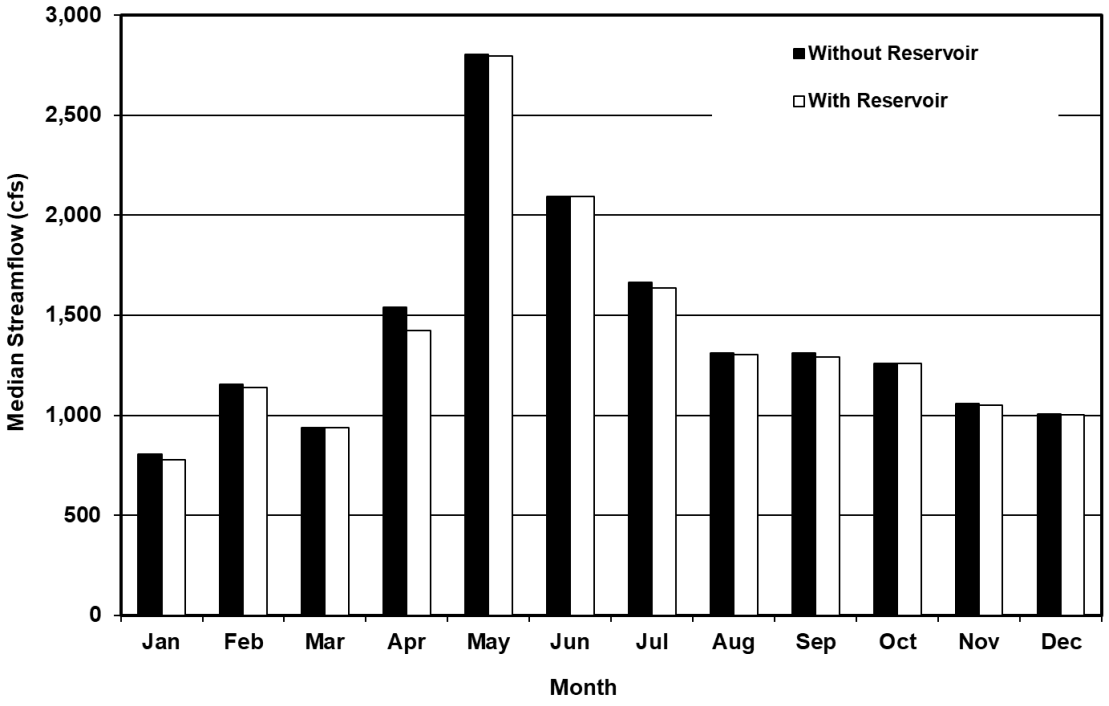
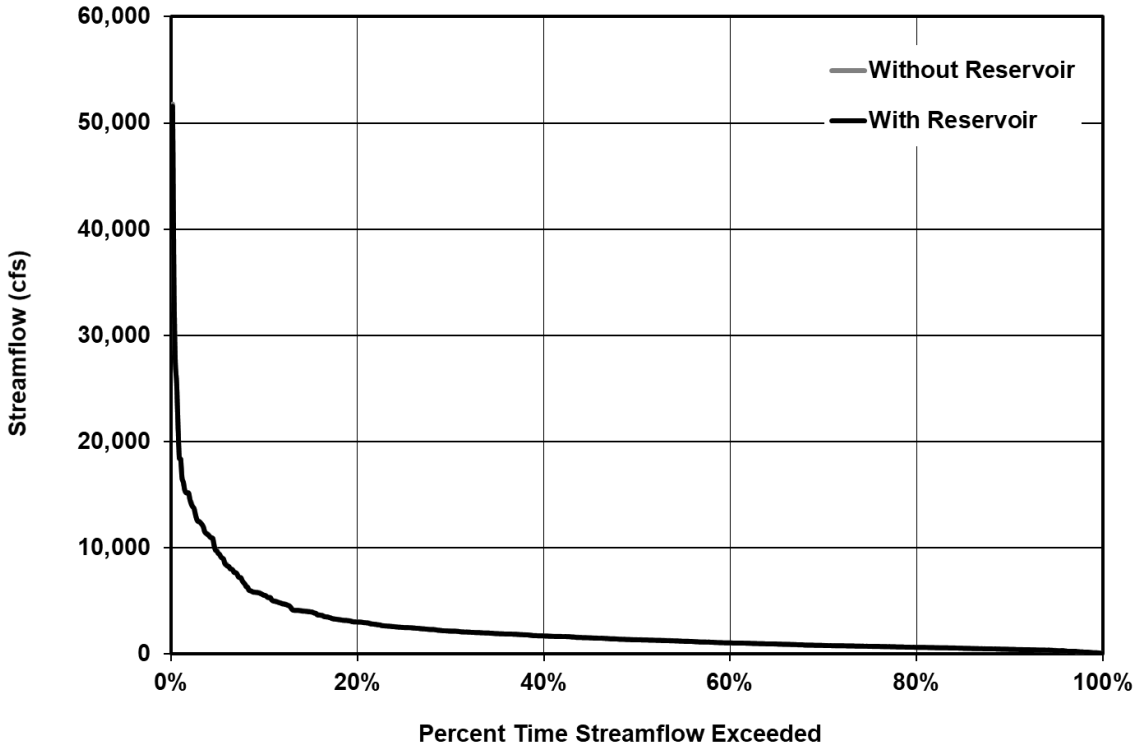


Figure 4.1-11 Streamflow Frequency Comparisons for the Brazos River with and without Diversions for Spring Branch Off-Channel Reservoir



4.1.3 Environmental Issues

Because of the greater yield and smaller project and unit cost (See Section 4.1.4), the Spring Brach OCR is considered the preferred OCR site. Therefore, environmental and implementation issues associated with the Hopes Creek OCR were not evaluated.

Existing Environment

The Spring Branch OCR site in Falls County is within the Texas Blackland Prairies Ecological Region, a fertile area of prairie and pastureland.[1] This region is located in northeast-central Texas west of the East Central Texas Plains and east of the Cross Timbers. The physiognomy of the region is made up of grassland and crops 300 to 800 feet above sea level. Much of the native vegetation has been displaced by agriculture and development.[2] The climate is characterized as subtropical humid, with warm summers. Average annual precipitation ranges between 28 and 40 inches.[3] The project area lies between the Carrizo and Trinity major aquifers, but is underlain by no major or minor aquifers.[4]

The proposed project is within an area identified as crops.[5] The crops vegetation type includes cultivated cover crops or row crops providing food and/or fiber for either man or domestic animals.

Potential Impacts

Aquatic Environments including Bays & Estuaries

FEMA has not completed a study to determine flood hazard for Falls County and a flood map has not been published.[6]. Several wetlands (2 freshwater emergent wetlands, 1 forested/shrub wetland, 28 freshwater ponds, and 41 riverine wetlands) were identified on the National Wetland Inventory (NWI) maps adjacent to the potential reservoir. A Nationwide Permit or coordination with the U.S. Army Corps of Engineers would be required for impacts to waters of the U.S. Two surface waters were identified on the TCEQ Surface Water Quality Viewer[7], the Brazos River (Segment #1242) and the Little

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[1] Gould, F.W., G.O. Hoffman, and C.A. Rechenthin, Vegetational Areas of Texas, Texas A&M University, Texas Agriculture Experiment Station Leaflet No. 492, 1960.

[2] Telfair, R.C., "Texas Wildlife Resources and Land Uses," University of Texas Press, Austin, Texas, 1999.

[3] Larkin, T.J., and G.W. Bomar, "Climatic Atlas of Texas," Texas Department of Water Resources, Austin, Texas, 1983.

[4] Texas Water Development Board (TWDB), *Aquifers*, http://www.twdb.texas.gov/groundwater/aquifer/index.asp accessed February 3, 2020.

[5] McMahan, C.A., R.F. Frye, and K.L. Brown, "The Vegetation Types of Texas," Texas Parks and Wildlife Department, Wildlife Division, Austin, Texas, 1984.

[6] FEMA, 2020. FEMA Flood Map Service Center. Accessed online https://msc.fema.gov/portal/search?AddressQuery=fall%20county#searchresultsanchor February 4, 2020.

[7] TCEQ, 2020. Surface Water Quality Viewer. Accessed online https://tceq.maps.arcgis.com/apps/webappviewer/index.html?id=b0ab6bac411a49189106064b70bbe778 February 4, 2020.

Brazos River (Segment #1242E), within the proposed project area, or within 5 miles. These stream segments have no water quality impairments.

Threatened & Endangered Species

The Texas Parks and Wildlife Department (TPWD) maintains a list of Rare, Threatened, and Endangered Species of Texas by County. This list includes the federal and state listing status and a habitat description for each species which may be a resident or migrant through the county. TPWD regularly updates the listing status, range data, and habitat descriptions on their published county lists, based on the most recently available data. The current list of rare, threatened and endangered species for Falls County can be found at https://tpwd.texas.gov/gis/rtest/.

According to the Information for Planning and Consultation (IPaC) website[8] maintained by the U.S. Fish & Wildlife Service (USFWS), the Whooping Crane and Texas fawnsfoot need to be considered for the proposed project. The Least Tern, Piping Plover, and Red Knot were also mentioned, but only need to be considered for wind energy projects.

Based on Texas Natural Diversity Data (TXNDD) obtained from the TPWD, there were four documented occurrences (sharpnose shiner, smalleye shiner, smooth pimpleback, and Texas fawnsfoot) in the within approximately one miles of the proposed OCR. Another documented occurrence of the smooth pimpleback was reported approximately 4.2 miles from the area of proposed improvements. No other documented occurrences of threatened, endangered or rare species or natural communities were reported within five miles of the project area. Although based on the best information available to TPWD, these data do not provide a definitive statement as to the presence, absence, or condition of special species, natural communities, or other significant features in the project area. On-site evaluations would be required by qualified biologists to confirm the occurrence of sensitive species or habitats.

A biological survey of the project area, to determine whether populations of threatened or endangered species, or potential habitats used by listed species occur in the area to be affected, should be conducted if this strategy is selected. At that time, a determination on whether any impacts or effects to listed species may occur would made. Coordination with TPWD and USFWS regarding threatened and endangered species with potential to occur in the project area should be initiated early in project planning.

Cultural Resources

A review of the Texas Historical Commission's publically-available GIS database showed one cemetery (Powers Cemetery) is mapped within the proposed OCR site. Additionally, three other cemeteries (Ferguson Cemetery, Shilo Cemetery, and Powers Chapel Cemetery) are located within one mile of the footprint for the proposed OCR.

There are no National Register Properties, National Register Districts, State Historic Sites, or Historical Markers within one mile of the proposed OCR. Prior to construction of proposed OCR, the project must be coordinated with the Texas Historical Commission and a cultural resources survey must be conducted to determine if any cultural resources

[8] USFWS, 2020. Information for Planning and Consultation. Accessed online https://ecos.fws.gov/ipac/location/FLFV27QWYJH3VFVFFBGPVMSLEM/resources February, 2020.

are present within the area. Any cultural resources identified during survey will need to be assessed for eligibility for inclusion in the National Register of Historic Places (NRHP) or as State Archeological Landmarks (SAL). Cultural resources that occur on public lands or within the Area of Potential Effect of publicly funded or permitted projects are governed by the Texas Antiquities Code (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archeological and Historic Preservation Act (PL93-291). Taking into consideration that the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the THC regarding impacts to cultural resources.

Threats to Natural Resources

Threats to natural resources include lower streamflows, declining water quality, and reduced inflows to reservoirs. This project would contribute to seasonally lower streamflows downstream of the reservoir site and potentially affect water quality through decreased flows.

Field surveys conducted at the appropriate phase of development should be employed to minimize the impacts of project construction and operations on sensitive resources.

4.1.4 Engineering and Costing

Cost estimates for the two selected main stem OCR sites were prepared using the TWDB uniform costing model are presented in Table 4.1-1. Project costs include construction of the dam, reservoir, Brazos River intake and pump station, and raw water pipeline from the Brazos River to the reservoir site. Comparison of the cost estimates indicate the Spring Branch OCR would provide a greater firm yield at a lower total project cost, annual cost, and unit cost of water.

Table 4.1-1. Cost Estimate Summary for Main Stem Off-Channel Reservoirs with Diversions from the Brazos River

Item	Estimated Costs for Spring Brach OCR Facilities	Estimated Costs for Hopes Creek OCR Facilities
Off-Channel Storage/Ring Dike	$31,177,000	$27,651,000
Brazos River Intake Pump Station	$36,856,000	$38,237,000
Transmission Pipeline (60 in dia., 0.5 miles and 60 in dia., 2.1 miles)	$1,059,000	$6,931,000
TOTAL COST OF FACILITIES	**$69,092,000**	**$72,819,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$24,129,000	$25,140,000
Environmental & Archaeology Studies and Mitigation	$4,320,000	$4,260,000
Land Acquisition and Surveying	$4,384,000	$4,332,000
Interest During Construction (3% for 4 years with a 0.5% ROI)	$5,607,000	$5,862,000
TOTAL COST OF PROJECT	**$107,532,000**	**$112,413,000**
ANNUAL COST		
Debt Service (3.5 percent, 20 years)	$3,800,000	$4,516,000
Reservoir Debt Service (3.5 percent, 40 years)	$2,506,000	$2,258,000
Operation and Maintenance		
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$11,000	$69,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$921,000	$956,000
Dam and Reservoir (1.5% of Cost of Facilities)	$468,000	$415,000
Pumping Energy Costs (0.08 $/kW-hr)	$148,000	$153,000
TOTAL ANNUAL COST	**$7,854,000**	**$8,367,000**
Available Project Yield (acft/yr)	**7,200**	**6,300**
Annual Cost of Water ($ per acft), based on a Peaking Factor of 1	**$1,091**	**$1,328**
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	**$3.35**	**$4.08**

4.1.5 Implementation Issues

The Spring Branch and Hopes Creek OCR water supply options are similar and have been compared to the plan development criteria, as shown in Table 4.1-2. The two OCR options meets each criterion.

Table 4.1-2. Evaluations of Hopes Creek and Spring Branch Off-Channel Reservoir Options to Enhance Water Supplies

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet needs
2. Reliability	2. High reliability
3. Cost	3. Reasonable (moderate to high)
B. Environmental factors	
1. Environmental Water Needs	1. Negligible impact
2. Habitat	2. Negligible impact
3. Cultural Resources	3. Low impact
4. Bays and Estuaries	4. Negligible impact
5. Threatened and Endangered Species	5. Low impact
6. Wetlands	6. Negligible 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	None
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	None

Implementation of one of the off-channel reservoir projects will require permits from various state and federal agencies, land acquisition, and design and construction of the facilities. A summary of the implementation steps for the project is presented below.

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality Water Right and Storage permits;
- U.S. Army Corps of Engineers Permits will be required for discharges of dredge or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act);
- Texas Commission on Environmental Quality administered Texas Pollutant Discharge Elimination System Storm Water Pollution Prevention Plan;
- General Land Office Easement if State-owned land or water is involved; and
- Texas Parks and Wildlife Department Sand, Shell, Gravel and Marl permit if state-owned streambed is involved.

State and Federal Permits may require the following studies and plans:

- Environmental impact or assessment studies;
- Wildlife habitat mitigation plan that may require acquisition and management of additional land;
- Flow releases downstream to maintain aquatic ecosystems;
- Assessment of impacts on Federal- and State-listed endangered and threatened species;
- Aquatic Resource Relocation Plan (ARRP) and a relocation permit may be required from TPWD if a dewatering event is required during construction; and
- Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resource recovery and cataloging; requires coordination with the Texas Historical Commission.

Land Acquisition Issues:

- Land acquired for reservoir and/or mitigation plans could include market transactions and/or eminent domain;
- Additional acquisition of rights-of-way and/or easements may be required; and
- Possible relocations or removal of residences, utilities, roads, or other structures.

4.2 Brushy Creek Reservoir

4.2.1 Description of Option

The proposed Brushy Creek Reservoir will serve water supply, recreation and flood control purposes in the Big Creek watershed. The reservoir site is located in Falls County on Brushy Creek, which is a tributary to Big Creek. The proposed reservoir is located approximately 26 miles southeast of the City of Waco and 8 miles east of the City of Marlin (Figure 4.2-1). This project was included as a water management strategy in the 2001, 2006, 2011, and 2016 Brazos G Regional Water Plans. Other Brushy Creek Reservoir studies include the 1984 Final Watershed Plan and Environmental Impact Statement for the Big Creek Watershed for Falls, Limestone, and McLennan Counties1 and the 2008 Reservoir Site Protection Study2.

Certificate of Adjudication 12-4355, as amended, authorizes 6,560 acre-feet of storage at a conservation level of 380.5 feet above mean sea level (ft-msl) in Brushy Creek Reservoir. The conservation pool of the reservoir will inundate an area of approximately 697 acres and the land required to create the reservoir has already been acquired by the City of Marlin.

The certificate also authorizes New Marlin City Lake and Marlin City Lake which impound 3,135 and 791 acre-feet of water, respectively. Marlin City Lake is used as a sedimentation basin. The City of Marlin is permitted to divert 4,000 acre-feet per year from New Marlin City Lake and/or Brushy Creek Reservoir for municipal purposes. The certificate also authorizes diversions between October and April from the Brazos River at the rate of 2,000 acft/yr for municipal purposes and 2,000 acft/yr for industrial purposes. A continuous release of 0.1 cfs must be made from Brushy Creek Reservoir to maintain instream flows. Table 4.2-1 is a summary of the authorizations made by Certificate No. 12-4355.

[1] USDA, 1984. *Final Watershed Plan and Environmental Impact Statement for the Big Creek Watershed for Falls, Limestone, and McLennan Counties*. U.S. Department of Agriculture, Soil Conservation Service. July 1984.
[2] TWDB, 2008. *Reservoir Site Protection Study* – Chapter 5.3 Brushy Creek Reservoir. Technical Report 370. Prepared for the Texas Water Development Board by R. J. Brandes and R. D. Purkeypile of the R.J. Brandes Company. July 2008. Pg 46-53.

Figure 4.2-1. Brushy Creek Reservoir Location

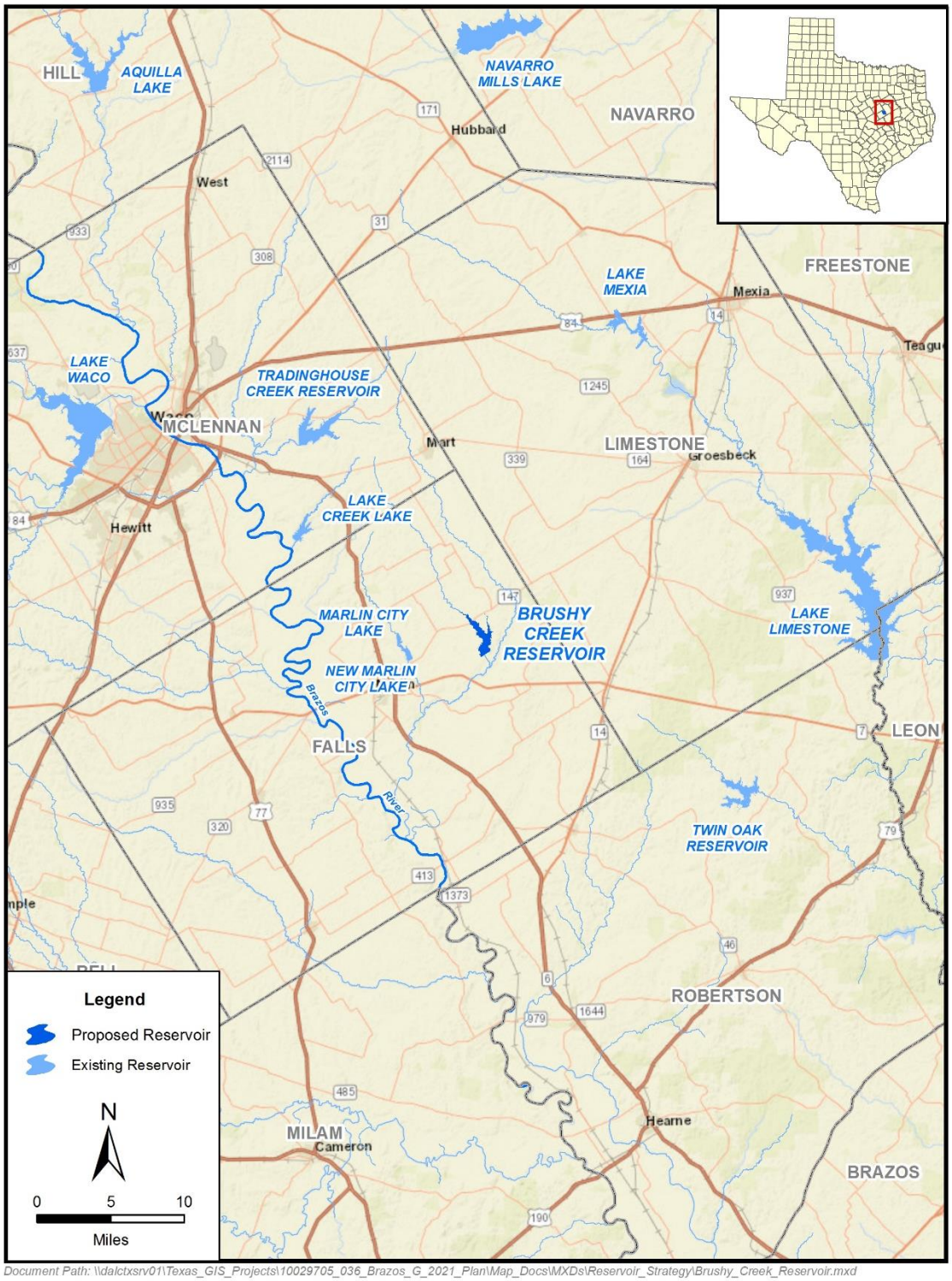

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Table 4.2-1. Summary of Authorizations for Certificate of Adjudication 12-4355

Source	*Storage (acft)*	*Impoundment Priority Date*	*Diversion (acft/year)*	*Use*	*Diversion Priority Date*
New Marlin Reservoir	3,135	4/9/1948	1,500	Municipal	4/9/1948
Brushy Creek Reservoir	2,921	11/22/1982	1,500	Municipal	11/27/1956
	3,639	12/3/1990	1,000	Municipal	11/22/1982
Marlin City Lake	650	11/1/1976			
	141	11/22/1982			
Brazos River			2,000	Municipal	11/27/1956
			2,000	Industrial	11/27/1956

4.2.2 Available Yield

Water potentially available for impoundment in the proposed Brushy Creek Reservoir is estimated using the TCEQ Brazos WAM Run 3. The model utilizes a January 1940 through December 1997 hydrologic period of record and assumes no return flows and permitted storages and diversions for all water rights in the basin. The model computes streamflow available for impoundment in Brushy Creek Reservoir without causing increased shortages to existing downstream rights and subject to the reservoir and diversion having to pass inflows to meet environmental flow standards. Additionally, impoundment of streamflows in Brushy Creek Reservoir is subject to a minimum required instream flow release of 0.1 cfs as specified in Special Condition G of Certificate of Adjudication 12-4355.

The firm yield of the reservoir is calculated to be 2,000 acre-feet per year assuming the authorized storage capacity of Brushy Creek Reservoir. This yield is in addition to the yield of the City's existing reservoir storage, i.e., New Marlin Reservoir. The elevation-area-capacity relationship assumed in the water availability analysis is shown in Table 4.2-2.

Figure 4.2-2 shows the simulated storage in Brushy Creek Reservoir assuming an annual diversion amount equal to the firm yield of 2,000 acft/yr. The storage frequency curve is presented in Figure 4.2-3.

Table 4.2-2. Elevation-Area-Capacity Relationship for Brushy Creek Reservoir

Elevation (feet)	Area (acres)	Capacity (acre-feet)
352	0	0
356	1	1
360	33	68
364	115	363
368	234	1,059
372	341	2,208
376	497	3,884
380	668	6,214
380.5*	697	6,560*

* Authorized conservation pool elevation and storage.

4.2.3 Environmental Issues

Existing Environment

The proposed Brushy Creek Reservoir site in Falls County lies within the Texas Blackland Prairies Ecological Region.[3] This region is characterized by gentle topography and black alkaline clay soils. Historically, the region was covered with native tall-grass prairies but today most of it has been converted to agriculture. The project area includes a vegetation type defined by Texas Parks and Wildlife (TPWD) as crops.[4] The climate of this area is characterized as subtropical humid and is noted for its warm summers. On average, area precipitation ranges from 36 to 38 inches per year.

There are no major aquifers beneath the project site, however, the Trinity Aquifer is located five miles to the northwest and the Carrizo Aquifer is seven miles to the southeast of the proposed reservoir site.

[3] Grifffith, Glenn, Sandy Bryce, James Omernik and Anne Rogers. 2007. Ecoregions of Texas. Texas Commission on Environmental Quality and Environmental Protection Agency, Austin, Texas.

[4] McMahan, Craig A., Roy G. Frye and Kirby L. Brown. 1984. The Vegetation Types of Texas Including Cropland. Texas Parks and Wildlife Department, Austin, Texas.

Figure 4.2-2. Simulated Storage in Brushy Creek Reservoir

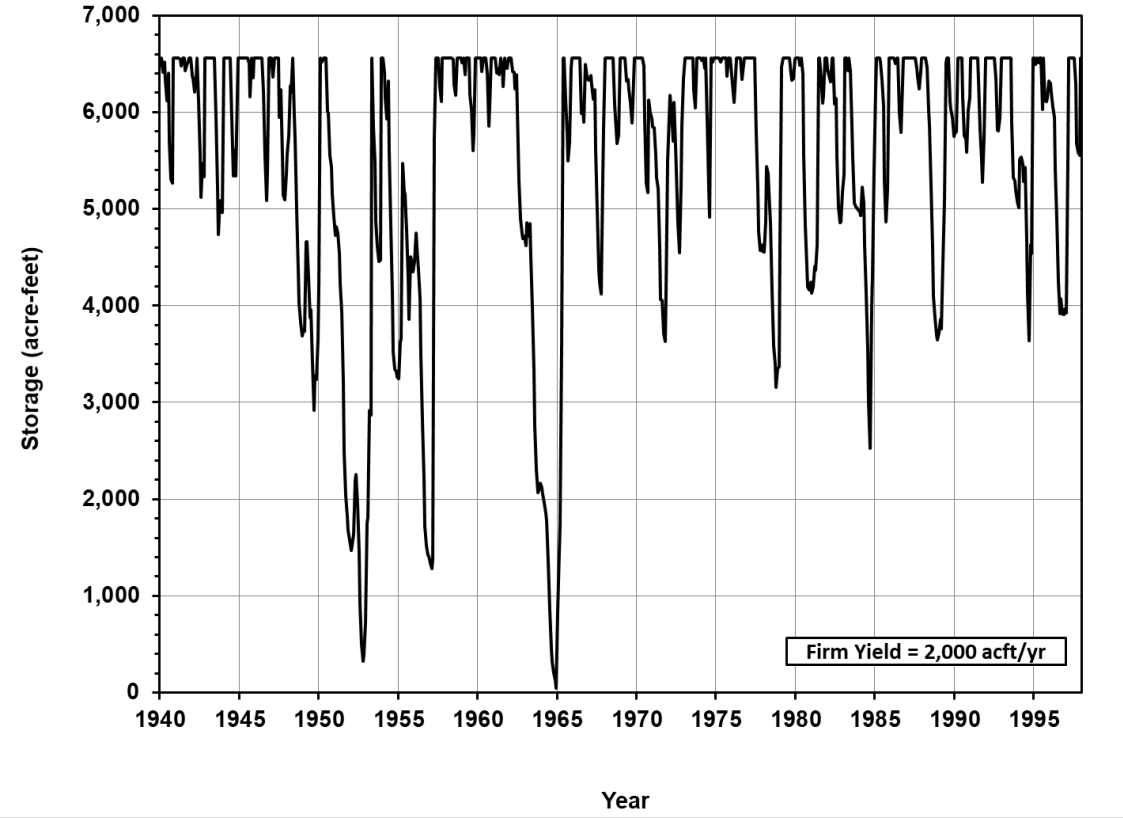
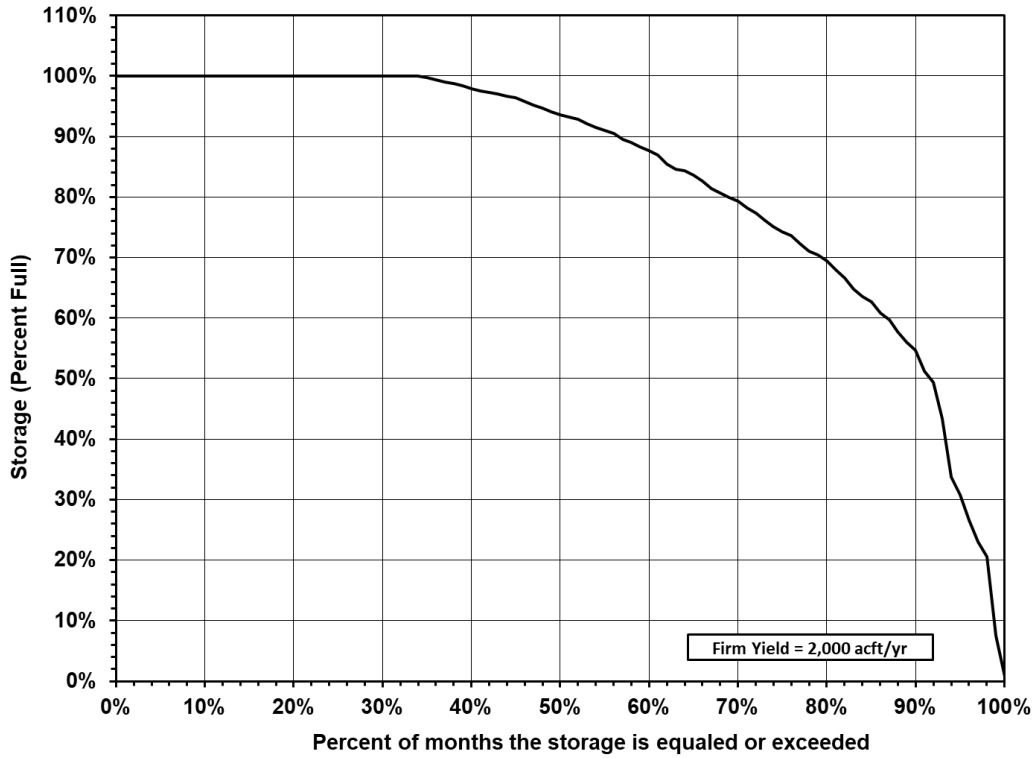


Figure 4.2-3. Storage Frequency Curve for Brushy Creek Reservoir



Potential Impacts

Aquatic Environments including Bays and Estuaries

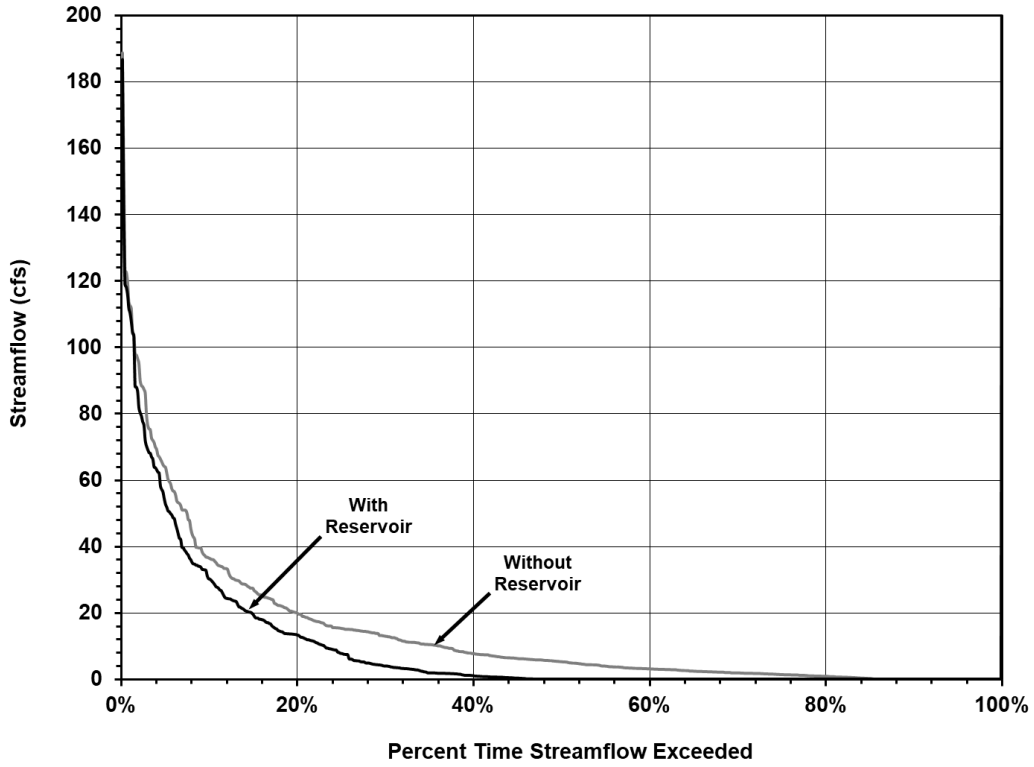
Construction of the Brushy Creek Reservoir project could reduce the quantity and variability of median monthly streamflows in Brushy Creek downstream of the reservoir (Table 4.2-3). Assuming annual diversions equal to the permitted amounts, these reductions could range from 1.9 cfs (95 percent) in October to 8.8 cfs (64 percent) in May. Figure 4.2-4 shows that without the reservoir, streamflow would likely cease 14% of the time. With the reservoir, streamflow will likely persist because a minimum release of 0.1 cfs is required to maintain instream flows. Without the required instream flow releases, streamflow would likely cease over 50% of the time.

Changes in streamflow could impact instream and riparian biological communities by potentially affecting their reproductive cycles and changing the composition of species. Substantial reductions in streamflow during the summer months could result in higher temperatures and higher concentrations of contaminants.

Table 4.2-3. Median Monthly Streamflow for Brushy Creek Reservoir

Month	Without Project (cfs)	With Project (cfs)	Difference (cfs)	Percent Reduction
January	6.9	1.6	5.4	77.6
February	6.6	0.2	6.4	97.1
March	6.7	1.4	5.3	78.6
April	6.3	1.6	4.8	75.2
May	13.7	4.9	8.8	64.0
June	11.3	3.0	8.2	73.2
July	3.7	0.1	3.6	97.3
August	3.4	0.1	3.3	97.1
September	2.3	0.1	2.2	95.8
October	2.0	0.1	1.9	95.1
November	3.1	0.1	3.0	96.8
December	5.8	0.2	5.6	95.8

Figure 4.2-4. Brushy Creek Reservoir Streamflow Frequency Comparison



Threatened & Endangered Species

The Texas Parks and Wildlife Department (TPWD) maintains a list of Rare, Threatened, and Endangered Species of Texas by County. This list includes the federal and state listing status and a habitat description for each species which may be a resident or migrant through the county. TPWD frequently updates the listing status, range data, and habitat descriptions on their published county lists, based on the most recently available data. The current list of rare, threatened and endangered species for Falls County can be found at https://tpwd.texas.gov/gis/rtest/.

Two bird species that could potentially occur in the vicinity of the Brushy Creek Reservoir site are federally listed as endangered. They are the whooping crane (*Grus americana*) and the interior least tern (*Sterna antillarum athalassos*). However, because these two birds are seasonal migrants, they are not likely to be impacted by the proposed project. There are no areas of critical habitat designated within or near the project area.[5]

The project area may provide potential habitat to endangered or threatened species listed for Falls County. A survey of the project area may be required prior to project construction to determine whether populations of or potential habitats used by listed species occur in the area to be affected. Coordination with TPWD and USFWS regarding threatened and endangered species with potential to occur in the project area should be initiated early in project planning.

[5] USFWS. Critical Habitat Portal. Accessed online at http://ecos.fws.gov/crithab/ May 13, 2019.

Wildlife Habitat

The quality of wildlife habitat in the Brushy Creek area has been previously impacted due to aggressive brush eradication efforts and the conversion of native habitats into agricultural lands. The reservoir would inundate approximately 697 acres of land at conservation capacity.[6] Landcover of the reservoir area includes 44% Upland Deciduous Forest, 39% Agricultural Land, 10% Grassland and 7% Shrubland. Current aerial photography shows riparian and wooded areas along Brushy Creek within the proposed reservoir area.

Cultural Resources

A cultural resource surface survey of the Brushy Creek Reservoir area was conducted in 1978[7]. The study identified nine prehistoric cultural resource sites located in the area to be inundated by the reservoir. In April 2005, another cultural resource survey of the site was conducted by TRC Environmental Corporation[8]. The 2005 survey revisited these nine sites and identified 15 additional sites. The 24 sites contained primarily diagnostic projectile points, debris from the manufacture of chipped stone tools, and a few burned rocks. The survey area did not completely cover the footprint of the dam or the emergency spillway. The study found six sites that have the potential to contribute important information about the region. Their eligibility for inclusion in the National Register of Historic Places (NRHP) and/or as State Archeological Landmarks (SAL) still needs to be assessed. The other 18 cultural sites investigated in the study do not have sufficient potential to be considered for inclusion in the NRHP or for designation as SALs. Cultural resources that occur on public lands or within the Area of Potential Effect of publicly funded or permitted projects are governed by the Archeological and Historic Preservation Act (PL93-291), the National Historic Preservation Act (PL96-515), and the Texas Antiquities Code (Title 9, Chapter 191, Texas Natural Resource Code of 1977).

The development of this strategy would include potential changes to in-stream flows in and below Brushy Creek which could affect aquatic and other species, and loss of riparian and other existing habitat in the reservoir and dam area. Development of the reservoir would inundate existing habitat areas resulting in habitat loss for some species and producing new habitat for others. It is anticipated that any additional facilities needed such as pipelines and pump stations would be positioned to avoid impacts to known cultural resources, sensitive habitats, wetlands or stream crossings as much as reasonably possible.

Agricultural Impacts

The Brushy Creek Reservoir site contains approximately 185 acres of Pasture/Hay fields and 84 acres of cropland. These two agricultural land uses account for roughly 25 percent of the reservoir footprint.

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[6] TWDB. 2008. Reservoir Site Protection Study. Report 370.

[7] Nunley, 1978. *Archeological Survey of Portions of Big Creek Watershed, Falls, Limestone and McLennan Counties, Texas*. Nunley Multimedia Productions, Miscellaneous Papers, No. 2, Dallas.

[8] TRC, 2006. *Cultural Resource Survey of the Proposed Brushy Creek Reservoir – Structure 19 Project Area, Falls County, Texas*. Technical Report 43211. Prepared for City of Marlin by J. M. Quigg, M. J. Archambeault, E. Schroeder, and P. M. Matchen of the TRC Environmental Corporation. July 2006.

4.2.4 Engineering and Costing

The Brushy Creek Reservoir strategy includes the construction of a rolled earth dam and a 12-inch diameter, 12-mile pipeline to deliver raw water supplies to the City of Marlin. Table 4.2-4 shows the estimated costs for the strategy, including the construction of the dam, land acquisition, resolution of conflicts, environmental permitting and mitigation, and engineering services. The City of Marlin has previously acquired the land for the reservoir; therefore, only land acquisition for the pipeline right-of-way is included in the costs.

The estimated cost of the project is $33.2 million. The annual costs of the project, including debt service and operation and maintenance, are estimated to be $2.5 million. The resulting unit cost of 2,000 acft/yr of raw water from the strategy is $1,247 per acft ($3.82 per 1,000 gallons).

Table 4.2-4. Cost Estimate Summary for Brushy Creek Reservoir

Item	Estimated Costs for Facilities
Dam and Reservoir (Conservation Pool 6,560 acft, 697 acres)	$5,924,000
Intake Pump Stations (1.9 MGD)	$5,802,000
Transmission Pipeline (12 in dia., 12 miles)	$5,468,000
Integration, Relocations, and Other	$4,146,000
TOTAL COST OF FACILITIES	**$21,340,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$7,196,000
Environmental & Archaeology Studies and Mitigation	$2,656,000
Land Acquisition and Surveying (72 acres)	$304,000
Interest During Construction (3% for 2 years with a 0.5% ROI)	$1,733,000
TOTAL COST OF PROJECT	**$33,229,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$1,567,000
Reservoir Debt Service (3.5 percent, 40 years)	$513,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$96,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$145,000
Dam and Reservoir (1.5% of Cost of Facilities)	$89,000

Table 4.2-4. Cost Estimate Summary for Brushy Creek Reservoir

Item	Estimated Costs for Facilities
Pumping Energy Costs (1,039,970 kW-hr @ 0.08 $/kW-hr)	$83,000
TOTAL ANNUAL COST	**$2,493,000**
Available Project Yield (acft/yr)	2,000
Unit Cost of Water ($ per acft)	$1,247
Unit Cost of Water ($ per 1,000 gallons)	$3.82

4.2.5 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 4.2-5 and the option meets each criterion.

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality Water Right and Storage permits have already been obtained;
- U.S. Army Corps of Engineers Permits will be required for discharges of dredge or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act);
- Texas Commission on Environmental Quality administered Texas Pollutant Discharge Elimination System Storm Water Pollution Prevention Plan;
- General Land Office Easement if State-owned land or water is involved; and
- Texas Parks and Wildlife Department Sand, Shell, Gravel and Marl permit if state-owned streambed is involved.

State and Federal Permits may require the following studies and plans:

- Environmental impact or assessment studies;
- Wildlife habitat mitigation plan that may require acquisition and management of additional land;
- Flow releases downstream to maintain aquatic ecosystems;
- Assessment of impacts on Federal- and State-listed endangered and threatened species;
- Aquatic Resource Relocation Plan (ARRP) and a relocation permit may be required from TPWD if a dewatering event is required during construction; and
- Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resource recovery and cataloging; requires coordination with the Texas Historical Commission.

Land Acquisition Issues:

- Land acquired for reservoir and/or mitigation plans could include market transactions and/or eminent domain;
- Additional acquisition of rights-of-way and/or easements may be required; and
- Possible relocations or removal of residences, utilities, roads, or other structures.

Table 4.2-5. Evaluations of Brushy Creek Off-Channel Reservoir Option to Enhance Water Supplies

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet needs
2. Reliability	2. High reliability
3. Cost	3. Reasonable (moderate to high)
B. Environmental factors	
1. Environmental Water Needs	Negligible impact
2. Habitat	Negligible impact
3. Cultural Resources	Low impact
4. Bays and Estuaries	Negligible impact
5. Threatened and Endangered Species	Low impact
6. Wetlands	Negligible 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	None
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	None

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4.3 Cedar Ridge Reservoir

4.3.1 Description of Option

Cedar Ridge Reservoir (CRR) is recommended in the 2001, 2006, 2011, and 2016 Brazos G Regional Plans. The proposed reservoir is located in Shackelford County on the Clear Fork of the Brazos River about 40 miles north of the City of Abilene (City), as shown in Figure 4.3-1. Initially located further downstream and known as the Breckenridge Reservoir, this project was originally studied in 1971 by the Texas Water Development Board. The proposed reservoir will contain approximately 227,127 acft of conservation storage and inundate 6,635 acres at the conservation storage level of 1,489 ft-msl. The contributing drainage area of the proposed reservoir is approximately 2,748 sq. miles. Additionally, Abilene and BRA have signed an interlocal agreement for the subordination of Possum Kingdom Reservoir water rights to the proposed CRR.

The water supply from CRR will be used to meet municipal shortages in the area, and Abilene plans to operate CRR as a supply in conjunction with its existing water supply system. Abilene is actively pursuing the necessary permits to implement this project and the information contained in this section is based on the water right permit application filed at the Texas Commission on Environmental Quality (TCEQ) and the Clean Water Act, Section 404 permit application filed with the U.S. Army Corps of Engineers, Ft. Worth District (USACE).

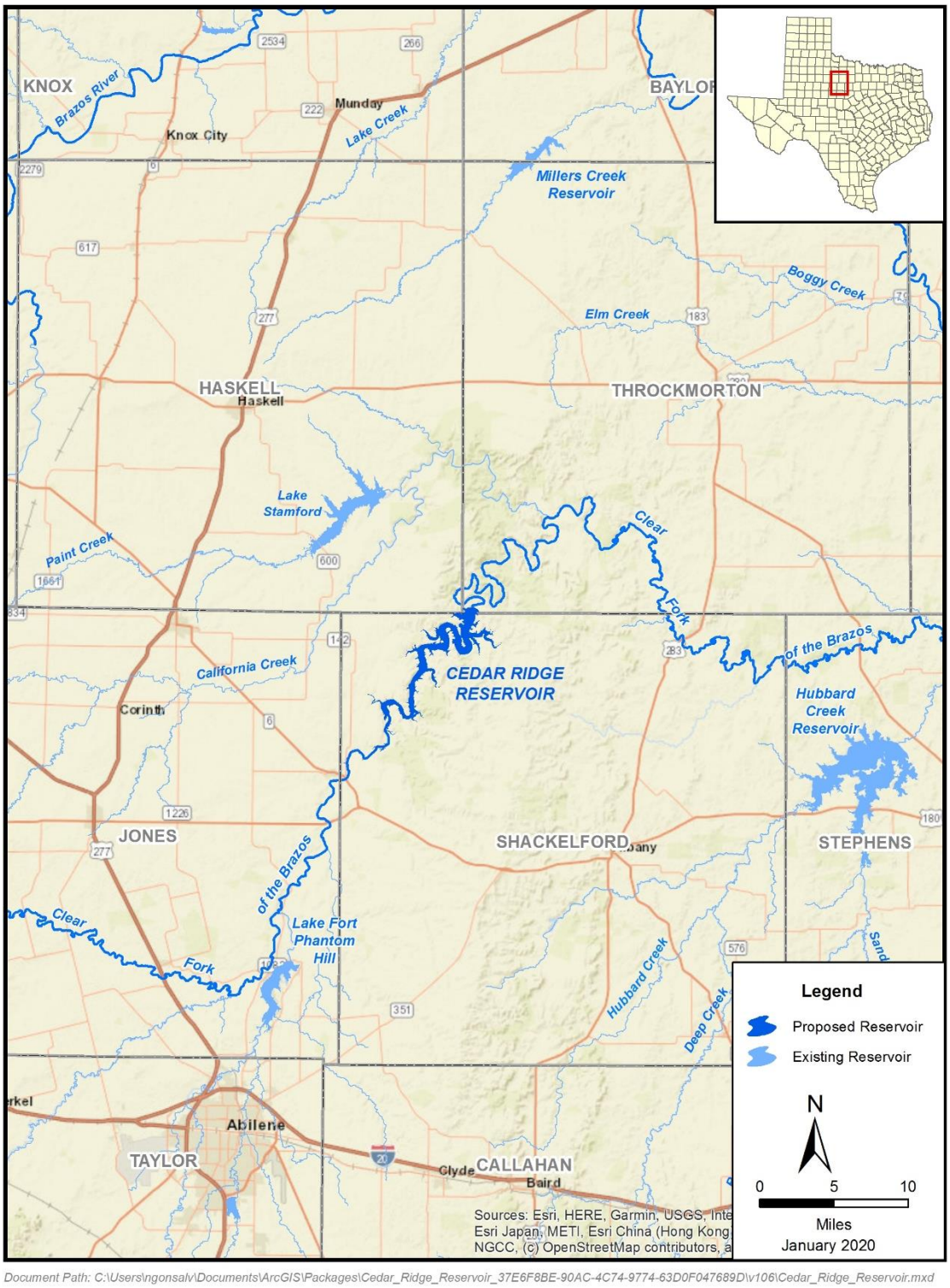
4.3.2 Available Yield

Abilene has applied for a water right permit with the TCEQ to impound 227,127 acft and divert up to 34,400 acft/yr of water from the reservoir for multi-purpose uses including: municipal, domestic, industrial, agriculture, livestock, steam-electric, mining, and recreation. The calculated firm yield of the reservoir using the TCEQ Brazos WAM is 36,300 acft/yr, assuming permitted storages and authorized diversions for all other water right holders in the Brazos basin for the 1940 to 1997 hydrologic period and subordination of Possum Kingdom Reservoir (C5155 owned by the BRA) water rights.

Severe drought conditions have occurred in the upper Brazos Basin resulting in a new drought of record for the Clear Fork watershed since 1997, which is outside of the period of record for the TCEQ Brazos WAM. A water availability analysis performed by HDR Engineering, Inc. as part of the Section 404 permitting process indicates the 2020 firm yield of CRR has been reduced to 22,500 acft/yr as a result of the severe drought conditions occurring from 1997 to 2016. For purposes of this evaluation, the more conservative 22,500 acft/yr firm yield is assumed for the project.

Additionally, the water availability analyses performed as part of the Section 404 permitting process considers future droughts more severe than the current drought of record to project future reliable supplies from the project. Those analyses project the firm yield of CRR to reduce to 10,100 acft/yr by 2070. For the purposes of this evaluation and for consistency with Abilene's previous water supply planning evaluations, it is assumed that the firm yield of CRR will be linearly reduced from 22,500 acft/yr in 2020 to 10,100 acft/yr in 2070.

Figure 4.3-1. Cedar Ridge Reservoir



Document Path: C:\Users\ngonsalv\Documents\ArcGIS\Packages\Cedar_Ridge_Reservoir_37E6F8BE-90AC-4C74-9774-63D0F047689D\v106\Cedar_Ridge_Reservoir.mxd

Figure 4.3-2 illustrates the simulated Cedar Ridge Reservoir storage levels operated at a firm yield demand of 22,500 acft/yr for the 1940 to 2016 historical period. The storage trace shows that the recent drought beginning in the late 1990s is significantly more severe than the drought of the 1950s.

Figure 4.3-3 illustrates the storage frequency of the simulated Cedar Ridge Reservoir subject to the firm yield demand of 22,500 acft/yr. Simulated reservoir contents remain above half full almost 80 percent of the time under the firm yield demand.

Figure 4.3-4 presents the changes in Clear Fork monthly median streamflows caused by impoundments in the reservoir considering pass-through flows for downstream senior water rights and environmental needs per TCEQ environmental flow requirements. Figure 4.3-5 compares the existing Clear Fork streamflow frequency characteristics for the full period (1940 – 2016) of the analysis without the project to simulated streamflow characteristics with the project.

Figure 4.3-2. Cedar Ridge Reservoir Firm Yield Storage Trace

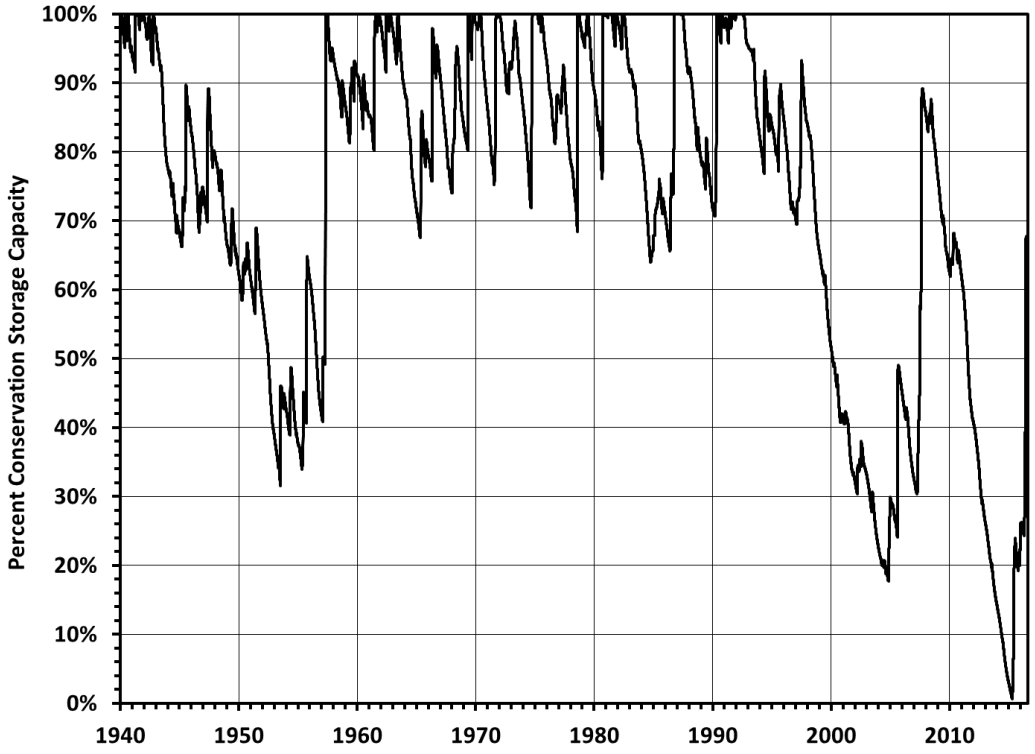


Figure 4.3-3. Cedar Ridge Reservoir Firm Yield Storage Frequency

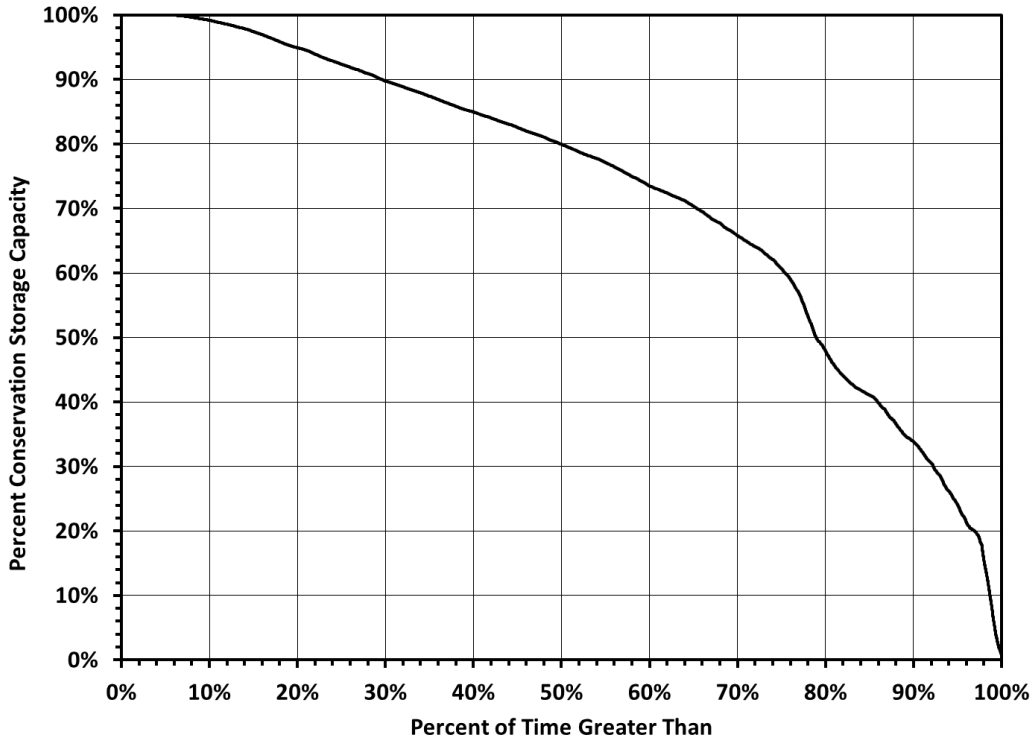


Figure 4.3-4. Cedar Ridge Reservoir Median Streamflow Comparison

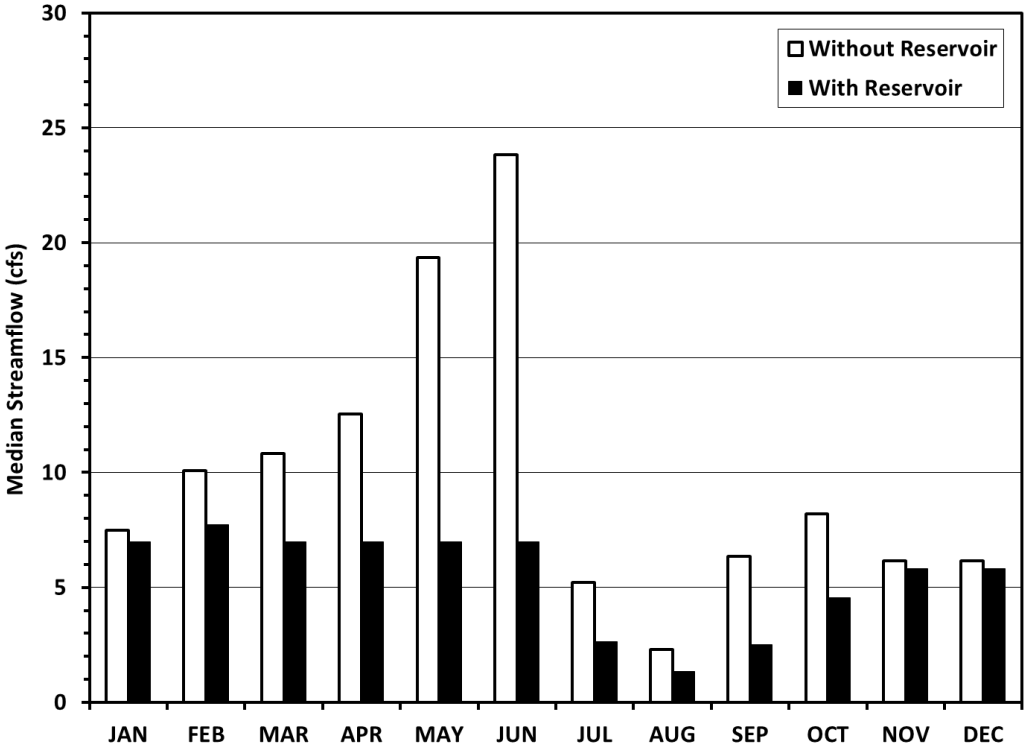
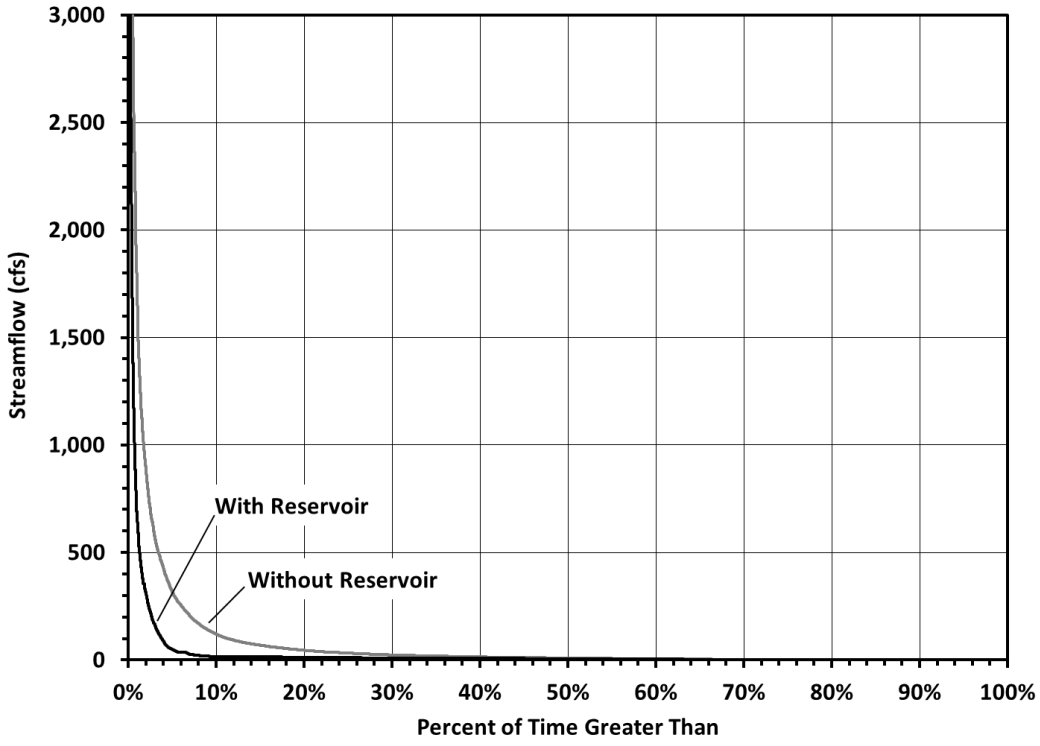


Figure 4.3-5. Cedar Ridge Reservoir Streamflow Frequency Comparison



4.3.3 Environmental Issues

The following section focuses on providing a general summary of environmental issues consistent with other water management strategies evaluated as part of the 2021 Brazos G Plan.

Existing Environment

The Cedar Ridge reservoir will inundate 6,635 acres at its conservation storage level of 1,489 ft-msl. The project will require an intake pump station, a water treatment plant expansion at one of the City's existing water treatment plants, and a transmission pipeline of approximately 29 miles. Water diverted from this reservoir will be used to meet water supply needs for the City and include existing and future customers.

Steep canyon walls are present throughout this area, ranging from 5 to 30 percent slopes with near-vertical cliffs in some areas. Soils in the study area are predominantly loamy and clayey with clayey soils occurring primarily in the upstream portions of the study area. General soil map units in the project area include the Palopinto-Throck and Clairemont-Grandfield-Clearfork soil units.

No major or minor aquifers underlie the project area. The Trinity Aquifer lies south of the project area and consists of interbedded sandstone, sand, limestone, and shale of

Cretaceous Age. The Seymour Aquifer is located west and north of the project area and is composed of isolated areas of alluvium.[1]

The climate in the study area is subtropical subhumid, with hot, dry summers and mild, dry winters. Temperatures range from an average low of 31°F in January to an average maximum of 97°F in July with a mean average temperature of 64°F.[2] The growing season is approximately 224 days, and annual precipitation averages between 25 and 28 inches. Most precipitation occurs from April to October during thunderstorms of short duration and high intensity. Recurring droughts are common in this area and can last many years.

The project area lies within the Limestone Plains subregion of the portion of the Central Great Plains ecoregion in Texas[3] and the vegetational area known as the Rolling Plains.[4] Although this subregion is principally covered by a mixed grass prairie dominated by grasses such as little bluestem (*Schizachyrium scoparium*), indiangrass (*Sorghastrum nutans*), and buffalograss (*Bouteloua dactyloides*), it also includes scattered trees such as honey mesquite (*Prosopis glandulosa*).

The dominant vegetation type found within the project area, as mapped by the TPWD, is mesquite brush, which covers approximately 61 percent of the conservation pool area of Cedar Ridge Reservoir.[5] Plants commonly associated with this vegetation type include narrow-leaf yucca (*Yucca glauca*), purple pricklypear (*Opuntia macrocentra*), juniper (*Juniperus* spp.), red grama (*Bouteloua trifida*), Texas grama (*Bouteloua rigidiseta*), purple three-awn (*Aristida purpurea* var. *purpurea*), James' rushpea (*Caesalpinia jamesii*), and wild buckwheat (*Eriogonum* spp.).[6]

The mesquite-lotebush shrub vegetation type is also found within the project area. This vegetation type is dispersed relatively evenly along the reservoir site, covering approximately 39 percent of the conservation pool area. Commonly associated plants in this vegetation type include honey mesquite, yucca (Yucca spp.), fragrant sumac (*Rhus aromatica*), elbowbush (*Forestiera pubescens*), cane bluestem (*Bothriochloa barbinodis*), silver bluestem (*Bothriochloa laguroides* ssp. *torreyana*), Texas wintergrass (*Nassella leucotricha*), Engelmann's daisy (*Engelmannia peristenia*), and bitter rubberweed (*Hymenoxys odorata*).[7]

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1 Texas Water Development Board (TWDB). 2010a. Major and Minor Aquifers of Texas; Maps online at http://www.twdb.state.tx.us/mapping/index.asp.

2 Handbook of Texas Online (HTO), s.v. "Shackelford County, Texas,". http://www.tshaonline.org/handbook/online/articles/SS/hcs8.htm.

3 Griffith, G. E., S. A. Bryce, J. M. Omernik, J. A.Comstock, A. C.Rogers, B.Harrison, and S. L. Hatch, and D. Bezanson. 2004. Ecoregions of Texas (color poster with map, descriptive text, and photographs): Reston, VA, U.S. Geological Survey.

4 Hatch, S. L., N. G. Kancheepuram, and L. E. Brown. 1990. Checklist of the Vascular Plants of Texas. Texas Agricultural Experiment Station. Texas A&M University, College Station.

5 McMahan, C. A., R. G. Frye, K. Brown. 1984. The Vegetation Types of Texas, Including Cropland. Wildlife Division, Texas Parks and Wildlife Department, Austin.

6 Ibid.

7 McMahan, C. A., R. G. Frye, K. Brown. 1984. The Vegetation Types of Texas, Including Cropland. Wildlife Division, Texas Parks and Wildlife Department, Austin.

Permanent impacts will occur to all the current vegetation located within the conservation pool of the reservoir and some portions of the construction area. This vegetation will be impacted either by clearing at the dam site or inundation by the reservoir. Temporary impacts may also occur to the vegetation located outside of the conservation pool area but within the flood pool area. These areas will be inundated only occasionally for a few days as floods will be passed through an ungated spillway. Pipeline areas will primarily impact vegetation during construction and maintenance activities with some areas returning to their original states after the initial disturbance.

Potential Impacts

Aquatic Environments including Bays & Estuaries

With the construction of the new reservoir, the current floodplains along the Clear Fork and its major tributaries within the new reservoir's conservation pool area will be inundated. Although some stream and wetland functions would be impacted due to inundation by the conservation storage area, the creation, enhancement, and/or protection of aquatic habitat resulting from the new reservoir will replace some of the biological, chemical, and physical functions of the impacted resources and habitats.

The anticipated impact of this project would be lower variability and reductions in the quantity of median monthly flows. Variability in flow is important to the instream biological community as well as riparian species and pass throughs for environmental needs are proposed to be in accordance with recently adopted TCEQ flow requirements. The TCEQ flow requirements for this segment of the Clear Fork were based, in part, on in-stream flow studies performed for the project to assure that adequate flows remained in the stream to maintain the existing biological community.

Although there may be some impacts on the biological community in the immediate vicinity of the project site and downstream, this project would not have a substantial influence on total discharge in the Brazos River or to freshwater inflows to the Brazos River estuary. As a new reservoir, Cedar Ridge Reservoir would be required to pass through environmental flows based on TCEQ's recently adopted environmental flow requirements.

Wildlife Habitat

The project area is located within the Kansan biotic province.[8] The Kansan Province is divided into three districts that include (from west to east) the short-grass plains, mixed-grass plains, and the mesquite plains. The project area is situated within the mesquite plains district. Within this district, the typical vegetation community generally consists of clusters of mesquite and other shrubs interspersed with open areas of grasses. Common wildlife species found in the Kansan Biotic Province include the Great Plains toad (*Anaxyrus cognatus*), turkey vulture (*Cathartes aura*), scaled quail (*Callipepla squamata*), big brown bat (*Eptesicus fuscus*) and eastern collared lizard (*Crotaphytus collaris*) among others. Wildlife species inhabiting the project area utilize it to varying extents depending on specific biologic need.

8 Blair, W. F. 1950. The biotic provinces of Texas. Texas Journal of Science 2:93–117.

Inundation of existing habitat by the reservoir will force non-aquatic species inhabiting these areas to relocate to surrounding suitable habitats unaffected by reservoir filling. Greater adverse impacts will occur to those wildlife species that currently utilize riparian habitats within the reservoir's footprint; however, similar habitats exist along upstream and downstream reaches of the Clear Fork, and additional riparian habitat will develop along portions of the reservoir shoreline after reservoir filling.

Threatened & Endangered Species

The Texas Parks and Wildlife Department (TPWD) maintains a list of Rare, Threatened, and Endangered Species of Texas by County. This list includes the federal and state listing status and a habitat description for each species which may be a resident or migrant through the county. TPWD regularly updates the listing status, range data, and habitat descriptions on their published county lists, based on the most recently available data. The current list of rare, threatened and endangered species for Haskell, Jones, Shackelford, and Throckmorton counties can be found at https://tpwd.texas.gov/gis/rtest/.

A search of the Texas Natural Diversity Database (TNDD)[9] identified the state threatened Brazos water snake as the only threatened or endangered species with documented occurrences within or near the new reservoir site. The plains spotted skunk, a species of concern, was also documented in the vicinity of the new reservoir; however, this species is not state or federally protected. While based on the best information available to TPWD, TNDD data do not provide a definitive statement as to the presence, absence, or condition of special species, natural communities, or other significant features in the project area.

Listed species with the potential to occur within the project area are discussed in the following paragraphs. These species include two birds, the Whooping Crane (*Grus americana*) and the Interior Least Tern (*Sterna antillarum athalassos*). These birds are federally listed as endangered and could occur within the project and surrounding areas as seasonal migrants. During migration, Whooping Cranes primarily utilize wetland areas as rest stops. Wetland habitat within the project area is limited, and occurrences of this species would be limited to occasional migratory stops. The Interior Least Tern typically nests on bare or sparsely vegetated areas associated with streams or lakes, such as sand and gravel bars, beaches, islands, and salt flats. Occasional migrants of these species are possible within the new reservoir site.

Two fishes, the sharpnose shiner (*Notropis oxyrhynchus*) and the smalleye shiner (*N. buccula*) are small, slender minnows endemic to the Brazos River Basin.[10] Historically, these fishes existed throughout the Brazos River and several of its major tributaries; however, both species have experienced significant population declines. General habitat associations for both species include relatively shallow water with moderate currents flowing through broad, open sandy channels. Surveys of the Clear Fork performed within

9 Texas Parks and Wildlife Department (TPWD). 2019. Element occurrence records for Haskell, Jones, Shackelford, and Throckmorton Counties. Texas Natural Diversity Database, Texas Parks and Wildlife Department.

10 Cross, F. B. 1953. A new minnow, Notropis bairdi buccula, from the Brazos River, Texas. Texas Journal of Science 5:252-259.

and downstream of the reservoir footprint indicate that suitable habitat for both the sharpnose and smalleye shiner is not present.

Two mussel species, the smooth pimpleback (*Quadrula houstonensis*) and the Texas fawnsfoot (*Truncilla macrodon*), are endemic to the Brazos River Basin and could potentially occur within or in the surrounding vicinity of the new reservoir footprint. The smooth pimpleback prefers small to moderate-sized streams and rivers, as well as moderate-sized reservoirs, and is typically found in substrates of mixed mud, sand and fine gravel in water flowing at a very slow to moderate rate.[11] While it is unlikely that the smooth pimpleback inhabits the reach of the Clear Fork to be impacted by the new reservoir, this species is known to tolerate impoundment.

The Texas fawnsfoot historically occurred in the Brazos and Colorado River drainages. Little is known about the preferred habitat of this species; however, it is known to be intolerant of impoundment.[12] Texas fawnsfoot specimens potentially occurring downstream of the new reservoir are not anticipated to be significantly impacted by the project, as this species has been reported to occur downstream of other impoundments along the Brazos River. Surveys of the project reach for mussels were conducted in 2009, 2010, and 2011. No live or recently dead specimens of either the smooth pimpleback or the Texas fawnsfoot were identified upstream, within, and downstream of the project reach.

The new reservoir could potentially cause adverse impacts to two state threatened reptile species. These species include the Texas horned lizard (*Phrynosoma cornutum*) and the Brazos water snake (*Nerodia harteri harteri*). The Texas horned lizard is a relatively small lizard that is known to occur in a variety of habitats, including short-grass prairie, mesquite grasslands, shrublands, desert scrub, and desert grasslands.[13] Potentially suitable habitat for the Texas horned lizard is present both within and surrounding the reservoir footprint. As the Cedar Ridge Reservoir fills, Texas horned lizards inhabiting areas within the reservoir footprint would be displaced. Potential impacts to this state-threatened lizard would likely be minimal given the estimated slow filling rate of the new reservoir and abundant suitable habitat immediately surrounding the project area.

The Brazos water snake is a highly aquatic, endemic Texas snake with a limited and patchy distribution along the upper Brazos River drainage in north-central Texas. Preferred habitat consists of shallow rocky riffles along the river that have a gently sloping rocky shoreline free of vegetation.[14] Investigation of the project area indicates that Brazos water snake populations and suitable habitat exist along the Clear Fork, both within and downstream of the proposed Cedar Ridge reservoir footprint. Potential impacts to the Brazos water snake from the construction of the Cedar Ridge Reservoir include the inundation and loss of existing habitat along the Clear Fork. However,

11 Howells, R. G., R. W. Neck, and H. D. Murray. 1996. Freshwater Mussels of Texas. Inland Fisheries Division, Texas Parks and Wildlife Department, Austin..

12 Ibid.

13 Price, A. H. 1990. Phrynosoma cornutum. Catalogue of American Amphibians and Reptiles. 469:1–7.

14 Scott, N. J., Jr., T. C. Maxwell, O. W. Thornton, Jr., L. A. Fitzgerald, and J. W. Flury. 1989. Distribution, habitat, and future of Harter's Water Snake, Nerodia harteri, in Texas. Journal of Herpetology 23:373-389.

geologic investigations of the Cedar Ridge Reservoir shoreline indicate that there will be significant areas of rocky shoreline that will provide significant habitat after the reservoir fills. Based on the occurrence and populations of Brazos Water Snakes that have continued to reproduce in Possum Kingdom Lake since its initial filling in 1941, it is anticipated that the Brazos Water Snake will have suitable habitat to maintain viable populations in Cedar Ridge Reservoir.

Cultural Resources

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available GIS datasets provided by the Texas Historical Commission (THC), there are no National Register Properties, National Register Districts, State Historic Sites, cemeteries, or historical markers located within or near the reservoir or pipeline project areas. The owner of the project is required to coordinate with the Texas Historical Commission regarding potential impacts to cultural resources.

The Texas Archeological Sites Atlas online database of the Texas Historical Commission (THC) was also consulted, and background research was conducted to determine any previous cultural resources survey efforts as well as the locations of previously recorded historic and archaeological resources in the project area. Records indicate that eight previously recorded prehistoric archaeological sites were located within a 1-mile radius of the reservoir area.

The City conducted preliminary Phase 1A archeological surveys and historical evaluations, and the results and recommendations from these Phase 1A surveys were provided to the TCEQ in the Water Rights application submitted on August 17, 2011, and to the THC and USACE under separate cover. Phase 1B surveys, including trenching at selected alluvial terrace locations, were initiated in 2011 and completed in 2012. The findings of the Phase 1B surveys were provided to the USACE and THC in support of Section 404 Permit coordination per the requirements of Section 106 of the National Historic Preservation Act (NHPA). The City will also coordinate the findings of the archeological surveys with the THC and TCEQ in conjunction with the review of the project under the Antiquities Code of Texas.

The Phase 1A and 1B investigations identified 66 prehistoric sites, five historic sites, and four multi-component sites. Four archeological sites located within the project area are recommended for further testing to determine their eligibility for listing in the National Register of Historic Places (NRHP) and designation as a State Archeological Landmark (SAL) by the City pending concurrence from the USACE and THC. Additionally, historical sites were evaluated, and 62 architectural resources at five sites were recorded. Fifty-seven of the sites are associated with the proposed Hendrick River Ranch Historic District. Evaluation of the pre-historic and historic resources in the area of potential effect of the reservoir will be conducted and documented per standard practices for determination of NRHP and SAL eligibility, and mitigation measures will be implemented, if necessary.

Specific project features, such as pipelines, generally have sufficient design flexibility to avoid most impacts or significantly mitigate potential impacts to geographically limited environmental and cultural resource sites. Field surveys conducted at the appropriate phase of development should be employed to minimize the impacts of project construction and operations on sensitive resources.

Threats to Natural Resources

Threats to natural resources include lower streamflows below the reservoir. However, due to the nutrient removal that will occur as a result of the new reservoir and a planned multi-level outlet, water quality downstream of the reservoir is anticipated to improve with respect to increasing dissolved oxygen concentrations, and lowering concentrations of any existing stream pollutants.

Agricultural Impacts

The Cedar Ridge Reservoir site contains approximately 35 acres of pasture and hay fields and 58 acres of cropland. These two agricultural land uses account for less than two percent of the reservoir footprint.

4.3.4 Engineering and Costing

The proposed CRR includes the construction of an earthen dam, principal spillway, emergency spillway, and appurtenant structures. eHT and HDR completed a study[15] in 2009 of the proposed Cedar Ridge Reservoir. Estimated costs for the reservoir included in the study are indexed to September 2018 dollars. Transmission facilities are sized to deliver the firm yield supply of 22,500 acft/yr with an estimated five percent downtime. Estimated capital costs for transmission facilities, relocations, and integration were provided by Abilene.

The capital cost of the project is estimated to be $159.1 million and includes the construction of the dam, land acquisition, and resolution of conflicts. Also included in the capital costs are facilities to deliver supplies to the City through a 42-inch, 29-mile pipeline. The total cost of the project is estimated to be $283.6 million and includes environmental permitting and mitigation, and technical services. A summary of the estimated costs for the project is provided in Table 4.3-1. The annual project costs are estimated to be $19.2 million, which includes annual debt service, operation and maintenance, and an annual payment to BRA for lost yield in Possum Kingdom Reservoir. The resulting unit cost to deliver the firm yield supply 22,500 acft/yr is $2.62 per 1,000 gallons or $853 per acft. Treatment costs are included in another water management strategy recommended for Abilene.

15 eHT and HDR, Op. Cit., November 2009.

Table 4.3-1. Cost Estimate for Cedar Ridge Reservoir

Item	Estimated Costs for Facilities
Dam and Reservoir	$81,831,000
Intake Pump Stations (21.1 MGD)	$12,105,000
Transmission Pipeline (42 in dia., 29 miles)	$50,122,000
Integration, Relocations, & Other	$15,012,000
TOTAL COST OF FACILITIES	**$159,070,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$53,168,000
Environmental & Archaeological Studies and Mitigation	$30,980,000
Land Acquisition and Surveying (9,985 acres)	$18,809,000
Interest During Construction (3% for 3 years with a 0.5% ROI)	$21,619,000
TOTAL COST OF PROJECT	**$283,646,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$7,835,000
Reservoir Debt Service (3.5 percent, 40 years)	$8,068,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$651,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$303,000
Dam and Reservoir (1.5% of Cost of Facilities)	$1,227,000
Pumping Energy Costs ($0.08 kwh)	$1,019,000
Purchase of Water (1,100 acft/yr @ 76.50 $/acft)	$84,000
TOTAL ANNUAL COST	**$19,187,000**
Available Project Yield (acft/yr)	**22,500**
Annual Cost of Water ($ per acft), based on a Peaking Factor of 1.53	**$853**
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1.53	**$2.62**

4.3.5 Implementation Issues

The CRR water supply option has been compared to the plan development criteria, as shown in Table 4.3-2, and the option meets each criterion.

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality Water Right and Storage permit (pending at TCEQ);
- U.S. Army Corps of Engineers Permit will be required for discharges of dredged or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act) (pending at the USACE-SWF);
- Texas Commission on Environmental Quality administered Texas Pollutant Discharge Elimination System Storm Water Pollution Prevention Plan;
- Texas General Land Office Easement if State-owned land or water is involved; and
- Texas Parks and Wildlife Department Sand, Shell, Gravel, and Marl permit if state-owned streambed is involved.

State and Federal Permits may require the following studies and plans:

- Environmental impact or assessment studies;
- Wildlife habitat mitigation plan that may require acquisition and management of additional land;
- Flow releases downstream to maintain aquatic ecosystems;
- Assessment of impacts on Federal- and State-listed endangered and threatened species;
- Aquatic Resource Relocation Plan (ARRP) and a relocation permit may be required from TPWD if a dewatering event is required during construction; and
- Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resource recovery and cataloging; requires coordination with the Texas Historical Commission.

Land Acquisition Issues:

- Land acquired for reservoir and mitigation plans could include market transactions or other local landowner agreements;
- Additional acquisition of rights-of-way and easements may be required; and
- Relocations or removal of residences, utilities, roads, or other structures.

Table 4.3-2. Comparison of Cedar Ridge Reservoir Plan Development Criteria

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet needs
2. Reliability	2. High reliability
3. Cost	3. Reasonable to High
B. Environmental factors	
1. Environmental Water Needs	1. Moderate impact
2. Habitat	2. High impact
3. Cultural Resources	3. Moderate impact based on surveys of the site
4. Bays and Estuaries	4. Low impact due to distance from the coast
5. Threatened and Endangered Species	5. Possible moderate 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	Potential impact on bottomland farms and habitat in the reservoir area
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	None
G. Third-Party Social and Economic Impacts from Voluntary Redistribution	None

4.4 Coryell County Off-Channel Reservoir

4.4.1 Description of Option

The Coryell County Off-Channel Reservoir (OCR) is located on a tributary adjacent to Cowhouse Creek about four miles southeast of the Coryell-Hamilton County Line, as shown in Figure 4.4-1. Supplies from the OCR would be used to meet needs in Coryell County and potentially Bell, Lampasas, Williamson, or Hamilton Counties.

The OCR would impound streamflow pumped from Cowhouse Creek from a diversion site directly downstream of the proposed OCR dam location. The OCR would consist of a 4,767 ft earthfill embankment dam on the Cowhouse Creek tributary stream with a crest elevation at 1,080 ft-msl. The OCR includes a 5 ft vertical freeboard and a conservation pool elevation of 1,075 ft-msl. At conservation pool elevation, the reservoir will have a storage capacity of 15,380 acft and inundate 445 surface acres. All flows from the small contributing drainage area to the OCR would be passed through the dam and not impounded.

For the project to be economically feasible, an agreement with the Brazos River Authority (BRA) would be required to subordinate Lake Belton water rights to diversions from Cowhouse Creek for impoundment in the OCR. Without subordination, the unappropriated flows in Cowhouse Creek are not sufficient to maintain adequate water levels in the OCR. Currently, BRA indicates that no subordination agreement is likely to be possible.

4.4.2 Available Yield

Water potentially available for impoundment in the proposed Coryell Off-Channel Reservoir was estimated using the TCEQ Brazos WAM Run 3. The model utilizes a January 1940 through December 1997 hydrologic period of record and assumes no return flows and permitted storages and diversions for all water rights in the basin. The model computes streamflow available for diversion from Cowhouse Creek into the Coryell OCR without causing increased shortages to existing downstream rights and subject to the subordination agreement with Lake Belton. Estimates of water availability were derived subject to all diversions and impoundments having to pass streamflows to meet TCEQ environmental flow standards.

Figure 4.4-1. Coryell County Off-Channel Reservoir

Document Path: \\dalctxsrv01\Texas_GIS_Projects\10029705_036_Brazos_G_2021_Plan\Map_Docs\MXDs\Reservoir_Strategy\Coryell_County_OCR.mxd

A 675 ft, 36-inch diameter pipeline would be used to deliver streamflow from Cowhouse Creek to the off-channel reservoir. Due to the short pipeline length, it was assumed the diversion system would be capable of transmitting water at a velocity of 7 feet per second (49.5 cfs). A possible 2,985 acft of water could be diverted per month if the transmission system operated every day at full capacity. However, for the transmission system to be able to operate, streamflow in Cowhouse Creek must exceed the pumping capacity (49.5 cfs) by 0.5 cfs to maintain enough suction head at the intake to transmit water. Streamflow was estimated at the diversion site using a drainage area ratio with available USGS daily streamgage data from 1950 to 2018 at Cowhouse Creek near Pidcoke, TX. The estimated streamflow indicates that on average, only 5.2 days per month exceed the required streamflow of 50.0 cfs. Therefore, it is assumed that the transmission system will only operate 5.2 days per month and transfer a maximum of 510 acre-feet per month of flow from Cowhouse Creek. Figure 4.4-2 illustrates the annual diversion amount under firm yield conditions from Cowhouse Creek used to refill storage. On average, 3,744 acft/yr of water would be diverted.

The calculated firm yield of the Coryell County OCR is 3,135 acft/yr. Figure 4.4-3 and Figure 4.4-4 illustrates the simulated Coryell County OCR storage levels for the 1940 to 1997 historical period, subject to the firm yield demand of 3,135 acft/yr and assuming subordination of Lake Belton and delivery of Cowhouse Creek diversions via a 36-inch pipeline. Simulated reservoir contents remain above 80 percent capacity about 32 percent of the time and above 50 percent capacity about 66 percent of the time. Results of the WAM simulation indicate the yield impact to Lake Belton is 2,536 acft/yr when subordinated to the Cowhouse Creek diversions for the OCR.

Figure 4.4-5 illustrates the change in streamflows in Cowhouse Creek caused by the project. The largest change in the Cowhouse Creek would be a decline in median streamflow of 9.21 cfs during February. Figure 4.4-6 illustrates the Cowhouse Creek streamflow frequency characteristics with and without the Coryell County OCR in place.

Figure 4.4-2. Coryell County Off-Channel Reservoir Firm Yield Diversions from Cowhouse Creek

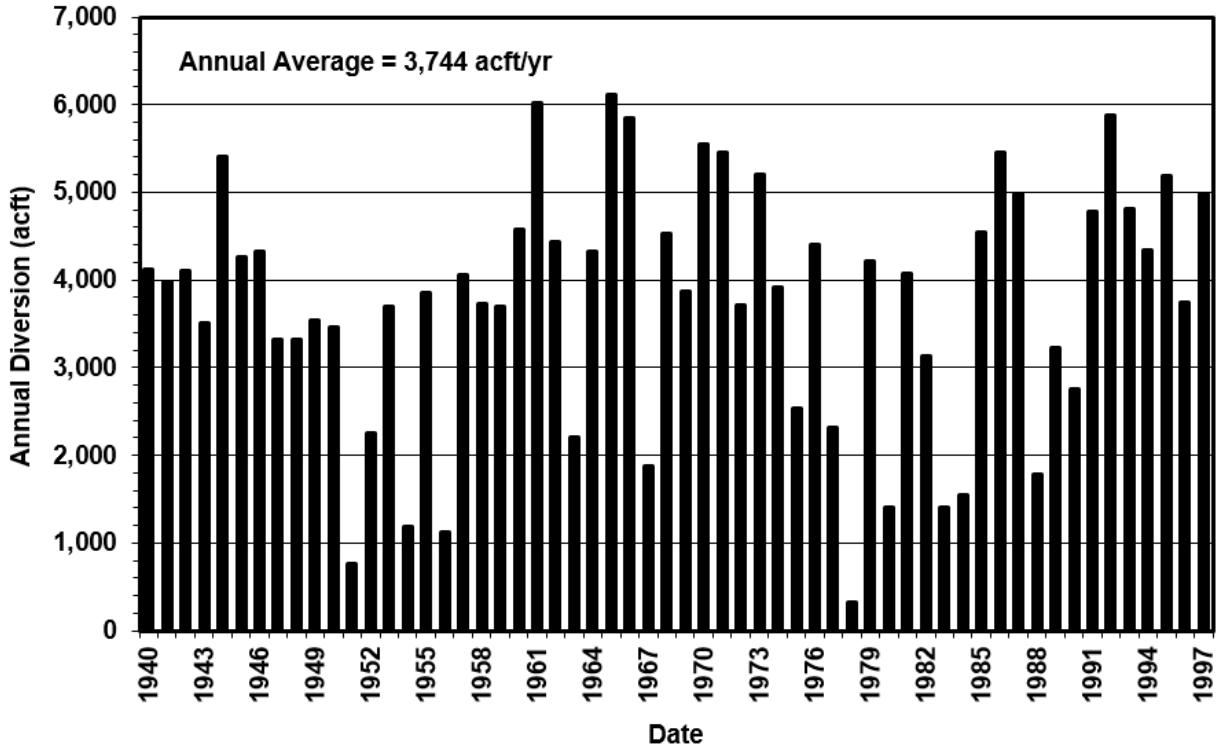


Figure 4.4-3. Coryell County Off-Channel Reservoir Storage Trace

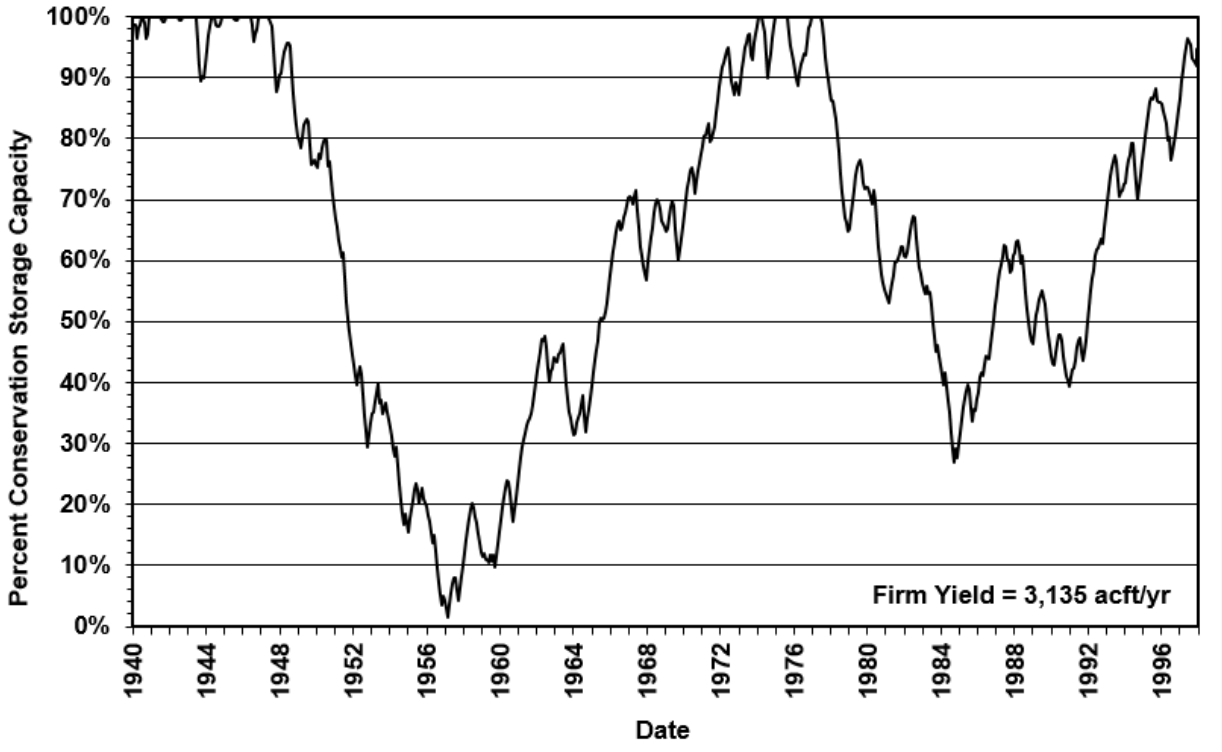


Figure 4.4-4. Coryell County Off-Channel Reservoir Storage Frequency at Firm Yield

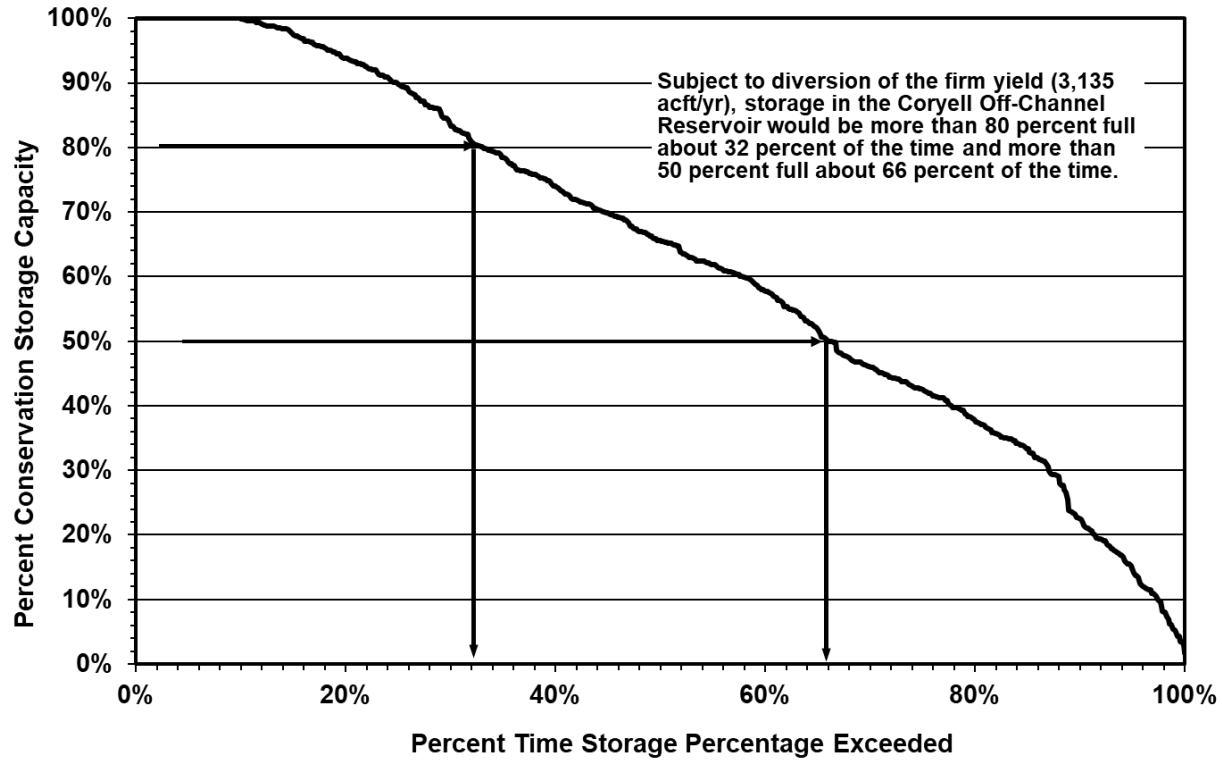


Figure 4.4-5. Cowhouse Creek Diversion Median Streamflow Comparison

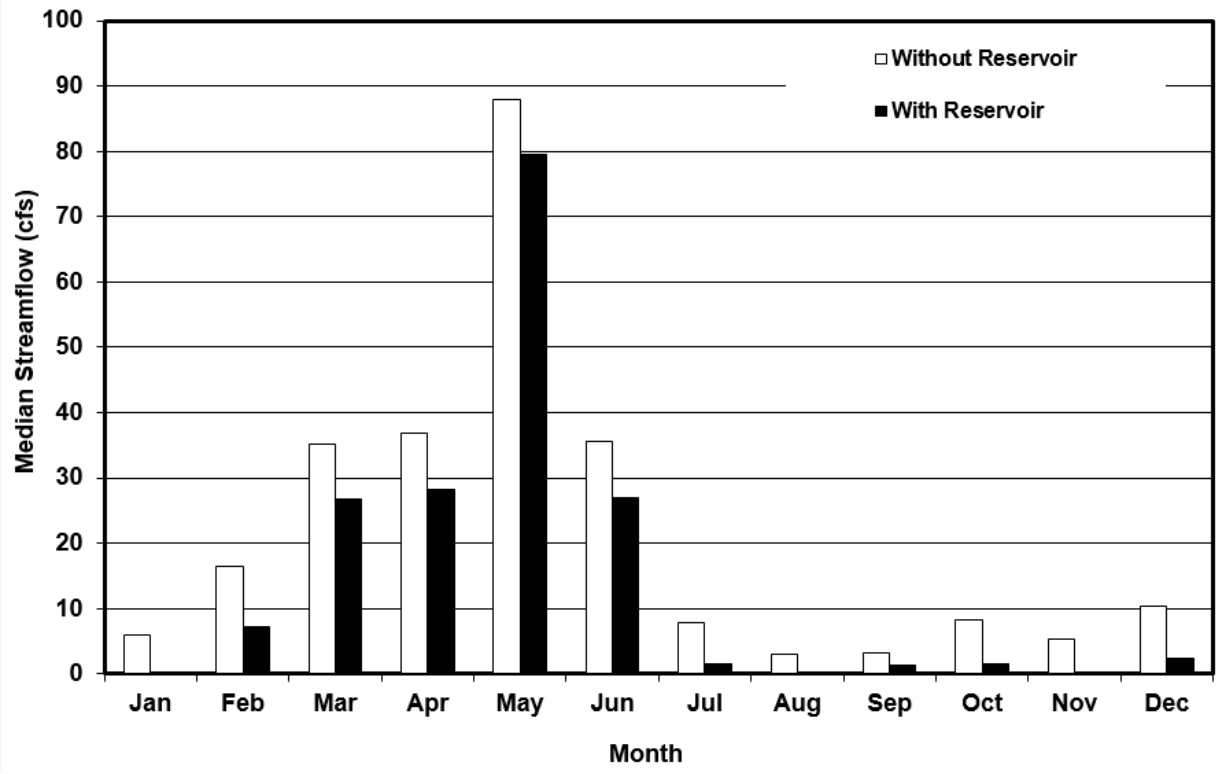
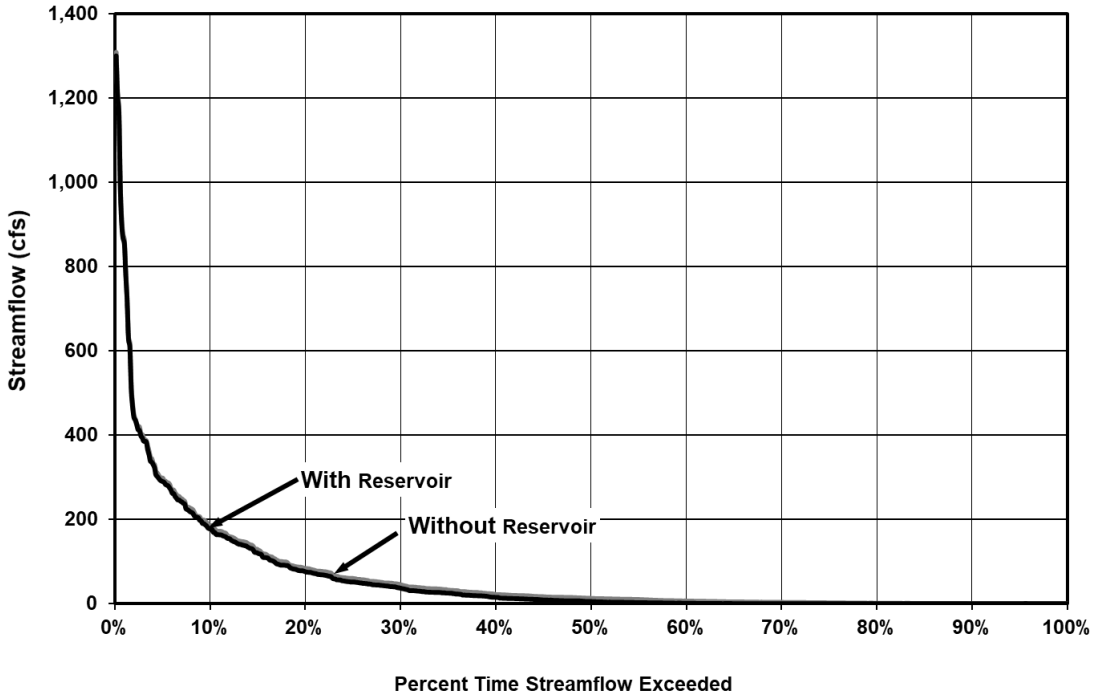


Figure 4.4-6. Cowhouse Creek Diversion Streamflow Frequency Comparison



4.4.3 Environmental Issues

Existing Environment

The Coryell County OCR involves the construction of a pipeline to capture flood water from Cowhouse Creek, and dam construction and inundation of approximately 445 acres in a tributary east of Cowhouse Creek. The proposed OCR site is located in northwestern Coryell County. The site is situated on the ecotone between the Central Oklahoma/Texas Plains and the Edwards Plateau Ecoregions[1] and is within the Balconian biotic province.[2] This region is characterized by rolling to hilly topography, with interspersed grassland and woodland, and soils ranging from the deep, fertile, black soils of the Central Oklahoma/Texas Plains to the shallow, dry limestone of the Edwards Plateau. The climate in this area is characterized as subtropical humid with warm summers. Average annual precipitation is approximately 33 inches.[3] The Trinity Aquifer is the only major aquifer underlying the project area.[4]

[1] Griffith, G.E., Bryce, S.A., Omernik, J.M., Comstock, J.A., Rogers, A.C., Harrison, B., Hatch, S.L., and Bezanson, D., 2004. Ecoregions of Texas. Reston, Virginia, U.S. Geological Survey.

[2] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.

[3] The Dallas Morning News, 2008, "Texas Almanac 2008-2009." Texas A&M University Press Consortium, College Station, Texas.

[4] Texas Water Development Board (TWDB), *Major and Minor Aquifers of Texas*, Maps online at http://www.twdb.state.tx.us/mapping/index.asp, 2004.

A Custom Soil Resource Report was completed for the Coryell County OCR site[5]. According to this report, five soil types underlie the project site. Doss-Real complex, 1-8 percent slopes, is the most abundant soil at 50% of the project area. These soils typically occupy backslopes of ridges. This soil is well drained, has a very low available water capacity and consists of clay loam to very gravelly clay loam. Wise clay loam soils occur within 30% of the project area. These soils are found on ridges, are well drained and have a low available water capacity. They are comprised of clay loam at the surface, underlain by silty clay loam and stratified very fine sandy loam to silty clay loam.

Nuff very stony silty clay loam, 2 to 6 percent slopes, which comprises approximately 11% of the reservoir area is typically found on the backslopes of ridges, is well drained and consists of a surface layer covered with cobbles, stones or boulders underlain by silty clay loam. Seawillow clay loam, 3 to 5 percent slopes, and Cisco fine sandy loam, 1 to 5 percent slopes, moderately eroded each occur in less than 7% of the project area. The Seawillow soils within the site occur on stream terraces, are well drained and consist of clay loam. Cisco soils in the project area are found on ridges, are well drained and have a moderate available water capacity. Fine sandy loam is found at the surface and below about 40 inches, and clay loam is present in the middle layers of these Cisco soils. Water areas comprise a little over one percent of the project area and include existing stock tanks. None of the soils found within the project area are considered to be prime farmland soils.

Vegetation within the project area is primarily Silver Bluestem-Texas Wintergrass Grassland with a smaller area of Oak-Mesquite-Juniper Parks/Woods[6]. Silver bluestem-Texas wintergrass grasslands could include the following commonly associated plants: little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), Texas grama (*Bouteloua rigidiseta*), three-awn (*Aristida sp.*), hairy grama (*Bouteloua hirsute*), tall dropseed (*Sporobolus asper*), buffalograss (*Bouteloua dactyloides*), windmillgrass (*Chloris verticillata*), hairy tridens (*Erioneuron pilosum*), tumblegrass (*Schedonnardus paniculatus*), western ragweed (*Ambrosia psilostachya*), broom snakeweed (*Gutierrezia sarothrae*), Texas bluebonnet (*Lupinus texensis*), live oak (*Quercus virginiana*), post oak (*Q. stellata*) and mesquite (*Prosopis glandulosa*). Commonly associated plants in the Oak-Mesquite-Juniper Parks/Woods include: post oak, Ashe juniper (*Juniperus ashei*), shin oak (*Q. sinuata*), Texas oak (*Q. buckleyi*), blackjack oak (*Q. marilandica*), live oak, cedar elm (*Ulmus crassifolia*), agarito (*Berberis trifoliolata*) , soapberry (*Sapindus saponaria*), sumac (*Rhus sp*.), hackberry (*Celtis reticulata*), Texas pricklypear (*Opuntia sp*.), Mexican persimmon (*Diospyros texana*), purple three-awn (*Aristida purpurea*), hairy grama, Texas grama, sideoats grama, curly mesquite (*Hilaria mutica*), and Texas wintergrass (*Stipa leucotricha*).

[5] NRCS. "Custom Soil Resource Report for Coryell County, Texas – Coryell County Off-Channel Site. November 24, 2014.

[6] McMahan, C. A., R. G. Frye and K. L. Brown, " The Vegetation Types of Texas -- Including Cropland," Texas Parks and Wildlife Department - PWD Bulletin 7000-120. 1984.

Potential Impacts

Aquatic Environments including Bays and Estuaries

The potential impacts of this project were evaluated at Cowhouse Creek where water will be pumped and diverted to the project site. At the diversion site on Cowhouse Creek, it is anticipated that there would be a reduction in the quantity of median monthly flows as shown in Table 4.4-1. Median monthly flows are expected to be reduced in all months of the year. Changes in flow variability at the diversion point is expected. Variability in flow is important to the instream biological community as well as riparian species and a reduction could influence the timing and success of reproduction as well as modify the current composition of species by favoring some and reducing suitability for others. Siting of the intake and pump station for this project should be situated as to result in minimal disturbance to existing area species.

Although there would be impacts in the immediate vicinity of the project site and downstream, it appears that this project, alone, would have minimal influence on total discharge in the Brazos River, resulting in a minimal influence on freshwater inflows to the Brazos River estuary. However, the cumulative impact of multiple projects of this type may reduce freshwater inflows into the estuary.

Threatened & Endangered Species

The Texas Parks and Wildlife Department (TPWD) maintains a list of Rare, Threatened, and Endangered Species of Texas by County. This list includes the federal and state listing status and a habitat description for each species which may be a resident or migrant through the county. TPWD regularly updates the listing status, range data, and habitat descriptions on their published county lists, based on the most recently available data. The current list of rare, threatened and endangered species for Coryell County can be found at https://tpwd.texas.gov/gis/rtest/.

Data from the TPWD Texas Natural Diversity Database[7] did not reveal any documented occurrences of listed species within the vicinity of the proposed Coryell OCR. However, these data are not a representative inventory of rare resources or sensitive sites. Although based on the best information available to TPWD, these data do not provide a definitive statement as to the presence, absence, or condition of special species, natural communities, or other significant features in the project area**.** On-site evaluations will be required by qualified biologists to confirm the occurrence of sensitive species or habitats. Coordination with TPWD and USFWS regarding threatened and endangered species with potential to occur in the project area should be initiated early in project planning.

[7] Texas Parks and Wildlife Department (TPWD), Texas Natural Diversity Database, November 10, 2014.

Table 4.4-1. Median Monthly Streamflow: Cowhouse Creek Diversion Site

Month	Without Project (cfs)	With Project (cfs)	Difference (cfs)	Percent Reduction
January	6.04	0.37	5.67	94%
February	16.48	7.27	9.21	56%
March	35.08	26.77	8.31	24%
April	36.74	28.17	8.57	23%
May	87.88	79.58	8.29	9%
June	35.54	26.90	8.63	24%
July	7.75	1.50	6.25	81%
August	3.07	0.26	2.81	91%
September	3.29	1.32	1.98	60%
October	8.34	1.62	6.71	81%
November	5.26	0.04	5.22	99%
December	10.31	2.28	8.03	78%

Wildlife Habitat

The primary impacts that would result from construction and operation of the proposed Coryell County OCR include conversion of approximately 445 acres of existing habitat within the conservation pool to open water. Projected wildlife habitat that will be impacted includes approximately 337 acres of Savanna Grassland, 76 acres of Ashe Juniper/Live Oak Shrubland, three acres of Ashe Juniper/Love Oak Slope Shrubland, one acre of Ashe Juniper Motte and Woodland, one acre of Ashe Juniper Slope Forest, seven acres of Oak/Hardwood Motte and Woodland, less than one acre of Oak/hardwood Slope Forest, 11 acres of Mesquite Shrubland, and seven acres of open water, primarily from existing stock tanks.[8] Siting of the raw water intake, pump station and raw water pipeline needed to complete the project should be located in an area that would result in minimal impacts to existing aquatic and terrestrial species. Impacts from the pipeline and associated appurtenances are anticipated to be low and primarily limited to the construction of these facilities and subsequent maintenance activities.

A number of vertebrate species could occur within the Coryell County OCR site including smaller mammals such as the eastern red bat (*Lasiurus borealis*), hispid cotton rat

[8] Texas Parks and Wildlife. Ecological Mapping Sytem GIS layer. Accessed at http://www.tpwd.state.tx.us/gis/data/ November 18, 2014.

(*Sigmodon hispidus*), white-footed mouse (*Peromyscus leucopus*), eastern fox squirrel (*Sciurus niger*), and woodland vole (*Microtus pinetorum*).[9] Reptiles and amphibians known from the county include the western rough green snake (*Opheodrys aestivus majalis*), Strecker's chorus frog (*Pseudacris streckeri*), Texas toad (*Bufo speciosus*), and Great Plains rat snake (*Elaphe guttata emoryi*) among others.[10] An undetermined number of bird species and a variety of fish species would also be expected to inhabit the various habitat types within the site, with distributions and population densities limited by the types and quality of habitats available.

Cultural Resources

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available GIS datasets provided by the Texas Historical Commission (THC) for the 2011 Regional Water Plan, there are no National Register Properties, National Register Districts, cemeteries, or historical markers are located within or near the project area. Because the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the Texas Historical Commission regarding potential impacts to cultural resources.

Threats to Natural Resources

This project would likely increase adverse effects on streamflow below the diversion point along Cowhouse Creek. Decreased stream flow would contribute to declines in dissolved oxygen and higher temperatures during summer periods. Additional impacts would be expected to terrestrial species found within the proposed OCR area that would be displaced by the reservoir filling. The project is expected to have negligible impacts to the streamflow and water quality in the Brazos River.

Agricultural Impacts

The Coryell County OCR site contains approximately zero acres of Pasture/Hay fields and 25 acres of cropland. These two agricultural land uses account for less than three percent of the reservoir footprint.

[9] Davis, William B. and David J. Schmidly. 1994. The Mammals of Texas. Texas Parks and Wildlife, Austin, Texas

[10] Dixon, James R., Amphibians and Reptiles of Texas. 1987, Texas A&M Press.

4.4.4 Engineering and Costing

The Coryell County OCR project would require additional facilities to divert water from Cowhouse Creek to the OCR. The facilities required for implementation of the project include:

- Raw water intake and pump station at the Cowhouse Creek diversion site with a capacity of 32 MGD;
- 674 feet of raw water pipeline (36-inch diameter) from the pump station to the off-channel reservoir;
- Off-channel dam including spillway, intake tower, and 451 acres of land for the reservoir and pipeline right-of-way.

A summary of the total project cost in September 2018 dollars is presented in Table 4.4-2. The total project cost of the Coryell County OCR project is estimated to be $82.6 million for surface water supply facilities. This includes the construction of the dam, land acquisition, resolution of conflicts, environmental permitting and mitigation, and technical services. The project costs also include the cost for the raw water facilities to convey surface water from the Cowhouse Creek diversion site to the off-channel reservoir. Costs associated with the transmission and treatment of raw water stored in the OCR to future customers is not included. The annual project costs are estimated to be $6,322,000. This includes annual debt service, operation and maintenance, pumping energy costs, and purchase of water from BRA for compensation of yield impacts to Lake Belton.

The off-channel project will be able to provide raw water prior to treatment and transmission of treated water to entities in Coryell County at a unit cost of $2,017 per ac-ft or $6.19 per 1,000 gallons.

Table 4.4-2. Cost Estimate Summary for Coryell County Off-Channel Reservoir

Item	Estimated Costs for Facilities
Dam and Off-Channel Reservoir (Conservation Pool 15,380 acft, 445 acres)	$25,140,000
Channel Dam and Intake Pump Stations (32 MGD)	$30,378,000
Transmission Pipeline (36 in dia., 674 feet)	$195,000
TOTAL COST OF FACILITIES	**$55,713,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$19,490,000
Environmental & Archaeology Studies and Mitigation	$1,526,000
Land Acquisition and Surveying (451 acres)	$1,549,000
Interest During Construction (3% for 2 years with a 0.5% ROI)	$4,306,000
TOTAL COST OF PROJECT	**$82,584,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$3,066,000
Reservoir Debt Service (3.5 percent, 40 years)	$1,827,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$2,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$691,000
Dam and Reservoir (1.5% of Cost of Facilities)	$418,000
Pumping Energy Costs	$124,000
Purchase of Water (2,536 acft/yr @ 76.5 $/acft)	$194,000
TOTAL ANNUAL COST	**$6,322,000**
Available Project Yield (acft/yr)	3,135
Annual Cost of Water ($ per acft), based on a Peaking Factor of 1	$2,017
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$6.19

4.4.5 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 4.4-3, and the option meets each criterion.

Table 4.4-3. Evaluations of Coryell County Off-Channel Reservoir Option to Enhance Water Supplies

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet needs
2. Reliability	2. High reliability
3. Cost	3. Reasonable (moderate to high)
B. Environmental factors	
1. Environmental Water Needs	1. Negligible impact
2. Habitat	2. Negligible impact
3. Cultural Resources	3. Low impact
4. Bays and Estuaries	4. Negligible impact
5. Threatened and Endangered Species	5. Low impact
6. Wetlands	6. Negligible 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	• None
E. Equitable Comparison of Strategies Deemed Feasible	• Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	• Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	• None

Implementation of the off-channel reservoir project will require permits from various state and federal agencies, land acquisition, and design and construction of the facilities. The project may also have an impact on the firm yield of Lake Belton, which may require mitigation with the Brazos River Authority in terms of a water supply contract in the amount of the firm yield impact. A summary of the implementation steps for the project is presented below.

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality Water Right and Storage permits;
- U.S. Army Corps of Engineers Permits will be required for discharges of dredge or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act);
- Texas Commission on Environmental Quality administered Texas Pollutant Discharge Elimination System Storm Water Pollution Prevention Plan;
- General Land Office Easement if State-owned land or water is involved; and,
- Texas Parks and Wildlife Department Sand, Shell, Gravel and Marl permit if state-owned streambed is involved.

State and Federal Permits may require the following studies and plans:

- Environmental impact or assessment studies;
- Wildlife habitat mitigation plan that may require acquisition and management of additional land;
- Flow releases downstream to maintain aquatic ecosystems;
- Assessment of impacts on Federal- and State-listed endangered and threatened species;
- Aquatic Resource Relocation Plan (ARRP) and a relocation permit may be required from TPWD if a dewatering event is required during construction; and
- Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resource recovery and cataloging; requires coordination with the Texas Historical Commission.

Land Acquisition Issues:

- Land acquired for reservoir and/or mitigation plans could include market transactions and/or eminent domain;
- Additional acquisition of rights-of-way and/or easements may be required; and
- Possible relocations or removal of residences, utilities, roads, or other structures.

4.5 City of Groesbeck Off-Channel Reservoir

4.5.1 Description of Option

The Groesbeck Off-Channel Reservoir is a proposed new reservoir adjacent to the Navasota River, northeast of the City of Groesbeck in Limestone County, as shown in Figure 4.5-1 and Figure 4.5-2. The City of Groesbeck uses surface water directly from the Navasota River and has water rights on the Navasota River that authorize diversion of 2,500 acft/yr and storage of 500 acft with a priority of June 1921. This water right is one of the more senior water rights in the Brazos River Basin.

The diversion point for the City of Groesbeck is just north (upstream) of the City and downstream (south) of Springfield Lake at Fort Parker. A natural spring occurs just below Springfield Lake that provides a base flow to the river just upstream of the City's diversion point during most years. However, during past drought periods the springflow has not been sufficient to meet the City's full water demand and the City was forced to use stored water from Springfield Lake. Springfield Lake is owned by the TPWD for recreation purposes; however, Groesbeck's 500 acft storage right extends to the lake. During drought periods, when the flow in the Navasota River is not adequate to meet the City's water needs, the City siphons water from storage in Springfield Lake over the dam and into the downstream river channel for subsequent diversion downstream at the water treatment plant intake.

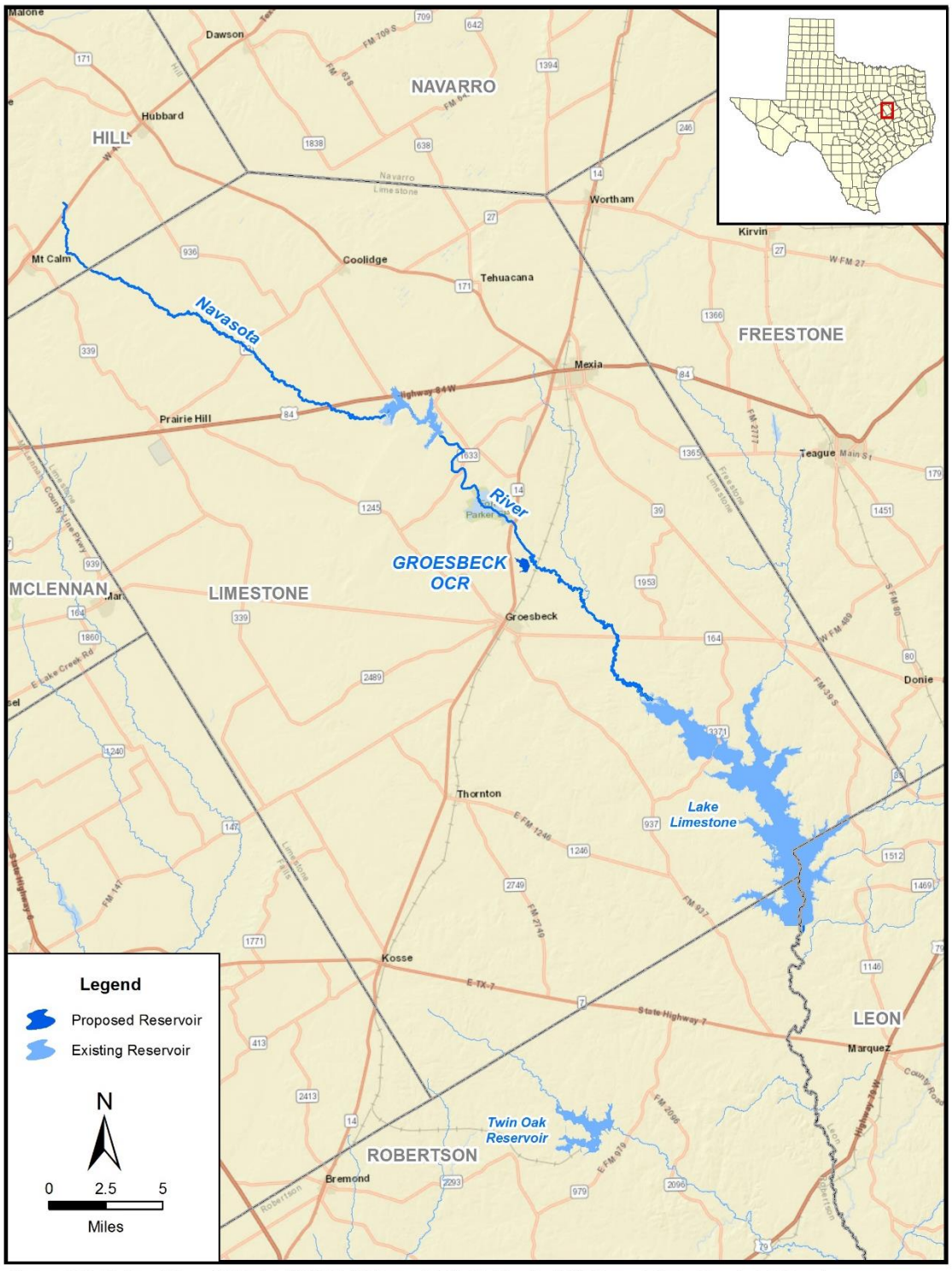
Springfield Lake was built in 1939 for the primary purpose of recreation. The lake is very shallow, originally storing about 3,100 acft over a surface area of 750 acres, making the average depth of the lake about 4 feet. Over the years, the lake has lost significant storage due to sedimentation. In 1991, the City of Groesbeck and the TPWD jointly participated in a project[1] to dredge the lake making the average lake depth approximately 4 feet over 500 acres. Groesbeck has relied on this storage during recent drought periods to meet their needs and has implemented water rationing in the City as recently as 1998.

A yield analysis of Springfield Lake was completed to determine the reliable supply to Groesbeck from its Navasota River diversion rights and storage in Springfield Lake. The shallow depth of about four feet and effective surface area of 500 acres of Springfield Lake results in the reservoir being very inefficient. In comparison, net evaporation rates during the extended drought periods of the 1950s were as high as 4.2 feet annually, which would severely deplete the reservoir storage without any diversions by the City. Results of the yield analysis indicate that the firm yield of the City's water right, supplemented with storage from Springfield Lake, is less than 200 acft/yr.

The City of Groesbeck's water use in 2011 was 736 acft. The Brazos G WAM modeling results indicate that there is no reliable yield associated with the City's right. Thus, the

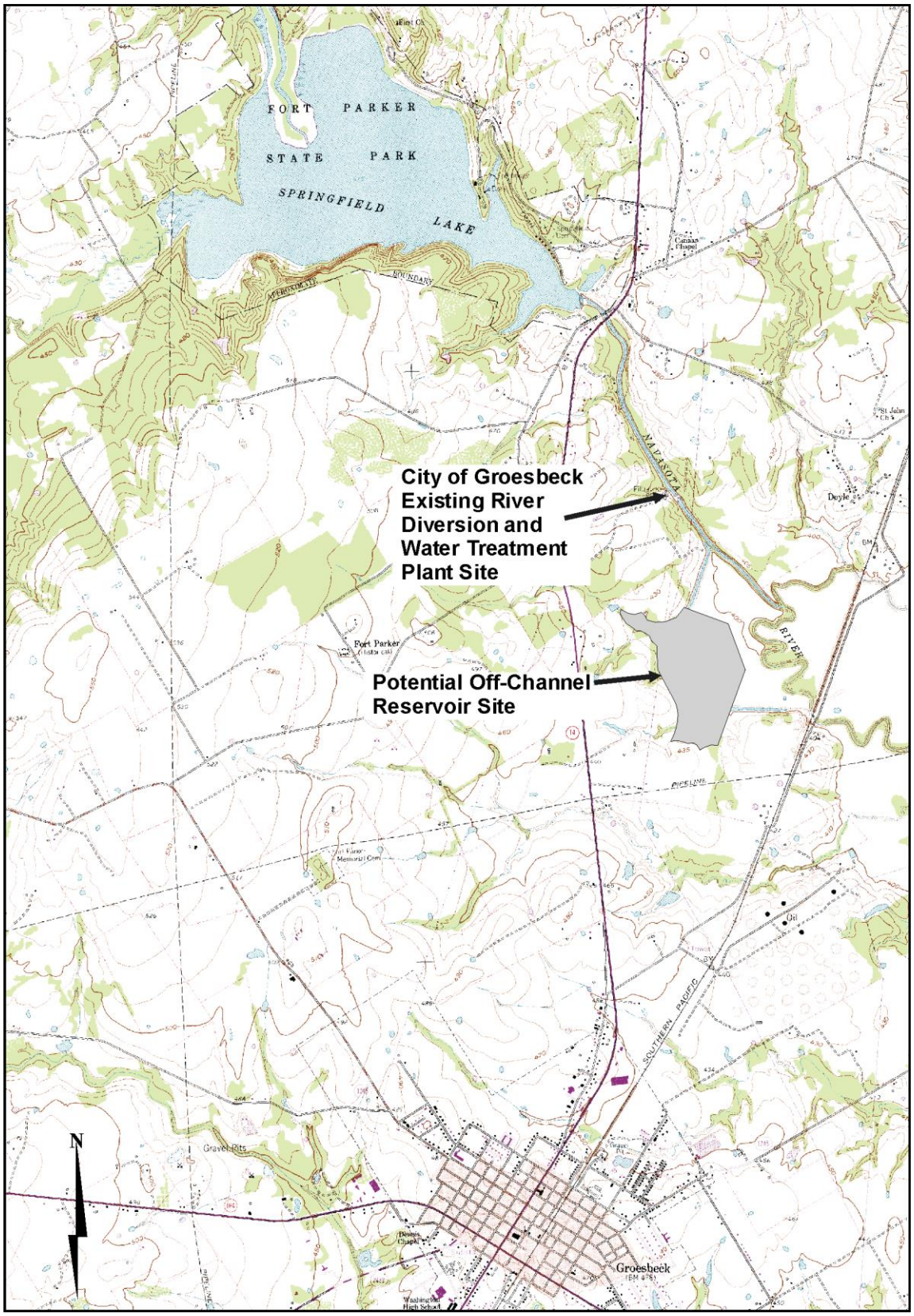
[1] Hunter & Associates, Inc., "A Plan for Dredging and Rehabilitation of Springfield Lake at Fort Parker, Limestone County, Texas," prepared for the City of Groesbeck and the Texas Parks and Wildlife Department, January 1991.

Figure 4.5-1. Location of Groesbeck Off-Channel Reservoir



Document Path: \\dalctxsrv01\Texas_GIS_Projects\10029705_036_Brazos_G_2021_Plan\Map_Docs\MXDs\Reservoir_Strategy\Groesbeck_OCR.mxd

Figure 4.5-2. Groesbeck Off-Channel Reservoir



City can expect substantially less than the authorized diversion of 2,500 acft/yr. As the City's demands grow, additional storage or a supplemental supply of water will be needed.

The off-channel reservoir alternative appears to be an economical solution to provide the City with a firm water supply, as the storage can be developed near the City's existing river diversion and water treatment facilities. A potential off-channel storage site along the Navasota River is shown in Figure 4.5-2. The dam would be an earthfill embankment that would extend approximately 1,500 feet and provide a conservation storage capacity of 2,317 acft at an elevation 420 ft-msl. The reservoir would inundate 146 surface acres and impound flows diverted from the Navasota River. All flows from the small watershed above the reservoir would be passed through the reservoir.

The City's senior water right with a diversion of 2,500 acft/yr and a priority of June 1921 would be utilized to divert water from the Navasota River to the off-channel reservoir. The City would then divert water from the reservoir for municipal use, allowing an increase in the City's current minimum annual diversion by providing an increase in storage of available flows for use during drought periods. Additionally, since the City's water right is senior to Lake Limestone, a subordination agreement with BRA is not required. The diversion amounts from the Navasota River into the off-channel reservoir will not exceed the original water right for the City. Any additional water diverted above the existing authorization would require the purchase of Lake Limestone supplies from BRA, or a subordination agreement with the BRA. Currently, BRA indicates that no subordination agreement is likely to be possible.

4.5.2 Available Yield

Water potentially available for impoundment in the proposed Groesbeck Off-Channel Reservoir was estimated using the TCEQ Brazos WAM Run 3 which assumes no return flows and permitted storages and diversions for all water rights in the basin. The model utilizes a January 1940 through December 1997 hydrologic period of record. The model computed the streamflow available for diversion from the Navasota River into the Groesbeck Off-Channel Reservoir without causing increased shortages to existing downstream rights. The off-channel reservoir was modeled such that it does not impound streamflow originating from its own contributing drainage area. Firm yield was computed subject to the reservoir and Navasota River diversion having to pass inflows to meet environmental flow standards associated with Senate Bill 3 (SB3).

A 24-inch diameter pipeline would be used to divert streamflow from the Navasota River to the off-channel reservoir. Assuming the pipeline would transmit water at a velocity of 5 feet per second (15.7 cfs), a possible 948 acft of water could be diverted per month if the transmission system operated every day at full capacity. However, for the transmission system to be able to operate, streamflow in the Navasota River must exceed the pumping capacity (15.7 cfs) by 0.5 cfs to maintain enough suction head at the intake to transmit water. Available USGS daily streamgage data from 1978 to 2018 for the Navasota River above Groesbeck (USGS Gage 08110325) indicates that 25 percent of the time or on average 7.6 days per month, the required streamflow of 16.2 cfs is exceeded. Therefore, it is assumed that the transmission system will only operate 7.6 days per month and transfer a maximum of 237 acft/mo of flow from the Navasota River. Figure 4.5-3 illustrates the annual diversions under firm yield conditions from the

Navasota River used to refill storage. On average, 2,065 acft/yr of water would be diverted.

The calculated firm yield of the Groesbeck Off-Channel Reservoir is 1,755 acft/yr. Figure 4.5-4 illustrates the simulated Groesbeck Off-Channel Reservoir storage levels for the 1940 to 1997 historical period, subject to the firm yield of 1,755 acft/yr and based on delivery of Navasota River diversions via a 24-inch pipeline. Figure 4.5-5 shows the storage frequency associated with firm yield. Simulated reservoir contents remain above 80 percent capacity and 61 percent of the time and above 50 percent capacity about 86 percent of the time.

Figure 4.5-6 illustrates the change in streamflows in the Navasota River caused by the project. From July through November, there is little or no water available in the stream. During January through June and December, there are decreases in median streamflow from the implementation of the off-channel reservoir. Figure 4.5-7 also illustrates the Navasota River streamflow frequency characteristics with the Groesbeck Off-Channel Reservoir in place.

Figure 4.5-3. Groesbeck OCR Firm Yield Diversions from Navasota River

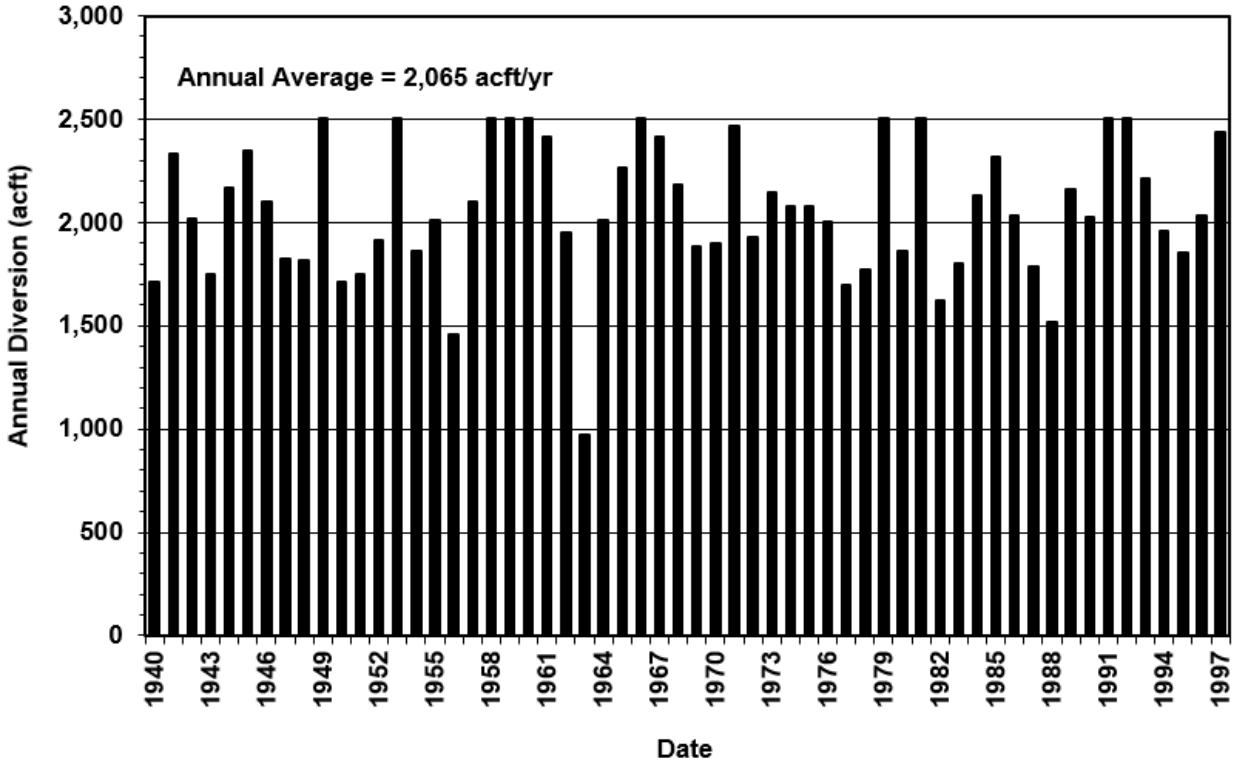


Figure 4.5-4. Groesbeck OCR Firm Yield Storage Trace

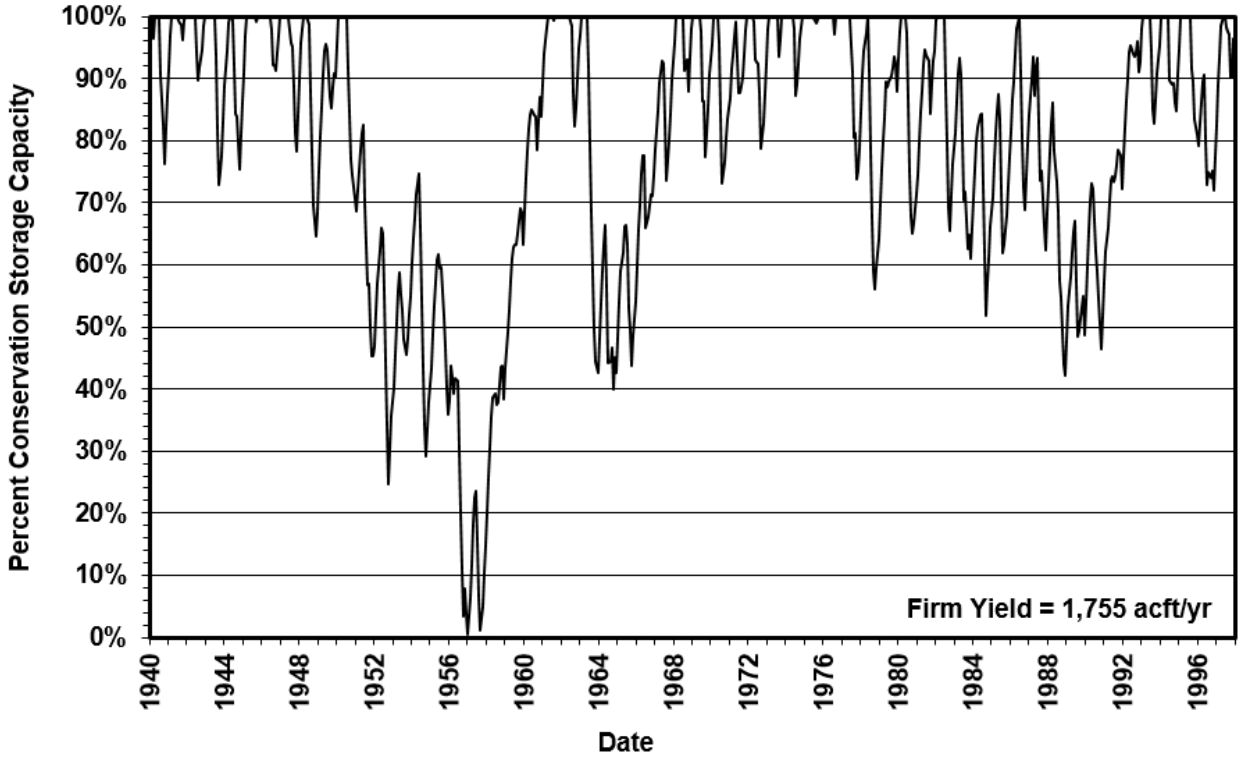


Figure 4.5-5. Storage Frequency at Firm Yield

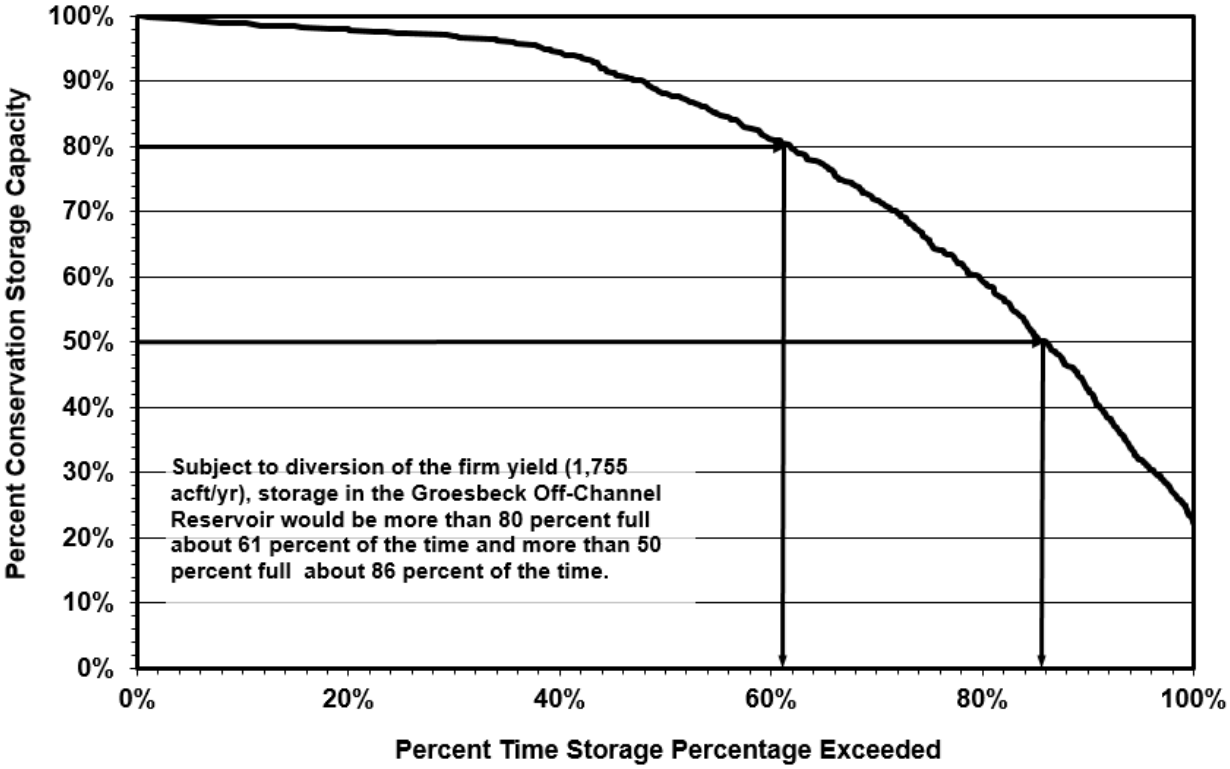


Figure 4.5-6. Navasota River Diversion - Median Streamflow Comparison

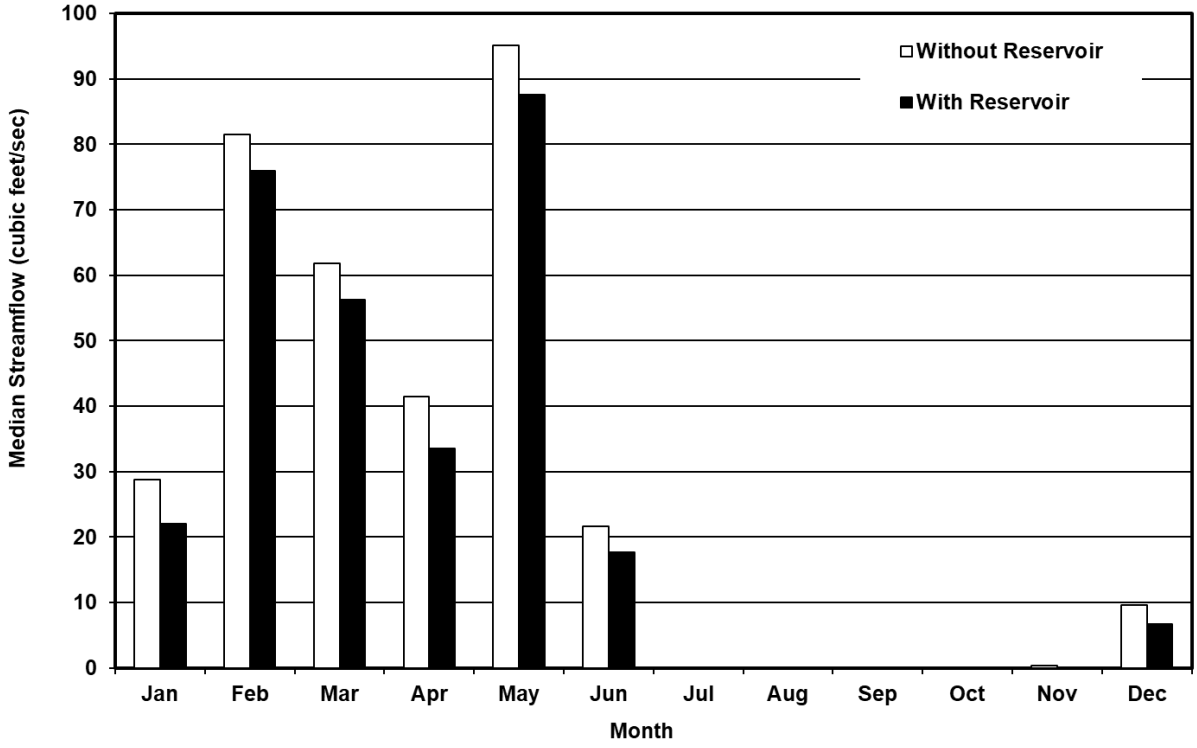
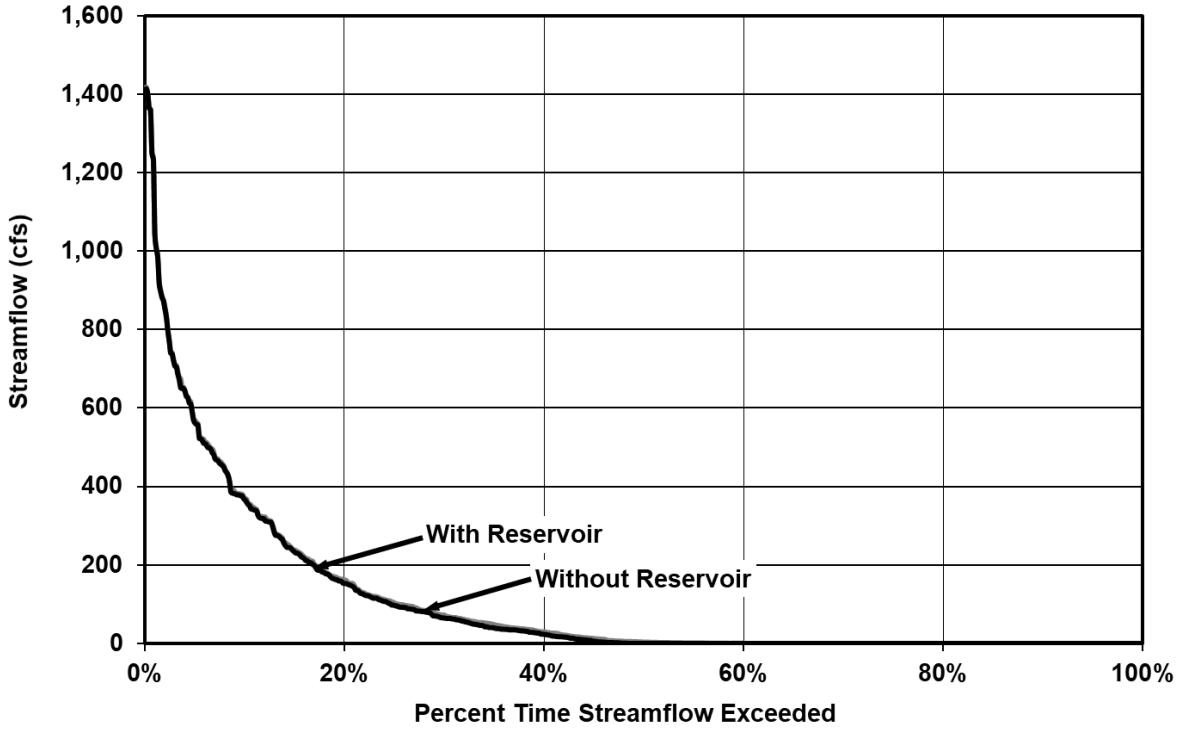


Figure 4.5-7. Navasota River Diversion- Streamflow Frequency Comparison



4.5.3 Environmental Issues

Existing Environment

The City of Groesbeck Off-Channel Reservoir site in Limestone County lies in the Blackland Prairies Vegetational Area.[2] This area is a rolling and well-dissected region that was historically a luxuriant tallgrass prairie dominated by little bluestem (*Schizachyrium scoparium* var. *frequens*), big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), and dropseeds (*Sporobolus* sp.). During the turn of the 20th century, the majority of the Blackland Prairie was cultivated for crops. Livestock production within this area has increased dramatically since the 1950s and now only about half of the area is used for cropland. Grazing pressure has caused an increase in grass species such as sideoats grama (*Bouteloua curtipendula*), hairy grama (*B. hirsuta*), Mead's sedge (*Carex meadii*), Texas Wintergrass (*Nassella leucotricha*) and buffalograss (*Buchloe dactyloides*). Common woody species of this area include mesquite (*Prosopis glandulosa*), huisache (*Acacia smallii*), oak (*Quercus* sp.) and elm (*Ulmus* sp.). Oak, elm, cottonwood (*Populus* sp.) and pecan are common larger tree species found along drainages in this area.

Based on vegetation types as defined by the Texas Parks and Wildlife Department (TPWD) the vegetation type that occurs within the project area is Elm-Hackberry Parks/ Woods.[3] Elm-Hackberry Parks/Woods could include the following commonly associated plants: mesquite (*Prosopis glandulosa*), post oak (*Quercus stellata*), woollybucket bumelia (*Sideroxylon lanuginosum*), honey locust (*Gleditsia triacanthos)*, coralberry (*Symphoricarpos orbiculatus*), pasture haw (*Crataegus spathulata*), elbowbush (*Forestiera pubescens*), Texas pricklypear (*Opuntia engelmannii* var. *lindheimeri*), tasajillo (Opuntia leptocaulis), dewberry (Rubus spp.), silver bluestem (Bothriochloa saccharoides), buffalograss (Buchloe dactyloides), western ragweed (Ambrosia cumanensis), giant ragweed (A. trifida), goldenrod (Solidago spp.), frostweed (Verbesina virginica), ironweed (Vernonia spp.), prairie parsley (Polytaenia nuttallii), and broom snakeweed (Gutierrezia sarothrae). Variations of this primary type may occur based on changes in the composition of woody and herbaceous species and the physiognomy of localized conditions and specific range sites.

The average annual precipitation for Limestone County is almost thirty-eight inches, and the temperatures range from an average low of 37° F in January to an average high of 96° in July. The average growing season lasts 255 days.4 No major or minor aquifer underlies the project area.[5]

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[2] Gould, F.W., G.O. Hoffman, and C.A. Rechenthin, Vegetational Areas of Texas, Texas A&M University, Texas Agriculture Experiment Station Leaflet No. 492, 1960.

[3] McMahan, C.A., R.F. Frye, and K.L. Brown, "The Vegetation Types of Texas Including Cropland," Texas Parks and Wildlife Department, Wildlife Division, Austin, Texas, 1984.

[4] Ellen Maschino, "LIMESTONE COUNTY," Handbook of Texas Online (http://www.tshaonline.org/handbook/online/articles/hcl09), accessed November 17, 2014.

[5] Texas Water Development Board (TWDB), *Major and Minor Aquifers of Texas*, Maps online at http://www.twdb.state.tx.us/mapping/index.asp, 2004.

Soil units found within the proposed off-channel reservoir area include Axtell fine sandy loam, 1 to 3 percent slopes, Edge fine sandy loam, 2 to 5 percent slopes, Kaufman clay, occasionally flooded, Lavender-Rock outcrop complex, Silawa fine sandy loam, 5 to 12 percent slopes and Whitesboro loam, frequently flooded. Of these six soil types only one, Kaufman clay, occasionally flooded is considered to be a prime farmland soil. This soil type is found within 49 acres or approximately 33.5 percent of the project area. Current aerial photography of the OCR site shows agricultural activity in the eastern portion of the area.

Potential Impacts

Aquatic Environments including Bays & Estuaries

The potential impacts of this project were evaluated in two locations, at the proposed reservoir site and in the Navasota River where water will be pumped and diverted to the project site. The potential impacts of this project are very different in the two locations. In the diversion site on the Navasota River, minimal impacts are anticipated in terms of a reduction in variability or quantity of median monthly flows. But in the proposed project site, there would be a moderate reduction in variability and dramatic reductions in the quantity of median monthly flows. Variability in flow is important to the instream biological community as well as riparian species and a reduction could influence the timing and success of reproduction as well as modify the current composition of species by favoring some and reducing suitability for others.

In the Navasota River, non-negligible reductions in streamflow would occur in January through June and December, as shown in Table 4.5-1. All other months would have little or no reduction in median monthly flow at the diversion. Because low-flows occur frequently without the project in place, the addition of this project would have minimal impact on these low-flow conditions. At the Navasota River diversion site, the 85 percent exceedance values would be 0.015 cfs without the project and zero cfs with the project.

Table 4.5-1. Median Monthly Streamflow: Navasota River Diversion Site

Month	Without Project (cfs)	With Project (cfs)	Difference (cfs)	Percent Reduction
January	28.82	21.98	6.84	24%
February	81.53	75.97	5.56	7%
March	61.77	56.22	5.55	9%
April	41.51	33.57	7.94	19%
May	95.16	87.54	7.62	8%
June	21.61	17.69	3.92	18%
July	0.04	0.00	0.04	100%
August	0.02	0.00	0.02	100%
September	0.03	0.00	0.03	100%
October	0.11	0.00	0.11	100%

Table 4.5-1. Median Monthly Streamflow: Navasota River Diversion Site

Month	Without Project (cfs)	With Project (cfs)	Difference (cfs)	Percent Reduction
November	0.30	0.00	0.30	100%
December	9.63	6.64	2.98	31%

Although there would be impacts in the immediate vicinity of the project site and downstream, it appears that this project, alone, would have minimal influence on total discharge in the Navasota or Brazos Rivers, in which case there would be minimal influence on freshwater inflows to the Brazos River estuary. However, the cumulative impact of multiple projects may reduce freshwater inflows into the estuary. As a new reservoir without a current operating permit, the Groesbeck Reservoir would likely be required to meet environmental flow requirements determined by site-specific studies.

Threatened & Endangered Species

The Texas Parks and Wildlife Department (TPWD) maintains a list of Rare, Threatened, and Endangered Species of Texas by County. This list includes the federal and state listing status and a habitat description for each species which may be a resident or migrant through the county. TPWD frequently updates the listing status, range data, and habitat descriptions on their published county lists, based on the most recently available data. The current list of rare, threatened and endangered species for Limestone County can be found at https://tpwd.texas.gov/gis/rtest/.

Data from the TPWD Texas Natural Diversity Database[6] did not reveal any documented occurrences of listed species within the vicinity of the proposed City of Groesbeck Off-Channel Reservoir. However these data are not a representative inventory of rare resources or sensitive sites. Although based on the best information available to TPWD, these data do not provide a definitive statement as to the presence, absence, or condition of special species, natural communities, or other significant features in the project area. On-site evaluations will be required by qualified biologists to confirm the occurrence of sensitive species or habitats. Coordination with TPWD and USFWS regarding threatened and endangered species with potential to occur in the project area should be initiated early in project planning.

Wildlife Habitat

Approximately 146 acres are estimated to be inundated by the reservoir. Projected wildlife habitat that will be impacted includes approximately 21 acres of floodplain hardwood forest, 33 acres of floodplain herbaceous vegetation, 7 acres of riparian hardwood forest, 30 acres of post oak motte and woodland areas, 13 acres of savanna grassland, 43 acres of crops and less than one acre of urban low intensity area.[7] Siting of the raw water intake, pump station and raw water pipeline needed to complete the

[6] Texas Parks and Wildlife Department (TPWD), Texas Natural Diversity Database, 04/18/2019.

[7] Texas Parks and Wildlife. Ecological Mapping Sytem GIS layer. Accessed at http://www.tpwd.state.tx.us/gis/data/ November 18, 2014.

project should be situated in a way that would result in minimal impacts to existing aquatic and terrestrial species. Impacts from this portion of the project are anticipated to be low and primarily limited to construction of these facilities and subsequent maintenance activities.

A number of vertebrate species could occur within the City of Groesbeck Reservoir site including smaller mammals such as the hispid cotton rat (*Sigmodon hispidus*), white-footed mouse (*Peromyscus leucopus*), eastern gray squirrel (*Sciurus carolinensis*), and common muskrat (*Ondatra zibethicus*).[8] Reptiles and amphibians known from the county include the central newt (*Notophthalmus viridescens louisianensis*), Strecker's chorus frog (*Pseudacris streckeri*), red-eared slider (*Trachemys scripta elegans*), and western rough green snake (*Opheodrys aestivus aestivus*) among others.[9] An undetermined number of bird species and a variety of fish species would also be expected to inhabit the various habitat types within the site, with distributions and population densities limited by the types and quality of habitats available.

Cultural Resources

Cultural resources that occur on public lands or within the Area of Potential Effect of publicly funded or permitted projects are governed by the Texas Antiquities Code (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available GIS datasets provided by the Texas Historical Commission (THC) for the 2011 Regional Water Plan, there are no National Register Properties, National Register Districts, cemeteries, or historical markers located within the project area. Because the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the Texas Historical Commission regarding potential impacts to cultural resources.

A search of the Texas Archeological Sites Atlas database indicates that 27 archeological sites have been documented within the general vicinity of the proposed reservoir. Fifteen of these sites were recorded by the Texas Parks and Wildlife Department as part of a survey of Fort Parker in 1994. While all of these sites lie outside the limits of the proposed reservoir, it is possible that similar unrecorded sites could occur within the project's Area of Potential Effect. These sites represent a variety of historic and prehistoric site types. Prior to reservoir inundation, the project must be coordinated with the Texas Historical Commission and a cultural resources survey must be conducted to determine if any cultural resources are present within the conservation pool. Any cultural resources identified during survey will need to be assessed for eligibility for inclusion in the National Register of Historic Places (NRHP) or as State Archeological Landmarks (SAL).

[8] Davis, William B. and David J. Schmidly. 1994. The Mammals of Texas. Texas Parks and Wildlife, Austin, Texas.

[9] Dixon, James R., Amphibians and Reptiles of Texas. 1987, Texas A&M Press.

Threats to Natural Resources

Threats to natural resources include lower stream flows, declining water quality, and reduced inflows to reservoirs. This project would likely increase adverse effects on stream flow below the reservoir site, but the reservoir would trap sediment and/or dilute pollutants, providing some positive benefits to water quality downstream. These benefits could be offset by declines in dissolved oxygen through decreased flows and higher temperatures during summer periods. The project is expected to have negligible impacts to the stream flow and water quality in the Navasota and Brazos Rivers. No significant impacts to any listed threatened or endangered species is anticipated from this project.

Agricultural Impacts

The Groesbeck OCR site contains approximately 54 acres of Pasture/Hay fields and zero acres of cropland. These two agricultural land uses account for roughly 37 percent of the reservoir footprint.

4.5.4 Engineering and Costing

The potential off-channel reservoir project for the City of Groesbeck would require additional facilities to divert water from the Navasota River to the off-channel reservoir site. The facilities required for implementation of the project included:

- Raw water intake and pump station at the Navasota River diversion site with a capacity of 10.2 MGD;
- 3,500 feet of raw water pipeline (24-inch diameter) from the pump station to the off-channel reservoir;
- Pump station at the off-channel reservoir site with a capacity of 3 MGD;
- 3,500 feet of raw water pipeline (12-inch diameter) from the off-channel pump station to the water treatment plant; and
- Off-channel dam including spillway, intake tower, and 146 acres of land for the reservoir.

A summary of the total project cost is presented in Table 4.5-2. The proposed Groesbeck Off-Channel Reservoir project would cost approximately $23.6 million for surface water supply facilities. This includes the construction of the dam, land acquisition, resolution of conflicts, environmental permitting and mitigation, and technical services. The project cost also includes the cost for the raw water facilities to convey surface water from the Navasota River to the off-channel reservoir and back to the City's existing water treatment plant. The annual project costs are estimated to be $1,853,000. This includes annual debt service, operation and maintenance, and pumping energy costs.

Table 4.5-2. Cost Estimate Summary for Groesbeck Off-Channel Reservoir

Item	Estimated Costs for Facilities
Off-Channel Storage/Ring Dike (Conservation Pool 2,317 acft, 146 acres)	$4,821,000
Intake Pump Stations (10.2 MGD & 3 MGD)	$10,103,000
Transmission Pipeline (24 in dia., 1 miles; 12 in dia., 0.7 miles)	$840,000
TOTAL COST OF FACILITIES	**$15,764,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$5,475,000
Environmental & Archaeology Studies and Mitigation	$561,000
Land Acquisition and Surveying (164 acres)	$568,000
Interest During Construction (3% for 2 years with a 0.5% ROI)	$1,231,000
TOTAL COST OF PROJECT	**$23,599,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$1,103,000
Reservoir Debt Service (3.5 percent, 40 years)	$371,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$8,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$253,000
Dam and Reservoir (1.5% of Cost of Facilities)	$72,000
Pumping Energy Costs (0.08 $/kW-hr)	$46,000
TOTAL ANNUAL COST	**$1,853,000**
Available Project Yield (acft/yr)	1,755
Annual Cost of Water ($ per acft), based on a Peaking Factor of 1	$1,056
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$3.24

4.5.5 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 4.5-3, and the option meets each criterion.

Table 4.5-3. Evaluations of Coryell County Off-Channel Reservoir Option to Enhance Water Supplies

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet needs
2. Reliability	2. High reliability
3. Cost	3. Reasonable (moderate to high)
B. Environmental factors	
1. Environmental Water Needs	1. Negligible impact
2. Habitat	2. Negligible impact
3. Cultural Resources	3. Low impact
4. Bays and Estuaries	4. Negligible impact
5. Threatened and Endangered Species	5. Low impact
6. Wetlands	6. Negligible 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	None
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	None

Implementation of the off-channel reservoir project for the City of Groesbeck will require permits from various state and federal agencies, land acquisition, and design and construction of the facilities. The project may also have an impact on the firm yield of Lake Limestone, which may require mitigation with the Brazos River Authority in terms of a water supply contract in the amount of the firm yield impact. A summary of the implementation steps for the project is presented below.

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality Water Right and Storage permits;
- U.S. Army Corps of Engineers Permits will be required for discharges of dredge or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act);
- Texas Commission on Environmental Quality administered Texas Pollutant Discharge Elimination System Storm Water Pollution Prevention Plan;

- General Land Office Easement if State-owned land or water is involved; and
- Texas Parks and Wildlife Department Sand, Shell, Gravel and Marl permit if state-owned streambed is involved.

State and Federal Permits may require the following studies and plans:

- Environmental impact or assessment studies;
- Wildlife habitat mitigation plan that may require acquisition and management of additional land;
- Flow releases downstream to maintain aquatic ecosystems;
- Assessment of impacts on Federal- and State-listed endangered and threatened species;
- Aquatic Resource Relocation Plan (ARRP) and a relocation permit may be required from TPWD if a dewatering event is required during construction.Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resource recovery and cataloging; requires coordination with the Texas Historical Commission; and

Land Acquisition Issues:

- Land acquired for reservoir and/or mitigation plans could include market transactions and/or eminent domain;
- Additional acquisition of rights-of-way and/or easements may be required; and
- Possible relocations or removal of residences, utilities, roads, or other structures.

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4.6 Hamilton County Off-Channel Reservoir

4.6.1 Description of Option

A potential water management strategy for Hamilton County is a new off-channel reservoir (OCR) located in the southeast corner of Hamilton County as shown in Figure 4.6-1. The proposed OCR will be located on the South Fork of Neils Creek and will contain approximately 49,849 acft of storage and inundate 1,374 acres at the conservation pool elevation of 1,080 ft-msl. The OCR would impound available streamflow diverted from the Leon River. For the project to be economically feasible, an agreement with the Brazos River Authority is required to subordinate water rights associated with Lake Belton to the Leon River diversions. Without the subordination agreement, the unappropriated flows available for diversion would not be sufficient to maintain adequate water levels in the proposed reservoir. Currently, BRA indicates that no subordination agreement is likely to be possible.

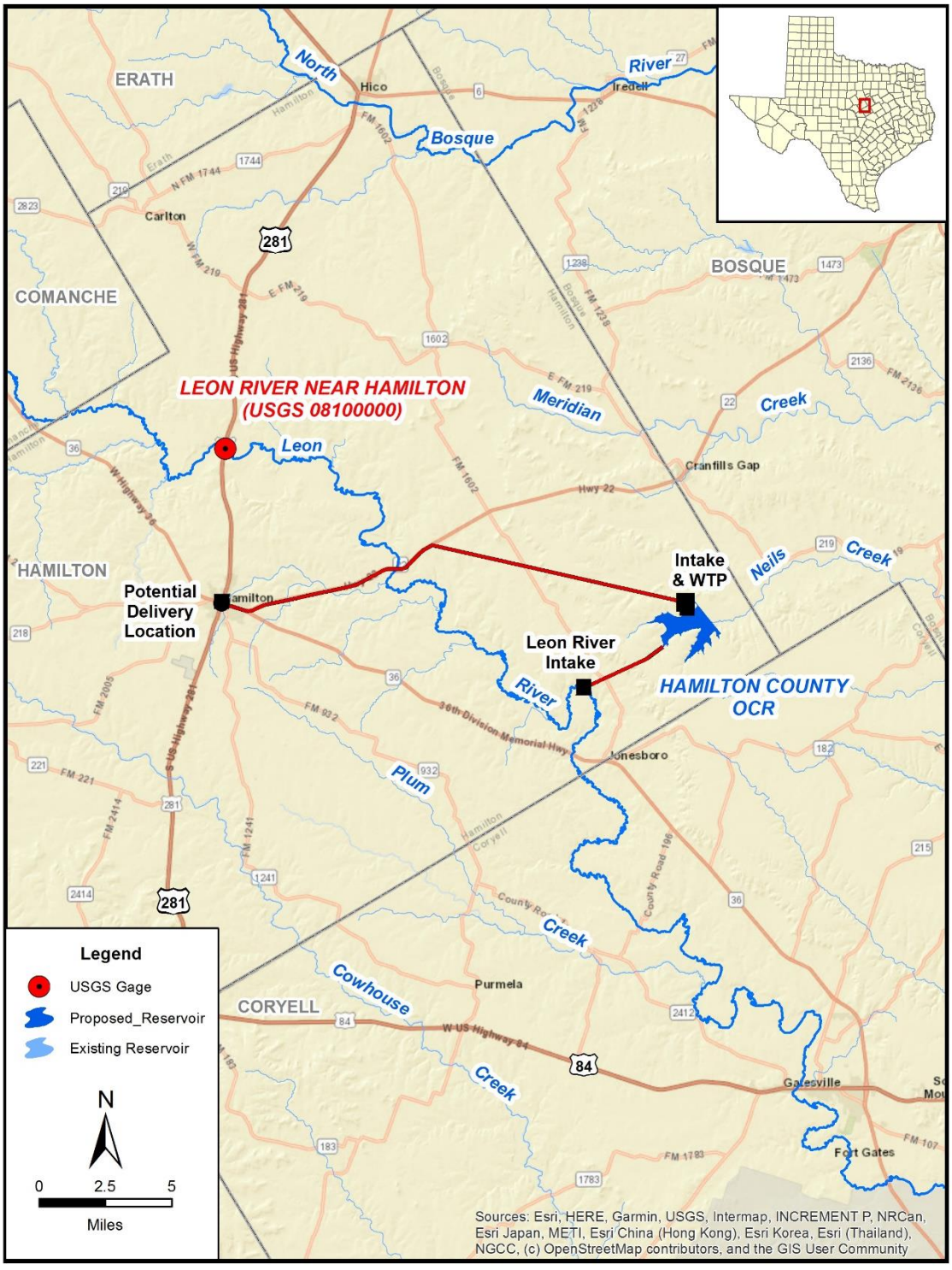
Raw water supplies from the project would be treated at a new water treatment facility located next to the OCR. The treated supplies would then be delivered to customers within Hamilton County to meet County-Other needs. Specific customers have not yet been identified; therefore, the treated water is assumed to be delivered to the City of Hamilton, located near the center of the county.

4.6.2 Available Yield

Water potentially available for impoundment in the proposed Hamilton County OCR is estimated using the TCEQ Brazos WAM Run 3. The model utilizes a January 1940 through December 1997 hydrologic period of record and assumes no return flows and permitted storages and diversions for all water rights in the basin. The OCR was modeled such that no streamflow contributing from its own drainage area is impounded. The model computed the streamflow available for diversion from Leon River into the Hamilton County OCR without causing increased shortages to existing downstream rights. Firm yield was computed subject to a subordination agreement regarding Lake Belton and TCEQ environmental flow standards.

The optimal Leon River diversion capacity was found to be 200 cfs. Daily gaged streamflow at the Leon River near Hamilton (USGS Gage 08100000) was available for the model simulation period. The location of the gage is shown in Figure 4.6-1. Recorded streamflows at the gage were used to estimate daily flows at the diversion site by adjusting for differences in contributing drainage areas between the two locations. Figure 4.6-2 provides a frequency of daily streamflows calculated at the Leon River diversion site. The frequency shows that streamflows are adequate to support the 200 cfs diversion approximately 20 percent of the time. This diversion constraint was included in the model simulation to more accurately estimate available flow for diversion from the Leon River.

Figure 4.6-1. Hamilton County Off-Channel Reservoir



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The calculated firm yield of the Hamilton County OCR is 9,275 acft/yr, assuming subordination of Lake Belton. Without subordination, the firm yield is 1,750 acft/yr. Figure 4.6-3 illustrates the simulated Hamilton County OCR storage levels under the firm yield demand of 9,275 acft/yr. The simulated storage levels show that the critical drought for the OCR occurs in the 1980's. Figure 4.6-4 shows the simulated storage frequency of the OCR under the same firm yield demand. The frequency shows that the OCR would remain at the conservation pool capacity more than 20 percent of the time and above 90 percent full for about half of the simulation period. Figure 4.6-5 provides the annual diversion volumes from the Leon River that are impounded by the OCR. The average annual diversion over the entire model simulation period is 12,372 acft/yr.

Figure 4.6-6 and Figure 4.6-7 show the simulated monthly median streamflow and streamflow frequency at the Leon River diversion site with and without the project. The largest reduction in median streamflow from implementing the project would occur in May with a reduction of 15 cfs or 6 percent. The streamflow frequency shows that there is not a significant reduction in monthly streamflows throughout the model simulation period with the project in place and in some months the median streamflow increases with the project. This is a result of Lake Proctor making additional releases upstream as part of the BRA system operations to compensate for the impact to Lake Belton from the subordination agreement.

Figure 4.6-2. Daily Streamflow at Leon River Diversion Site

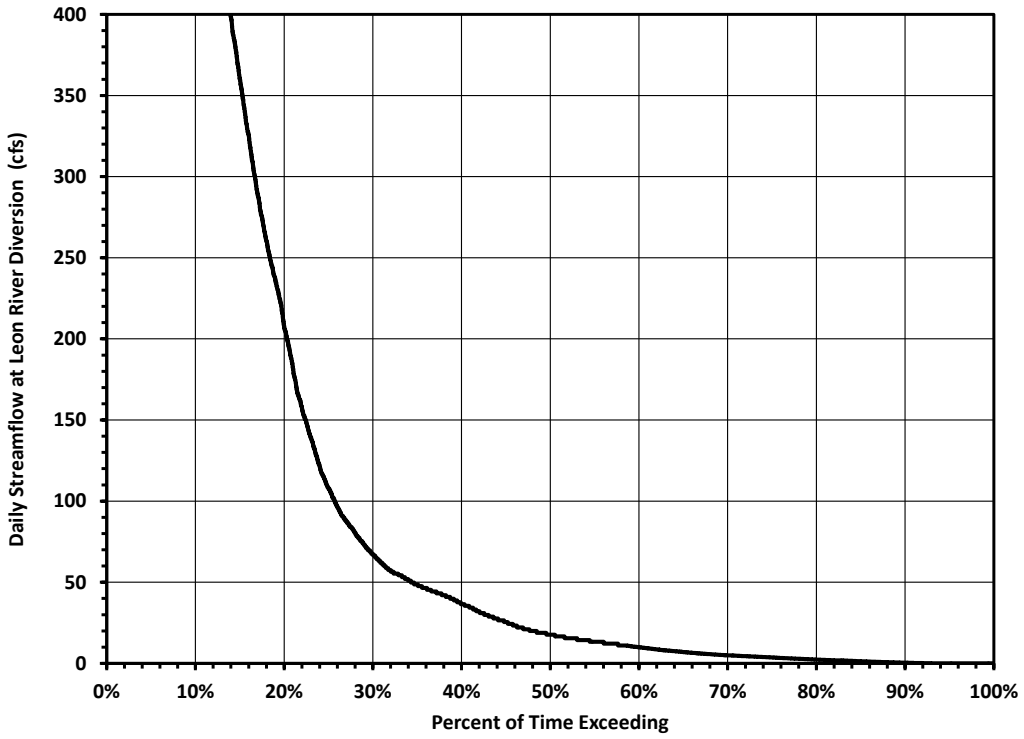


Figure 4.6-3. Hamilton County Reservoir Storage Trace

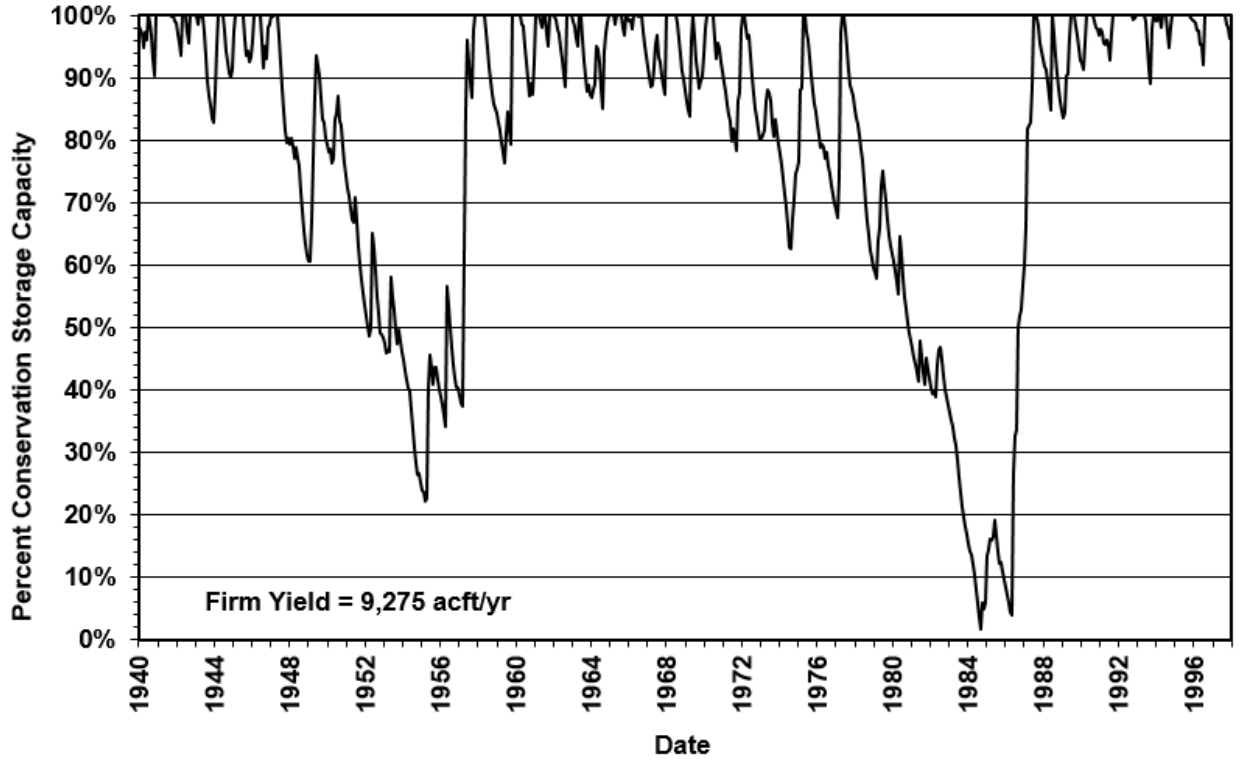


Figure 4.6-4. Hamilton County Reservoir Storage Frequency

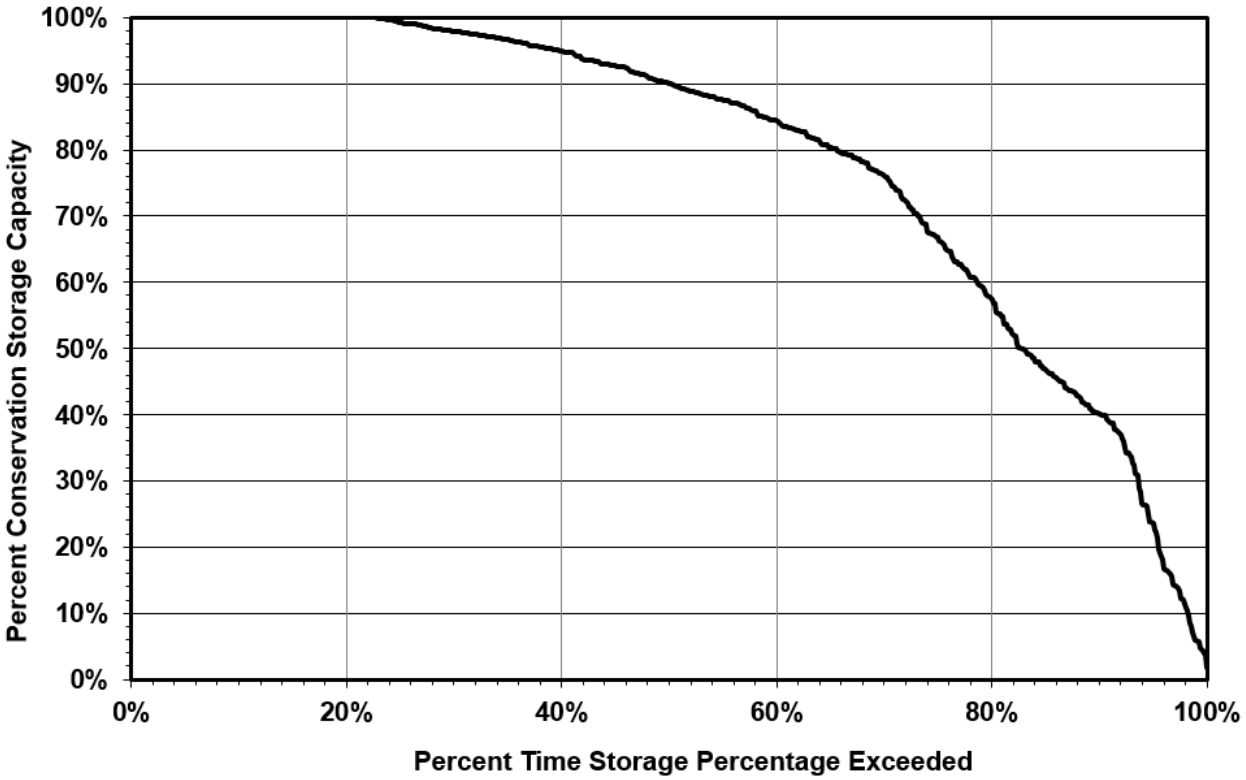


Figure 4.6-5. Annual Diversions from Leon River

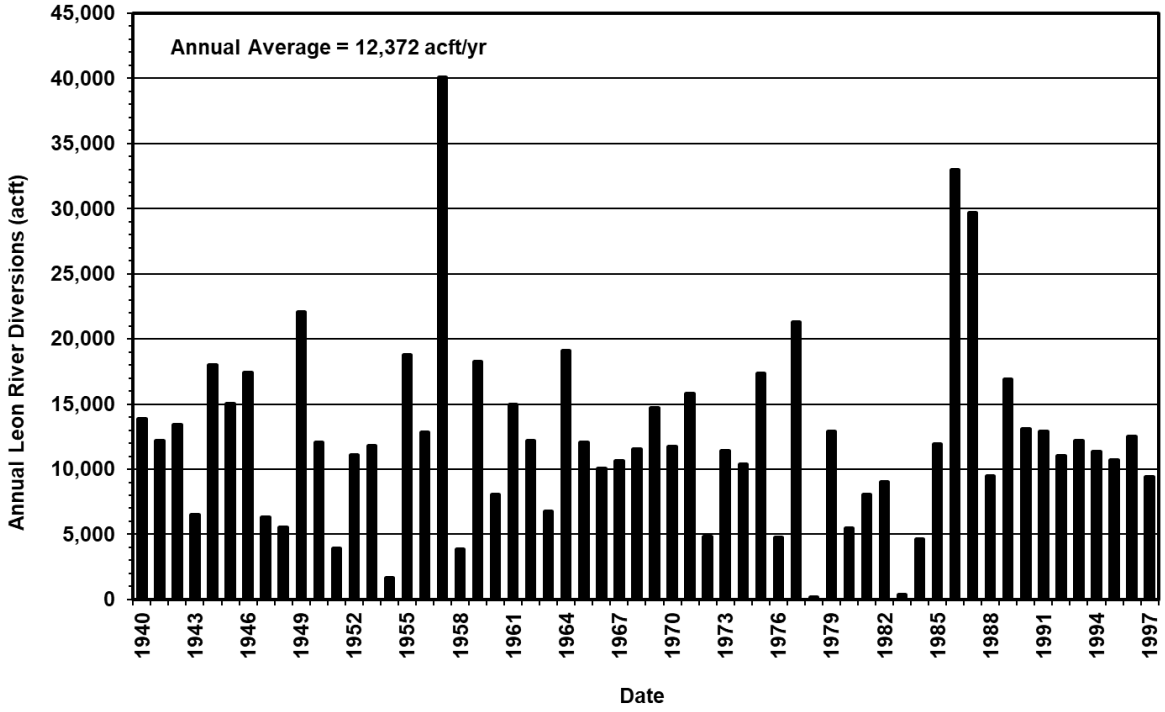


Figure 4.6-6. Leon River Simulated Monthly Median Streamflow with and without Diversion

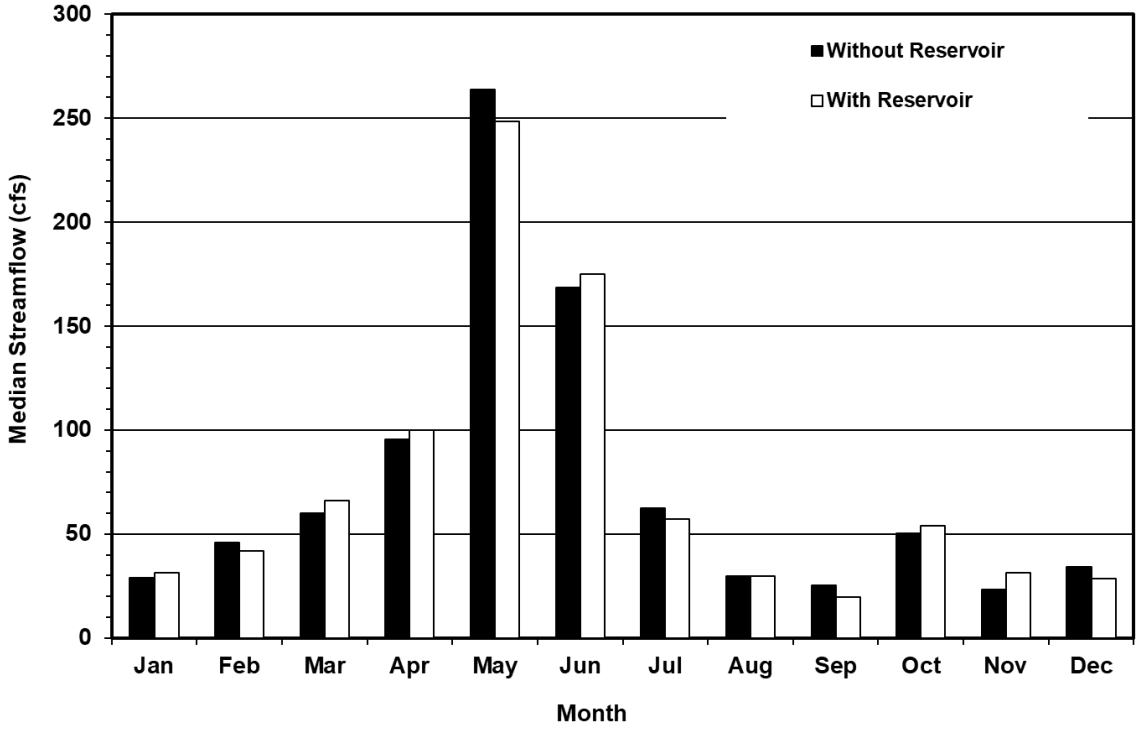
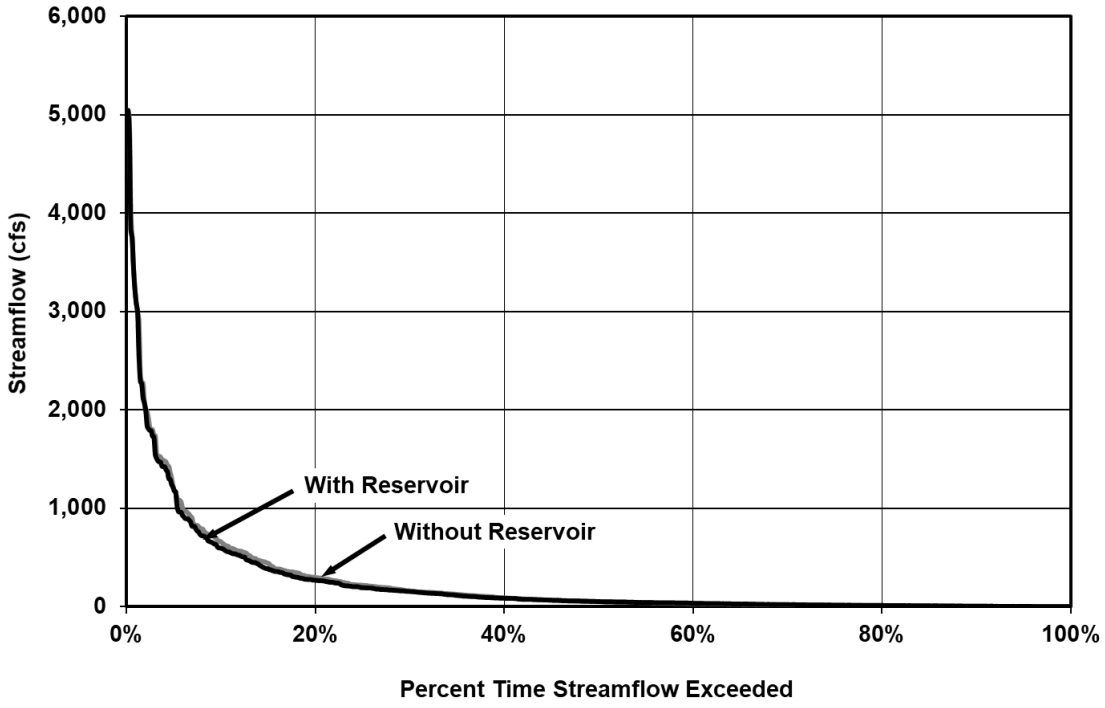


Figure 4.6-7. Leon River Simulated Streamflow Frequency with and without Diversion



4.6.3 Environmental Issues

Existing Environment

The Hamilton County OCR strategy involves the construction of an OCR along South Fork Neils Creek, an intake and pipeline from the Leon River to the OCR, a new water treatment plant and a transmission pipeline to the city of Hamilton. The proposed OCR site is located in eastern Hamilton County. The site is situated in the Cross Timbers Ecoregion[1] and is primarily located within the Balconian biotic province, with a small section on the western limits occurring within the Texan biotic province.[2] The Cross Timbers ecoregion is considered to be a transitional area found between prairie areas to the west and the forested hills of eastern Oklahoma and Texas. This area is used primarily for rangeland and pastureland, but some areas include forested sections. The mean annual precipitation of this area is 30-34 inches and the mean temperature ranges from 32 to 57 degrees Fahrenheit. The Trinity Aquifer is the only major aquifer underlying the project area.[3]

[1] Griffith, G.E., Bryce, S.A., Omernik, J.M., Comstock, J.A., Rogers, A.C., Harrison, B., Hatch, S.L., and Bezanson, D., 2004. Ecoregions of Texas. Reston, Virginia, U.S. Geological Survey.

[2] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.

[3] Texas Water Development Board (TWDB), *Major and Minor Aquifers of Texas*, Maps online at http://www.twdb.state.tx.us/mapping/index.asp, 2004.

A Custom Soil Resource Report was completed for the Hamilton County OCR site[4]. According to this report, sixteen soil types underlie the project site. Krum silty clay, 1 to 5 percent slopes, is the most abundant soil at 42% of the project area. These soils typically occupy the backslopes of ridges and are well drained. They have a moderately available water capacity and consist of silty clay. Krum silty clay, 1 to 5 percent slopes is considered to be a prime farmland soil. Topsey clay loam, 1 to 5 percent slopes is the next most abundant soil type and is found in 12% of the project area. These soils which are found on ridges are well drained and considered to be prime farmland soils. All other soil types are included in 7% or less of the OCR area. Water areas comprise a little over two percent of the project area and include a portion of South Fork Neils Creek and existing stock tanks.

Vegetation types which occur within the OCR area include Bluestem Grassland and Oak-Mesquite-Juniper Parks/Woods.[5] Bluestem Grassland areas include plants such as bushy bluestem (Andropogon glomeratus), slender bluestem (Schizachyrium tenerum), silver bluestem (Bothriochloa saccharoides), three awn (Aristida ssp.), buffalograss (Bouteloua dactyloides), southern dewberry (Rubus trivialis), live oak (*Quercus virginiana*), mesquite (*Prosopis glandulosa*), and baccharis (*Baccharis neglecta*). Commonly associated plants in the Oak-Mesquite-Juniper Parks/Woods vegetation type include: post oak (*Q stellata*), Ashe juniper (*Juniperus ashei*), shin oak (*Q. sinuata*), Texas oak (*Q. buckleyi*), blackjack oak (*Q. marilandica*), live oak, cedar elm (*Ulmus crassifolia*), agarito (*Berberis trifoliolata*) , soapberry (*Sapindus saponaria*), sumac (*Rhus sp*.), hackberry (*Celtis reticulata*), Texas pricklypear (*Opuntia sp*.), Mexican persimmon (*Diospyros texana*), purple three-awn (*A. purpurea*), curly mesquite (*Hilaria mutica*), and Texas wintergrass (*Stipa leucotricha*).

Vegetation found along the two project pipeline routes includes the two vegetation types described above in addition to areas of Silver Bluestem-Texas Wintergrass Grassland.[6] Silver bluestem-Texas Wintergrass Grasslands include the following commonly associated plants: little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), Texas grama (*Bouteloua rigidiseta*), hairy grama (*Bouteloua hirsute*), tall dropseed (*Sporobolus asper*), windmillgrass (*Chloris verticillata*), hairy tridens (*Erioneuron pilosum*), tumblegrass (*Schedonnardus paniculatus*), western ragweed (*Ambrosia psilostachya*), broom snakeweed (*Gutierrezia sarothrae*), Texas bluebonnet (*Lupinus texensis*), live oak, post oak and mesquite.

Potential Impacts

Aquatic Environments including Bays & Estuaries

The potential aquatic impacts of this project were evaluated at the Leon River where water will be diverted to the OCR site. Streamflow available for diversion from the Leon

[4] NRCS. "Custom Soil Resource Report for Hamilton County, Texas – Hamilton Off-Channel Site. February 17, 2015.

[5] McMahan, C. A., R. G. Frye and K. L. Brown, " The Vegetation Types of Texas -- Including Cropland," Texas Parks and Wildlife Department – PWD Bulletin 7000-120. 1984.

[6] McMahan, C. A., R. G. Frye and K. L. Brown, " The Vegetation Types of Texas -- Including Cropland," Texas Parks and Wildlife Department – PWD Bulletin 7000-120. 1984.

River into the OCR are not anticipated to cause increased shortages to existing downstream rights or significant impact to existing aquatic species. The river diversion would be required to pass inflows which meet the environmental flow criteria for stream flow. However, a difference in the variability of monthly flow conditions at the diversion point might also be anticipated. Variability in flow is important to the instream biological community as well as riparian species and a reduction could influence the timing and success of reproduction as well as modify the current composition of species by favoring some and reducing suitability for others.

Because the OCR has no naturalized flow originating from its own drainage area, no environmental flow criteria pass-through requirements are needed for this site. However, impacts to aquatic species within the OCR area would occur as habitats change from the existing intermittent stream condition to a reservoir environment.

Siting of the Leon River intake and pump station for this project should be situated as to result in minimal disturbance to existing area species. Although there would be impacts in the immediate vicinity of the project site and downstream, it appears that this project, alone, would have minimal influence on total discharge in the Brazos River, resulting in a minimal influence to freshwater inflows to the Brazos River estuary. However, the cumulative impact of multiple projects of this type may reduce freshwater inflows into the estuary.

Threatened & Endangered Species

The Texas Parks and Wildlife Department (TPWD) maintains a list of Rare, Threatened, and Endangered Species of Texas by County. This list includes the federal and state listing status and a habitat description for each species which may be a resident or migrant through the county. TPWD regularly updates the listing status, range data, and habitat descriptions on their published county lists, based on the most recently available data. The current list of rare, threatened and endangered species for Hamilton County can be found at https://tpwd.texas.gov/gis/rtest/.

Data from the TPWD Texas Natural Diversity Database[7] did not reveal any documented occurrences of listed species within the vicinity of the proposed Hamilton OCR. However documented occurrences of the smooth pimpleback mussel, a state threatened species, are located along the Leon River approximately two miles downstream of the project intake. Although based on the best information available to TPWD, these data do not provide a definitive statement as to the presence, absence, or condition of special species, natural communities, or other significant features in the project area. On-site evaluations will be required by qualified biologists to confirm the occurrence of sensitive species or habitats. Coordination with TPWD and USFWS regarding threatened and endangered species with potential to occur in the project area should be initiated early in project planning.

Wildlife Habitat

The primary impacts that would result from construction and operation of the proposed Hamilton OCR include conversion of approximately 1,374 acres of existing habitat within

[7] Texas Parks and Wildlife Department (TPWD), Texas Natural Diversity Database, 06/06/2019.

the conservation pool to open water. Projected wildlife habitat that will be impacted includes approximately 794 acres of Savanna Grassland that encompass 58% of the OCR area. An additional 30% of this area includes wood or forest areas and approximately four percent includes shrubland. Smaller percentages of row crops, urban herbaceous vegetation also occur within the OCR area.[8]

Siting of the raw water intake, pump station, and raw water pipeline to the OCR should be located as feasible in areas that would result in minimal impacts to existing aquatic and terrestrial species. The transmission pipeline to the City of Hamilton as currently planned includes approximately 18 miles of 24-in pipeline. The eastern half of this pipeline would occur within areas that are relatively undeveloped and the western portion primarily occurs within the right-of-way of existing roadways. The use of previously disturbed areas such as the right-of-way areas would reduce the impacts associated with the pipeline construction and maintenance. The transmission pipeline also crosses numerous waterways including the Leon River and a number of creeks and tributaries. Best Management Practices utilized during construction activities would minimize impacts to the project area habitats and existing species. Impacts from the project pipelines and associated appurtenances are anticipated to be primarily limited to the construction of these facilities and subsequent maintenance activities.

A number of vertebrate species could occur within the Hamilton County OCR site including smaller mammals such as the eastern red bat (*Lasiurus borealis*), hispid cotton rat (*Sigmodon hispidus*), white-footed mouse (*Peromyscus leucopus*), and eastern fox squirrel (*Sciurus niger*).[9] Reptiles and amphibians known from the county include the Great Plains rat snake (*Elaphe guttata guttata*), western coachwhip (*Masticophis flagellum flagellum*), and Texas horned lizard (*Phrynosoma cornutum*) among others.[10] An undetermined number of bird species and a variety of fish species would also be expected to inhabit the various habitat types within the site, with distributions and population densities limited by the types and quality of habitats available.

Cultural Resources

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available GIS datasets provided by the Texas Historical Commission (THC), there are no National Register Properties, National Register Districts, or State Historic Sites located within or near the OCR or pipeline project areas. One cemetery occurs within the OCR area and 2 occur within one mile of the transmission pipeline. Twenty-one historical markers occur within one mile of the transmission pipeline, all within the city limits of Hamilton. Avoidance of cultural resources located near the pipelines, water treatment plant and intake structure are probable with careful location of these facilities. Because the owner or controller of the

[8] Texas Parks and Wildlife. Ecological Mapping Sytem GIS layer. Accessed at http://www.tpwd.state.tx.us/gis/data/ 06/06/2019.

[9] Davis, William B. and David J. Schmidly. 1994. The Mammals of Texas. Texas Parks and Wildlife, Austin, Texas

[10] Dixon, James R., Amphibians and Reptiles of Texas. 1987, Texas A&M Press.

project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the Texas Historical Commission regarding potential impacts to cultural resources.

Threats to Natural Resources

This project could possibly have adverse effects on stream flow below the diversion point along the Leon River. Decreased stream flow would contribute to declines in dissolved oxygen and higher temperatures during summer periods. The project is expected to have negligible impacts to the stream flow and water quality in the Brazos River. Additional impacts would be expected to terrestrial species found within the proposed OCR area that would be displaced by the reservoir filling. Impacts associated with the transmission pipelines and water treatment plants are anticipated to be limited to the construction of these facilities and continued maintenance of these areas.

Agricultural Impacts

The Hamilton County Reservoir site does not contain Pasture/Hay fields or cultivated cropland. No impacts are expected for agricultural land use.

4.6.4 Engineering and Costing

The potential OCR project for Hamilton County would require additional facilities to divert water from the Leon River to the OCR site and to treat and transmit water from the OCR to the City of Hamilton. The facilities required for implementation of the project include:

- Raw water intake and pump station at the Leon River diversion site with a capacity of 200 cfs (129 MGD);
- 3 Miles of raw water pipeline (72-inch diameter) from the pump station to the OCR;
- OCR dam including spillway, intake tower, and 1,374 acres of land for the reservoir;
- A new 8.7 MGD water treatment plant, intake and pump station at the OCR Site; and
- 18-mile, 24-in treated water pipeline to County-Other distribution lines.

A summary of the total project cost in September 2018 dollars is presented in Table 4.6-1. The proposed Hamilton Creek OCR project would cost approximately $248.3 million for surface water supply facilities. This includes the construction of the dam, land acquisition, environmental permitting and mitigation, and technical services. The project costs also include the cost for the raw water facilities to convey surface water from the Leon River diversion site to the OCR and the transmission and treatment water stored in the OCR to the distribution line. The annual project costs are estimated to be approximately $29.4 Million. This includes annual debt service, operation and maintenance, pumping energy costs, and purchase of water from BRA for compensation of yield impacts to Lake Belton. The OCR project would be able to provide 9,275 acft/yr of treated water at a unit cost of $3,170 per acft or $9.73 per 1,000 gallons.

Table 4.6-1. Cost Estimate Summary for Hamilton County Off-Channel Reservoir

Item	Estimated Costs for Facilities
Dam and Reservoir (Conservation Pool 49,849 acft, 1,374 acres)	$17,279,000
Leon River Channel Dam & Intake Pump Station (129 MGD)	$52,628,000
Leon River Diversion Pipeline (72 in dia., 3 miles)	$9,961,000
OCR Intake Pump Station (8.7 MGD)	$19,523,000
OCR Transmission Pipeline (24 in dia., 18 miles)	$26,445,000
Water Treatment Plant (8.7 MGD)	$37,256,000
TOTAL COST OF FACILITIES	**$163,092,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$55,262,000
Environmental & Archaeology Studies and Mitigation	$5,262,000
Land Acquisition and Surveying (1,664 acres)	$5,767,000
Interest During Construction (3% for 3 years with a 0.5% ROI)	$18,925,000
TOTAL COST OF PROJECT	**$248,308,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$10,342,000
Reservoir Debt Service (3.5 percent, 40 years)	$1,885,000
Operation and Maintenance	
Pipelines, Wells, and Storage Tanks (1% of Cost of Facilities)	$364,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$1,804,000
Dam and Reservoir (1.5% of Cost of Facilities)	$259,000
Water Treatment Plant (2.5% of Cost of Facilities)	$2,635,000
Pumping Energy Costs (0.08 $/kW-hr)	$7,429,000
Purchase of Water (3,590 acft/yr @ 76.5 $/acft)	$275,000
TOTAL ANNUAL COST	**$29,406,000**
Available Project Yield (acft/yr)	9,275
Annual cost of Water ($ per acft)	$3,170
Annual cost of Water ($ per 1,000 gallons)	$9.73

4.6.5 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 4.6-2 and the option meets each criterion.

Table 4.6-2. Evaluations of Hamilton County Off-Channel Reservoir Option to Enhance Water Supplies

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet needs
2. Reliability	2. High reliability
3. Cost	3. High
B. Environmental factors	
1. Environmental Water Needs	Moderate impact
2. Habitat	Moderate impact
3. Cultural Resources	Low impact
4. Bays and Estuaries	Negligible impact
5. Threatened and Endangered Species	Low impact
6. Wetlands	Negligible 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	None
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	None

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality Water Right and Storage permits;
- U.S. Army Corps of Engineers Permits will be required for discharges of dredge or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act);
- Texas Commission on Environmental Quality administered Texas Pollutant Discharge Elimination System Storm Water Pollution Prevention Plan;

- General Land Office Easement if State-owned land or water is involved; and
- Texas Parks and Wildlife Department Sand, Shell, Gravel and Marl permit if state-owned streambed is involved.

State and Federal Permits may require the following studies and plans:

- Environmental impact or assessment studies;
- Wildlife habitat mitigation plan that may require acquisition and management of additional land;
- Flow releases downstream to maintain aquatic ecosystems;
- Assessment of impacts on Federal- and State-listed endangered and threatened species;
- Aquatic Resource Relocation Plan (ARRP) and a relocation permit may be required from TPWD if a dewatering event is required during construction; and
- Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resource recovery and cataloging; requires coordination with the Texas Historical Commission.

Land Acquisition Issues:

- Land acquired for reservoir and/or mitigation plans could include market transactions and/or eminent domain;
- Additional acquisition of rights-of-way and/or easements may be required; and
- Possible relocations or removal of residences, utilities, roads, or other structures.

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4.7 NCTMWA Lake Creek Reservoir (formerly Millers Creek Off-Channel Reservoir)

4.7.1 Description of Option

A potential water management strategy for North Central Texas Municipal Water Authority (NCTMWA) is a new reservoir located on Lake Creek in the southeast corner of Knox County as shown in Figure 4.7-1. The proposed Lake Creek diversion site for the Millers Creek Augmentation WMS is shown in Figure 4.7-1 for comparison purposes.

The proposed NCTMWA Lake Creek Reservoir, also known as the Millers Creek Off-Channel Reservoir, will contain approximately 58,560 acft of conservation storage and inundate 2,866 acres at the conservation pool elevation of 1,400 ft-msl. The reservoir would impound Lake Creek streamflow and diversions from the Brazos River. Almost all of the streamflow originating in Lake Creek must be passed downstream for senior water rights at Possum Kingdom Reservoir. A subordination agreement with the BRA regarding Possum Kingdom Reservoir would allow for these inflows to be impounded by the NCTMWA Lake Creek Reservoir, thus significantly increasing the yield of the project. Currently, BRA indicates that no subordination agreement is likely to be possible.

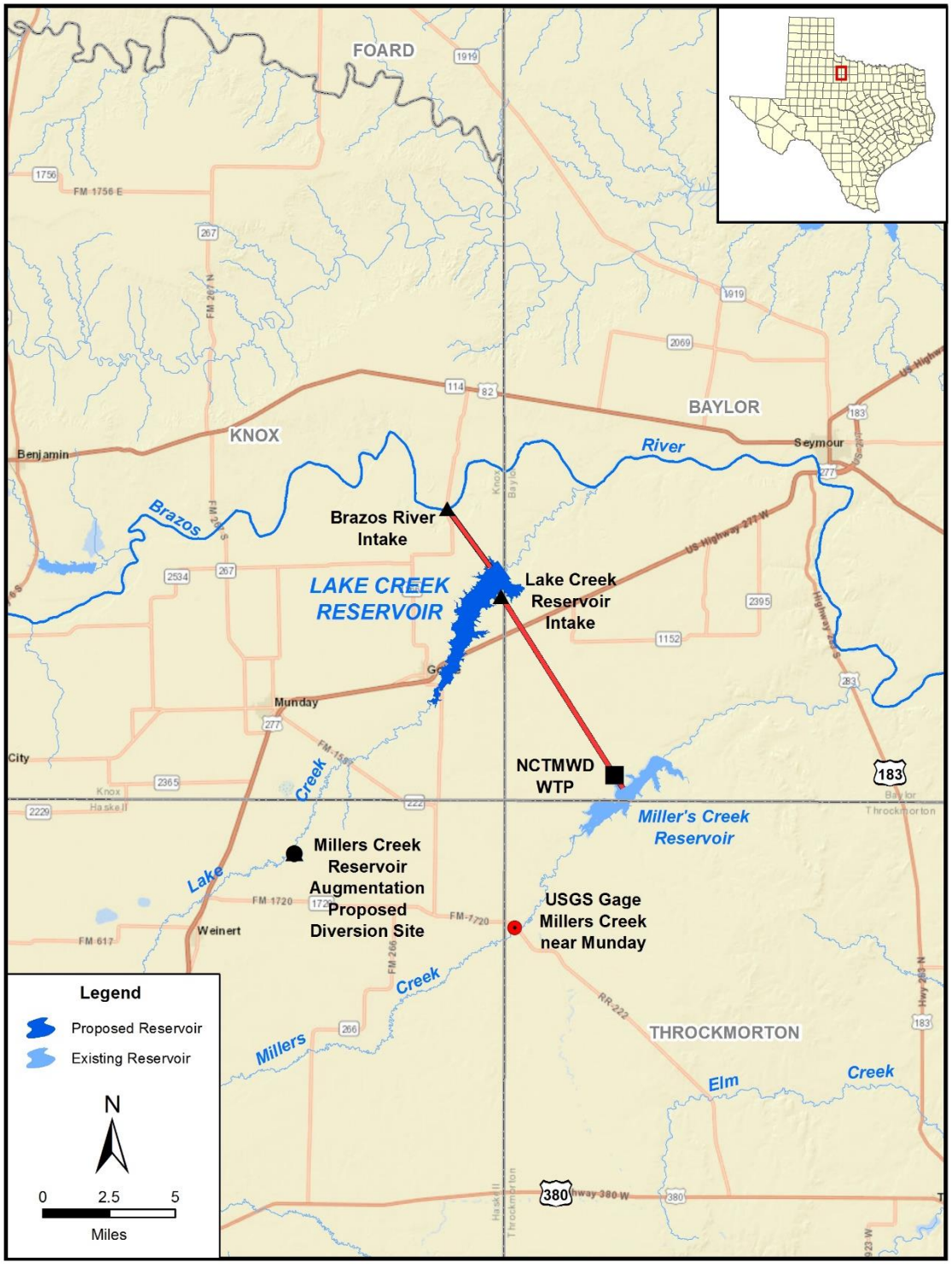
Diversions from the Brazos River would be transported through a 3-mile, 120-in pipeline to the reservoir for impoundment. Due to water quality concerns in the main stem of the Brazos River, diversions would only occur during flood flow periods. However, a significant portion of the available streamflow during high flow periods is now appropriated by BRA under the System Operations permit. As a result, a contract with BRA for non-firm system water during these high flow periods is necessary for adequate supplies to be diverted from the Brazos River for impoundment in NCTMWA Lake Creek Reservoir.

Stored water in the reservoir would be transported to the NCTMWA WTP or Millers Creek Reservoir via an 8-mile, 30-in pipeline. NCTMWA would have the operational flexibility to treat the supplies or discharge the raw water into Millers Creek Reservoir if storage is available. A 12.1 MGD expansion of the WTP would also be required to treat the additional raw water supplied by the project.

4.7.2 Available Yield

Water potentially available for impoundment in the proposed NCTMWA Lake Creek Reservoir was estimated using the TCEQ Brazos WAM Run 3 which assumes no return flows and permitted storages and diversions for all water rights in the basin. The model utilizes a January 1940 through December 1997 hydrologic period of record and includes

Figure 4.7-1. NCTMWA Lake Creek Reservoir



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TCEQ environmental flow standards. The model computed the streamflow available for impoundment with Possum Kingdom Reservoir subordination and diversions from the Brazos River without causing increased shortages to existing downstream rights.

The calculated firm yield of the NCTMWA Lake Creek Reservoir project is 12,900 acft/yr. Figure 4.7-2 provides the individual contributions to the total firm yield from junior reservoir impoundments, the Possum Kingdom subordination and the Brazos River diversions. The project would not provide any firm supplies without the subordination agreement or Brazos River diversions. The Brazos River diversions provide the greatest contribution to the firm yield (8,100 acft/yr) and are required to make the project economically feasible. The subordination agreement would result in a 1,270 acft/yr yield impact to Possum Kingdom Reservoir.

Figure 4.7-3 provides the annual volumes of reservoir impoundments and Brazos River diversion for the model simulation period.

Figure 4.7-2. NCTMWA Lake Creek Reservoir Firm Yield Components

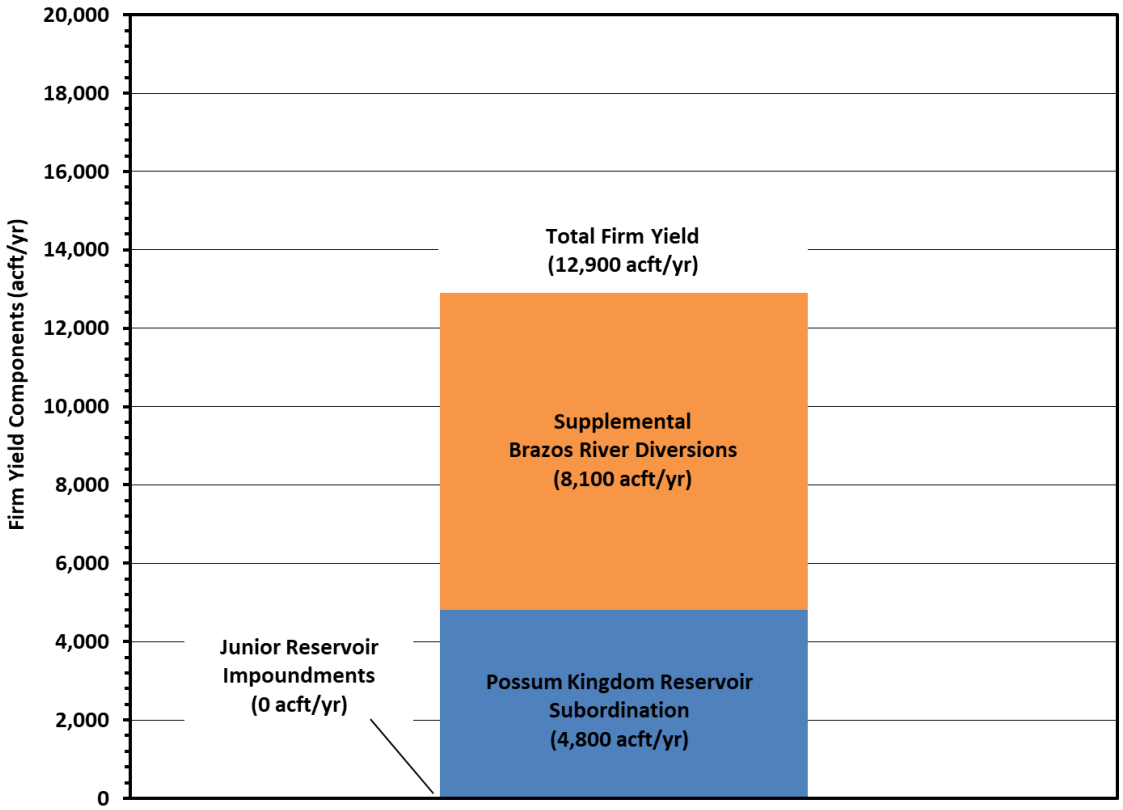


Figure 4.7-3. Annual NCTMWA Lake Creek Impoundments and Brazos River Diversions

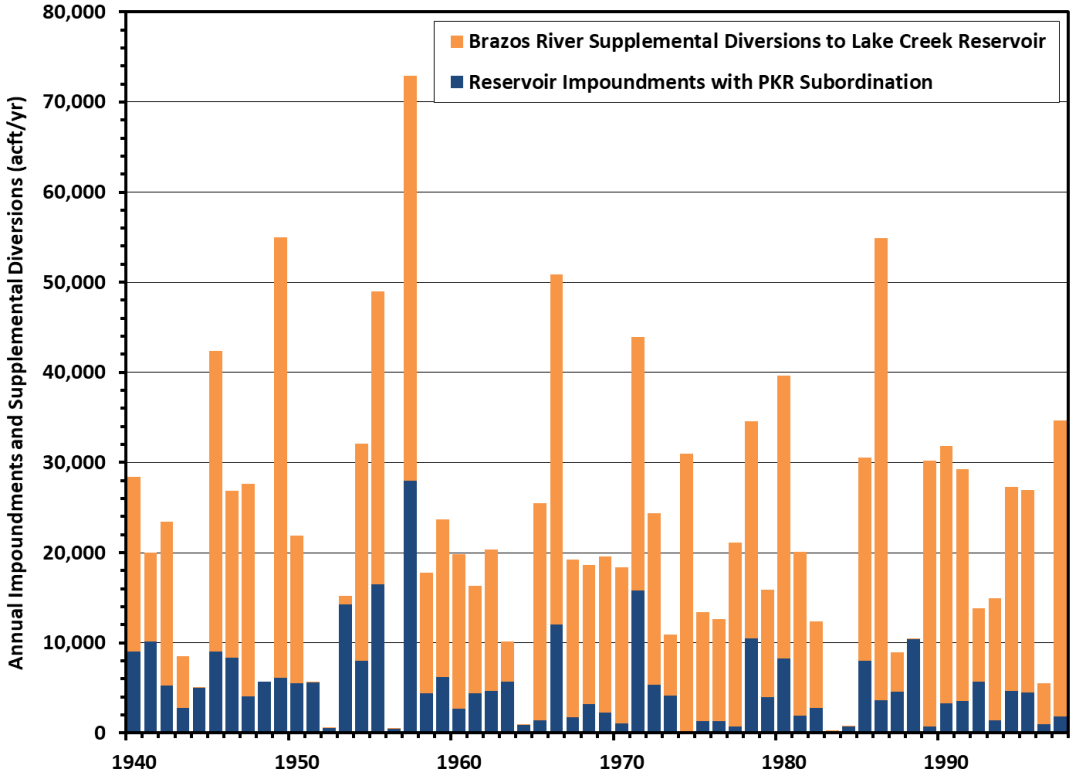


Figure 4.7-4 illustrates the storage trace of NCTMWA Lake Creek Reservoir for the 57-year model simulation period under the firm yield demand of 12,900 acft/yr. Figure 4.7-5 provides a frequency of the storage in NCTMWA Lake Creek Reservoir under the firm yield demand. The storage frequency reveals that the reservoir remains full about 10 percent of the time and over half full approximately 82 percent of the time.

Figure 4.7-6 presents the monthly changes in the Lake Creek median streamflow values from reservoir impoundments. Even though the reservoir would only be able to impound flows in excess of that required for downstream senior water rights and environmental needs, median streamflow values are reduced to zero for all months.

Figure 4.7-7 compares the existing Lake Creek streamflow frequency characteristics without the project to simulated streamflow characteristics with NCTMWA Lake Creek Reservoir in place. For times when flows are less than the upper quartile, there are minimal reductions from the project because streamflows without the project are less than 6 cfs. There is a more pronounced reduction in streamflows during periods when flows are in the upper quartile because the reservoir has more frequent opportunities to impound significant streamflows.

Figure 4.7-8 and Figure 4.7-9 provide similar median streamflow statistics and streamflow frequency for the Brazos River at the diversion site. The figures reveal that the greatest reduction in streamflows occurs during the months of May and June when flood flows typically occur the most.

Figure 4.7-4. NCTMWA Lake Creek Reservoir Firm Yield Storage Trace

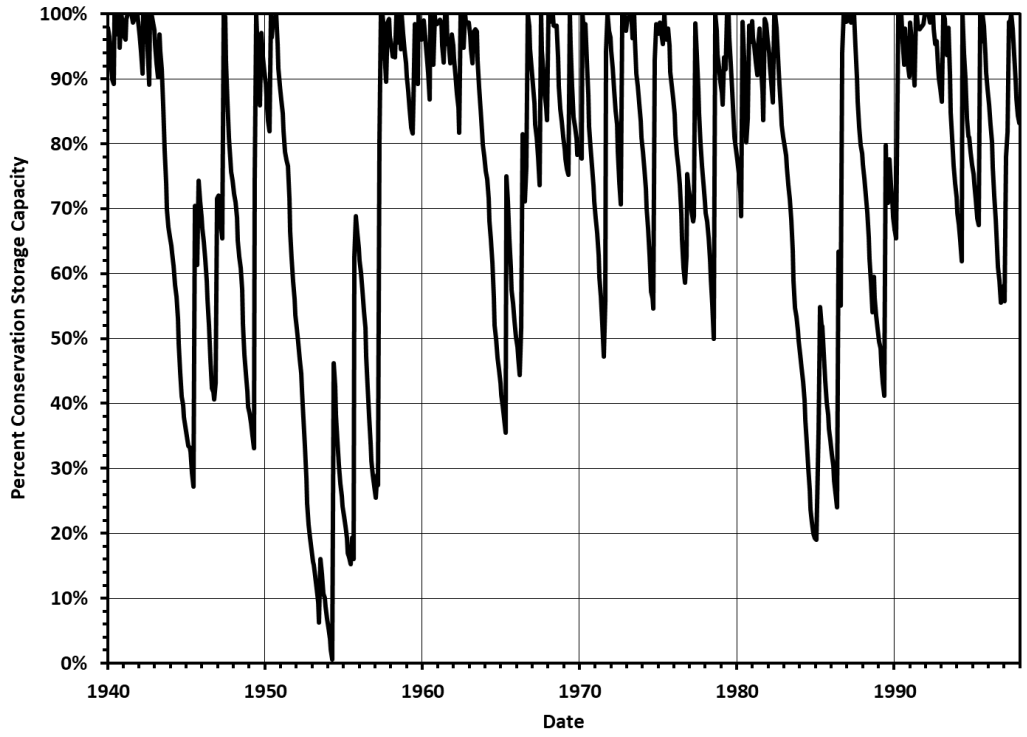


Figure 4.7-5. NCTMWA Lake Creek Reservoir Firm Yield Storage Frequency

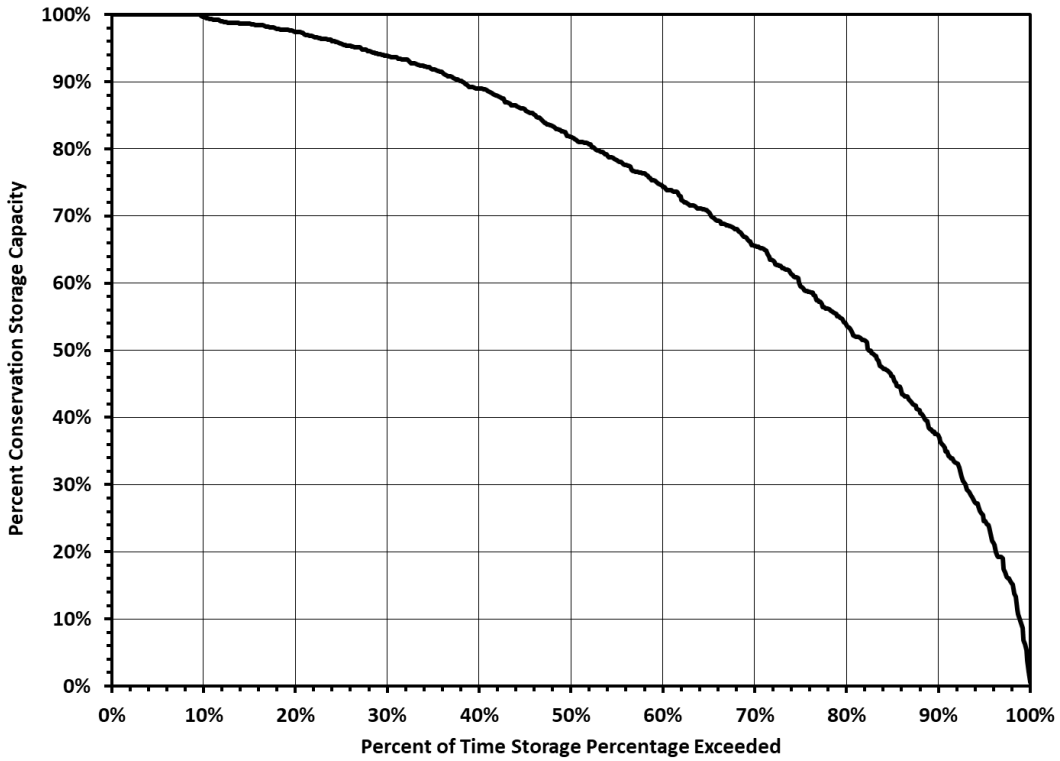


Figure 4.7-6. Lake Creek Median Streamflow Comparison

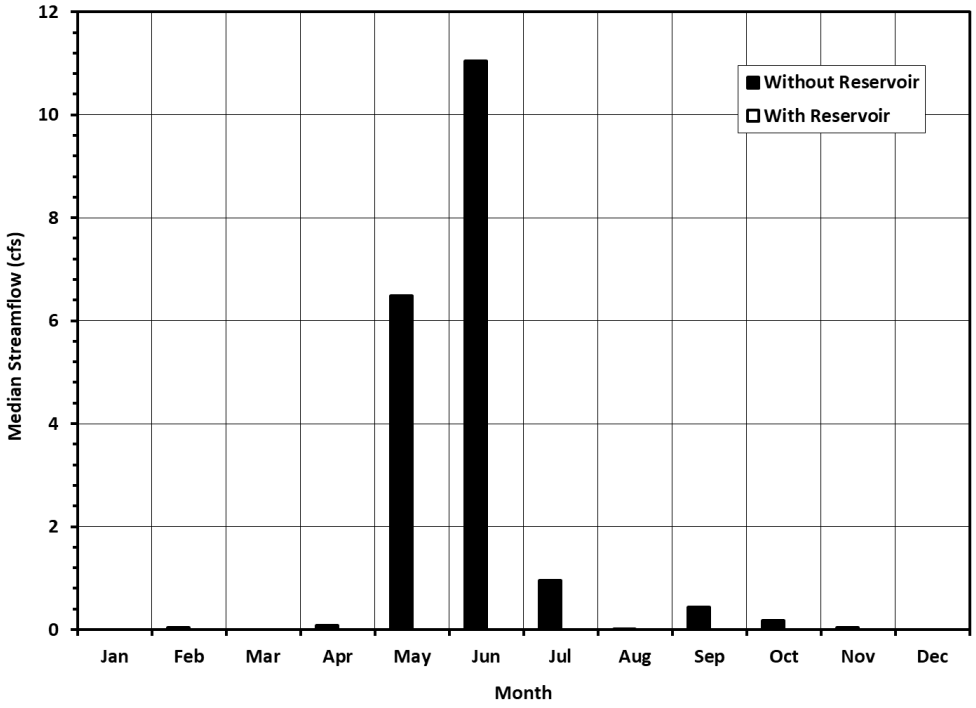


Figure 4.7-7. Lake Creek Streamflow Frequency Comparison

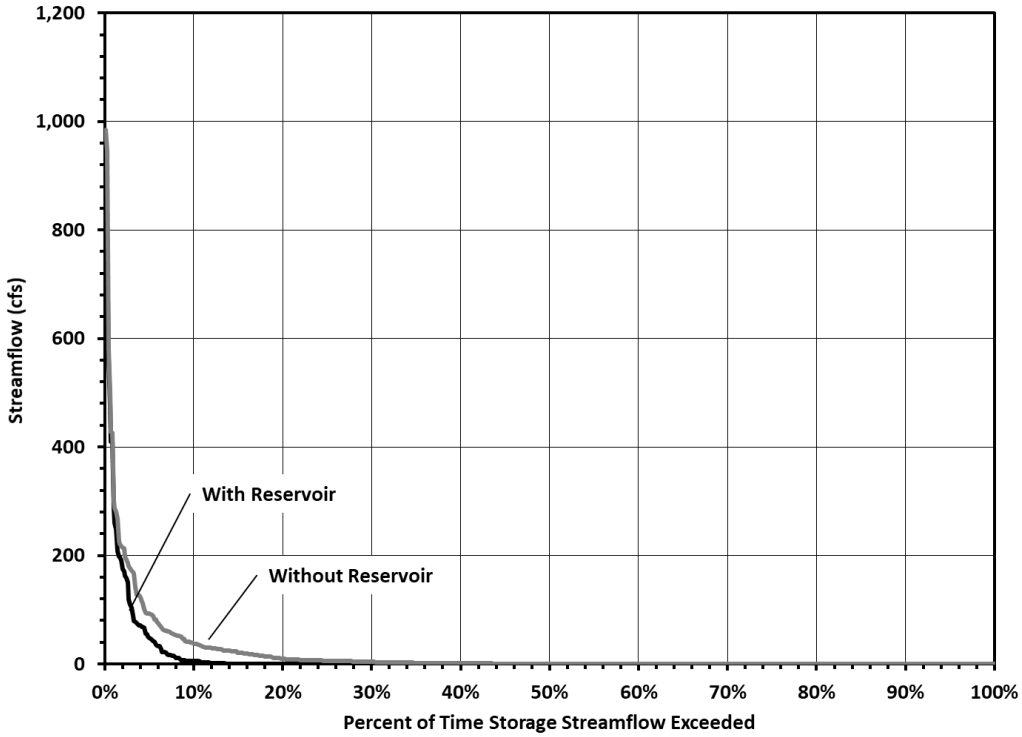


Figure 4.7-8. Brazos River Diversion Median Streamflow Comparison

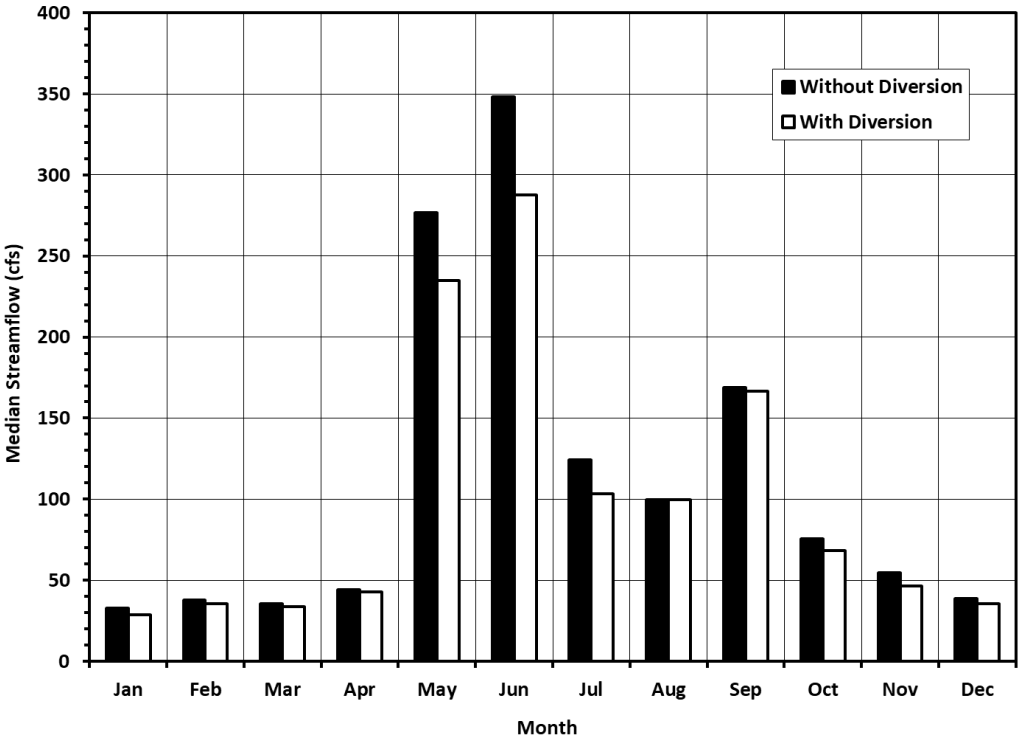
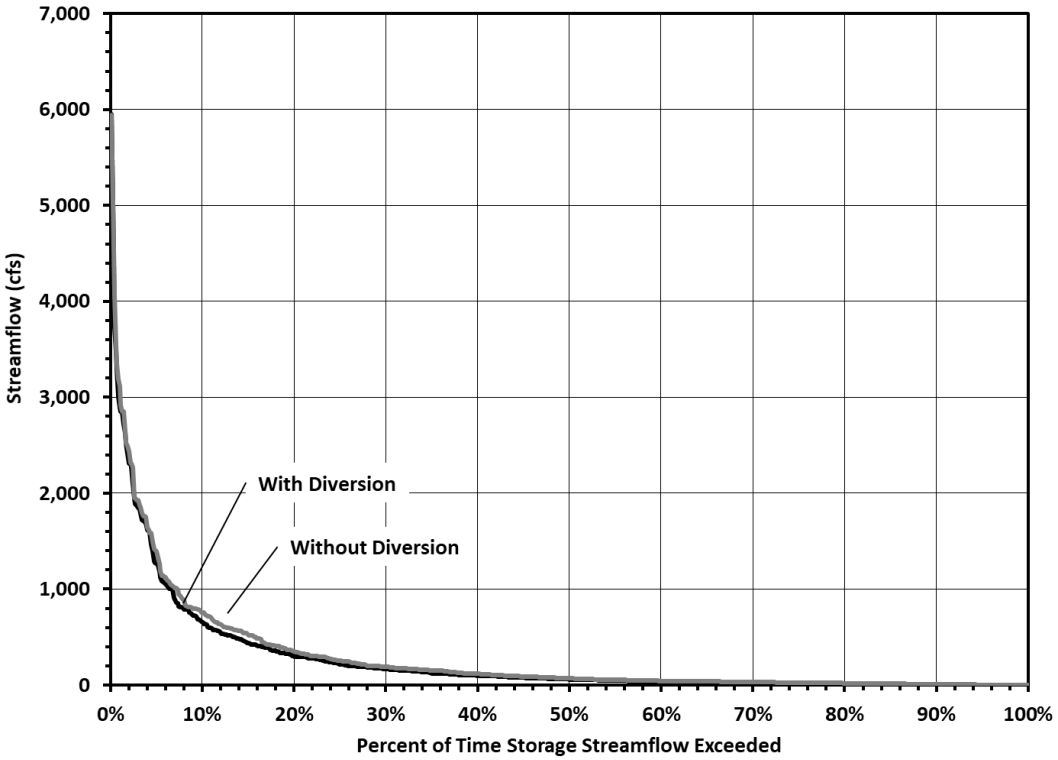


Figure 4.7-9. Brazos River Diversion Streamflow Frequency Comparison



4.7.3 Environmental Issues

The proposed NCTMWA Lake Creek Reservoir (LCR) project will consist of three components. These include: 1) an on-channel reservoir on Lake Creek, 2) an intake and pump station at the Brazos River and associated pipeline to NCTMWA Lake Creek Reservoir to provide supplemental diversions to the reservoir, and 3) an intake and pipeline from NCTMWA Lake Creek Reservoir to the existing water treatment plant (WTP) located near Millers Creek Reservoir which will be expanded.

The proposed project would occur in the Central Great Plains Ecoregion of Texas. The majority of this ecoregion is now cropland, but once included either grassland or a mixed transitional prairie. The project area includes two major vegetation types as defined by Texas Parks and Wildlife (TPWD), the majority type includes crops, however smaller portions of Mesquite/Saltcedar Brush/Woods occur along the margins of rivers and other drainages. Plants commonly found within the Mesquite/Saltcedar Brush/Woods vegetation type include Creosotebush (*Larrea tridentata*), cottonwood (*Populus* ssp.), desert willow (*Chilopsis linearis*), common buttonbush (*Cephalanthus occidentalis*), whitethorn acacia (Acacia constricta), lotebush (Ziziphus obtusifolia), Johnsongrass (*Sorghum halepense*), bushy bluestem (*Andropogon glomeratus*), and Mexican devil-weed (*Leucosyris spinosa*).

The Texas Parks and Wildlife Department (TPWD) maintains a list of Rare, Threatened, and Endangered Species of Texas by County. This list includes the federal and state listing status and a habitat description for each species which may be a resident or migrant through the county. TPWD regularly updates the listing status, range data, and habitat descriptions on their published county lists, based on the most recently available data. The current list of rare, threatened and endangered species for Baylor and Knox counties can be found at https://tpwd.texas.gov/gis/rtest/.

Two fish species, the sharpnose shiner (*Notropis oxyrhynchus*) and smalleye shiner (*Notropis buccula*) are listed as endangered by the USFWS. These two minnows are native to the arid prairie streams of Texas and are considered to be in danger of extinction. The USFWS has designated approximately 623 miles of the Upper Brazos River Basin and the upland areas extending beyond the river channel by 98 feet on each side as critical habitat for these two fish. These areas occur within the counties of Baylor, Crosby, Fisher, Garza, Haskell, Kent, King, Knox, Stonewall, Throckmorton and Young. In addition, TPWD has identified a number of stream segments throughout the state as ecologically significant on the basis of biological function, hydrologic function, riparian conservation, exceptional aquatic life uses, and/or threatened or endangered species. The segment of the Brazos River, located within the project area, is listed by TPWD as an Ecologically Significant River and Stream Segment.

Potential impacts to these species could occur from the construction and operation of the intake and pump station proposed along the Brazos River intended to provide supplemental diversion to NCTMWA Lake Creek Reservoir. Appropriate site selection and screening technology must be considered during the project system design as part of the overall effort to avoid or minimize potential impacts to aquatic species. Coordination with USFWS would be required for listed species within the project area.

Construction of the water transmission pipelines located between the Brazos River and LCR and from LCR to the WTP near Millers Creek Reservoir would include the clearing and removal of woody vegetation. Surveys for protected species should be conducted within the proposed construction corridors where preliminary evidence indicates their existence. State threatened species, including the Texas horned lizard (*Phrynosoma cornutum*), and Brazos water snake (*Nerodia harteri*) are dependent on shrubland or riparian habitat. Because the majority of pipeline construction will occur in previously disturbed areas such as croplands the destruction of potential habitat utilized by terrestrial species will be minimized.

Although suitable habitat for several state threatened species may exist within the project area, no significant impact to these species is anticipated due to limited area that will be impacted by the project, the abundance of similar habit nearby and these species ability to relocate to those areas if necessary. The presence or absence of potential habitat does not confirm the presence or absence of a listed species. No species-specific surveys were conducted in the project area for this report.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available GIS datasets provided by the Texas Historical Commission (THC), there are no National Register Properties, National Register Districts, cemeteries, or historical markers located within the project area. However, there is a high probability for undocumented significant cultural resources to occur within the alluvial deposits and terrace formations associated with waterways, specifically the intermittent and perennial aquatic resources. A review of archaeological resources in the proposed project area should be conducted during the project planning phase.

Specific project features, such as pump stations, and pipelines generally have sufficient design flexibility to avoid most impacts or significantly mitigate potential impacts to geographically limited environmental and cultural resource sites. Field surveys conducted at the appropriate phase of development should be employed to minimize the impacts of project construction and operations on sensitive resources.

Taking into consideration that the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the THC regarding impacts to cultural resources. The project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding any impacts to waters of the United States or wetlands.

Agricultural Impacts

The NCTMWA Lake Creek Reservoir site contains approximately zero acres of Pasture/Hay fields and 203 acres of cropland. These two agricultural land uses account for roughly seven percent of the reservoir footprint.

4.7.4 Engineering and Costing

In addition to the new reservoir, the potential NCTMWA Lake Creek Reservoir project for NCTMWA would require additional facilities to divert water from the Brazos River to the

reservoir Site on Lake Creek and from the reservoir to the water treatment plant at Millers Creek Reservoir. The facilities required for implementation of the project include:

- A raw water intake and pump station at the Brazos River diversion site with a capacity of 400 cfs (258 MGD);
- 3-mile, 120-inch pipeline from the pump station to the NCTMWA Lake Creek Reservoir;
- On-channel dam including spillway, intake tower, and 2,866 acres of land for the reservoir;
- 12.1 MGD intake and pump station at NCTMWA Lake Creek Reservoir;
- 8-mile, 30-in pipeline to NTMWD WTP and Millers Creek Reservoir; and
- 12.1 MGD expansion of the NTMWD WTP.

A summary of the total project cost in September 2018 dollars is presented in Table 4.7-1. The estimated total project cost for the proposed NCTMWA Lake Creek Reservoir project is $259.0 million. This cost includes land acquisition, resolution of conflicts, environmental permitting and mitigation, and technical services. The annual project costs are estimated to be $21.4 million. This includes annual debt service, operation and maintenance, pumping energy costs, and purchase of firm and non-firm water from BRA. The off-channel reservoir project will be able to provide treated water at a unit cost of $1,657 per acft or $5.08 per 1,000 gallons.

Table 4.7-1. Cost Estimate for NCTMWA Lake Creek Reservoir

Item	Estimated Costs for Facilities
Dam and Reservoir	$54,091,000
Brazos River Intake Pump Station & Channel Dam (258 MGD)	$52,038,000
Brazos River Transmission Pipeline (120 in dia., 3 miles)	$19,686,000
Reservoir Intake Pump Station (12.1 MGD)	$8,050,000
Transmission Pipeline (30 in dia., 8 miles)	$9,190,000
Water Treatment Plant Expansion (12.1 MGD)	$27,167,000
TOTAL COST OF FACILITIES	**$170,222,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$58,134,000
Environmental & Archaeological Studies and Mitigation	$5,449,000
Land Acquisition and Surveying (3,012 acres)	$5,456,000
Interest During Construction (3% for 1 years with a 0.5% ROI)	$19,740,000
TOTAL COST OF PROJECT	**$259,001,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$11,866,000
Reservoir Debt Service (3.5 percent, 40 years)	$4,231,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$289,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$1,497,000
Dam and Reservoir (1.5% of Cost of Facilities)	$814,000
Water Treatment Plant	$1,902,000
Pumping Energy Costs ($0.08 kwh)	$434,000
Purchase of Firm Water (1,270 acft/yr @ $76.50 /acft)	$97,000
Purchase of Non-Firm Water (3,235 acft/yr @ $76.50/acft)	$247,000
Total Annual Cost	**$21,377,000**
Available Project Yield (acft/yr)	**12,900**
Annual Cost of Water ($ per acft)	**$1,657**
Annual Cost of Water ($ per 1,000 gallons)	**$5.08**

4.7.5 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 4.7-2, and the option meets each criterion.

Table 4.7-2. Comparison of NCTMWA Lake Creek Reservoir Project to Plan Development Criteria

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet needs
2. Reliability	2. High reliability
3. Cost	3. Reasonable to High
B. Environmental factors	
1. Environmental Water Needs	1. Moderate impact
2. Habitat	2. High impact
3. Cultural Resources	3. High impact
4. Bays and Estuaries	4. Low impact due to distance from coast
5. Threatened and Endangered Species	5. Possible moderate 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	Potential impact on bottomland farms and habitat in reservoir area
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	None
G. Third Party Social and Economic Impacts from Voluntary Redistribution	None

Implementation of the reservoir project will require permits from various state and federal agencies, land acquisition, and design and construction of the facilities. The project may also have an impact on the firm yield of Possum Kingdom, which may require mitigation with the Brazos River Authority in terms of a water supply contract in the amount of the firm yield impact. A summary of the implementation steps for the project is presented below.

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality Water Right and Storage permits;
- U.S. Army Corps of Engineers Permits will be required for discharges of dredge or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act);
- Texas Commission on Environmental Quality administered Texas Pollutant Discharge Elimination System Storm Water Pollution Prevention Plan;

- Texas General Land Office Easement if State-owned land or water is involved; and
- Texas Parks and Wildlife Department Sand, Shell, Gravel and Marl permit if state-owned streambed is involved.

State and Federal Permits may require the following studies and plans:

- Environmental impact or assessment studies;
- Wildlife habitat mitigation plan that may require acquisition and management of additional land;
- Flow releases downstream to maintain aquatic ecosystems;
- Assessment of impacts on Federal- and State-listed endangered and threatened species;
- Aquatic Resource Relocation Plan (ARRP) and a relocation permit may be required from TPWD if a dewatering event is required during construction.
- Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resource recovery and cataloging; requires coordination with the Texas Historical Commission; and

Land Acquisition Issues:

- Land acquired for reservoir and/or mitigation plans could include market transactions or other local landowner agreements;
- Additional acquisition of rights-of-way and/or easements may be required; and
- Possible relocations or removal of residences, utilities, roads, or other structures.

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4.8 Red River Off-Channel Reservoir

4.8.1 Description of Option

The Red River Off-Channel Reservoir (OCR) strategy was originally evaluated in the 2014 Dallas Long Range Water Supply Plan (LRWSP) as an alternative strategy. The project has the potential to generate a significant amount of supply for water users in the Region C and Brazos G planning areas. The LRWSP estimates the project can produce 310,000 acft/yr of firm supply on an annual basis with 114,000 acft/yr of this supply assumed to be dedicated to the City of Dallas in Region C. The remaining 196,000 acft/yr is assumed to be available for delivery to Possum Kingdom Reservoir for use in Brazos G.

The project includes a 750 cfs intake and pump station to divert and transmit water from the Red River near Arthur City through approximately 2 miles of 132-in pipeline to three OCRs in series. The first OCR consists of a 2,500 acft basin for initial sediment settling and subsequent removal. The next OCR would consist of a 5,300 acft basin for water quality improvement and additional sediment removal. Finally, a third OCR would consist of a 32,000 acft storage basin to allow for extended pumping during those times when flow in the Red River is extremely low or water quality is impaired.

A 535 cfs intake and pump station would then deliver supplies from the final OCR to the Region C drop-off location in Lake Ray Roberts through a 144-inch, 100-mile transmission pipeline. Delivery of the remaining supplies to Possum Kingdom Reservoir would require a 120-inch, 107-mile transmission pipeline. The delivery system is designed with a 1.25 peaking factor to allow for over pumping to compensate for delivery shortages during periods when diversions from the OCR are not available. Facilities required for this strategy are shown in Figure 4.8-1 and Figure 4.8-2 provides further detail of the OCR layout and flow of water through the three OCRs.

Several key issues would need to be overcome to make the project feasible. These issues include bank stability for the intake structure along the Red River, water quality and sediment control, invasive species, and regulatory and permitting issues considering the Red River Compact.

Figure 4.8-1. Red River Off-Channel Reservoir Pipeline Route

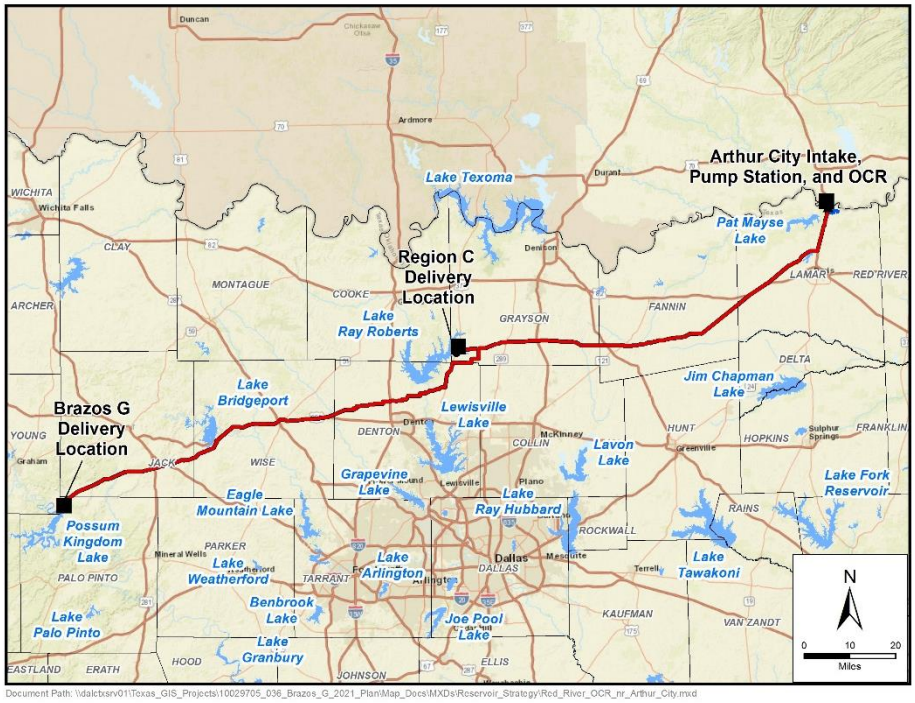
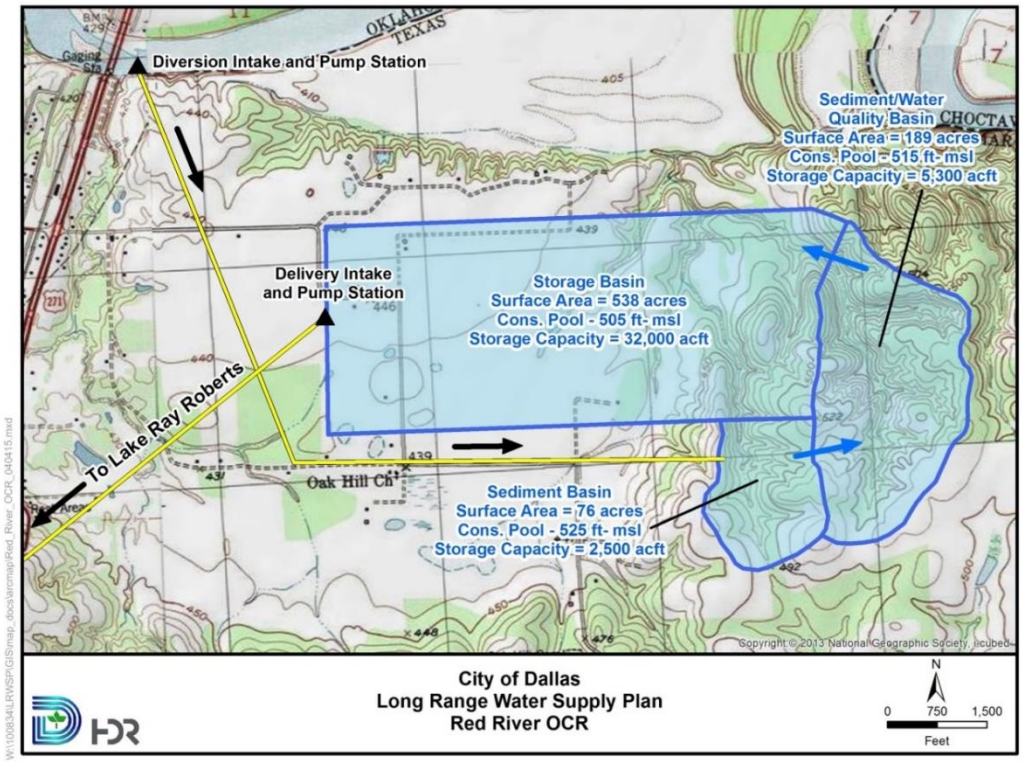


Figure 4.8-2. Red River Off-Channel Reservoir Project



4.8.2 Available Yield

Water potentially available for diversion and impoundment in the proposed Red River OCR was estimated using the TCEQ Red River WAM Run 3. The TCEQ Red River WAM includes only the Texas portion of streamflows potentially available for diversion from the Red River, utilizes a January 1948 through December 1998 hydrologic period of record, assumes no return flows and permitted storages and diversions for all Texas water rights in the basin. The model computed streamflow available for diversion from the Red River at Arthur City into the OCR without causing increased shortages to existing downstream rights, and subject to the instream flow targets of the Red River Basin Interstate Compact.

TCEQ environmental flow standards have not been adopted in the Red River Basin and because the TCEQ Red River WAM includes only the Texas portion of streamflows potentially available for diversion from the Red River, Consensus Criteria for Environmental Flow Needs (CCEFN) instream flow requirements could not be accurately modeled to consider environmental flow needs. Review of historical streamflows recorded at the Red River at Arthur City gage (USGS 07335500) show daily historical streamflows are greater than the 750 cfs maximum diversion rate of the proposed intake more than 95 percent of the time during the WAM period of record, indicating the project will have limited impact on daily flows in the Red River at the proposed diversion site. Likewise, historical streamflow recorded at the Red River at Index gage (USGS 07337000) show daily historical streamflows are greater than the 750 cfs maximum diversion rate more than 99 percent of the time, indicating diversions would unlikely be limited to comply with the Red River Compact.

Results of the availability analysis indicate the project can produce an annual firm yield of 310,000 acft/yr.Figure 4.8-3 and Figure 4.8-4 provide time series and frequency plots of storage of the 32,000 acft OCR. For the yield analysis, the storage capacities of the two smaller OCR sedimentation basins were not considered. The storage frequency indicates that the 32,000 acft OCR would remain full almost 90 percent of the time. During the WAM simulation, the OCR storage is emptied in several months. However, since the delivery pump station capacity is sized with a 1.25 peaking factor, shortages during these months were overcome with the additional delivery capacity in the following months to keep the annual reliability at 100 percent.

Figure 4.8-5 presents the changes in the Red River at Arthur City monthly median streamflows caused by impoundments in the reservoir considering flows passed through for downstream senior water rights and environmental needs in accordance with TCEQ environmental flow requirements. Figure 4.8-6 compares the existing Red River at Arthur City streamflow frequency characteristics for the full period of the analysis with and without the project.

Figure 4.8-3. Red River Off-Channel Reservoir Firm Yield Storage Trace

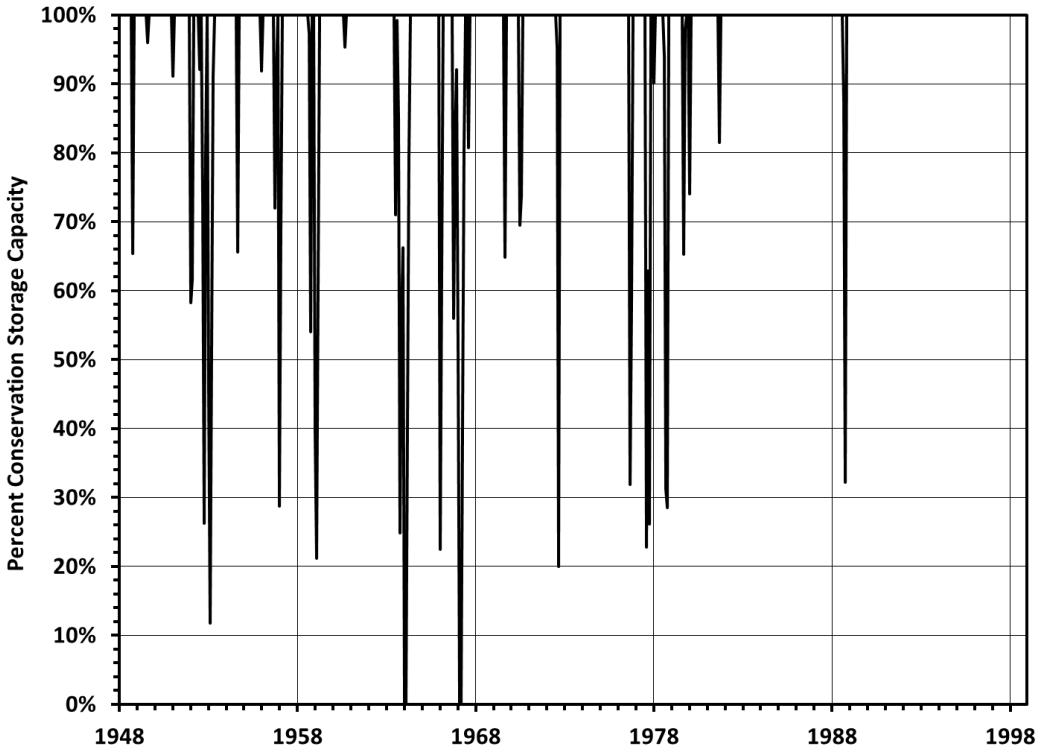


Figure 4.8-4. Red River Off-Channel Reservoir Firm Yield Storage Frequency

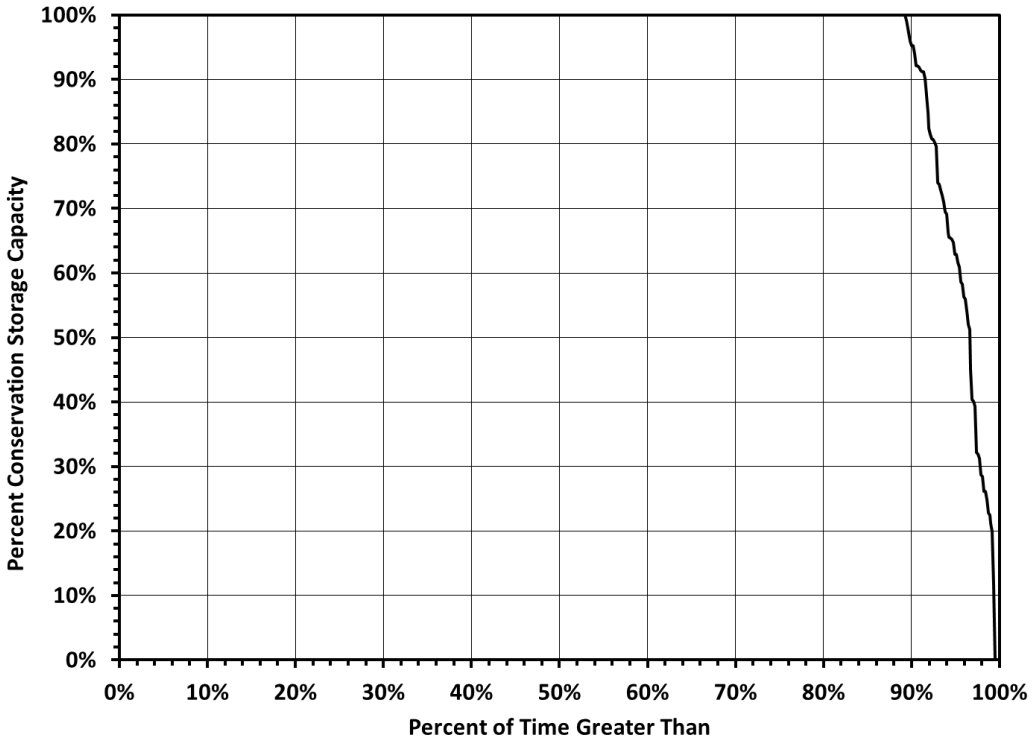


Figure 4.8-5. Red River at Arthur City Median Streamflow Comparison

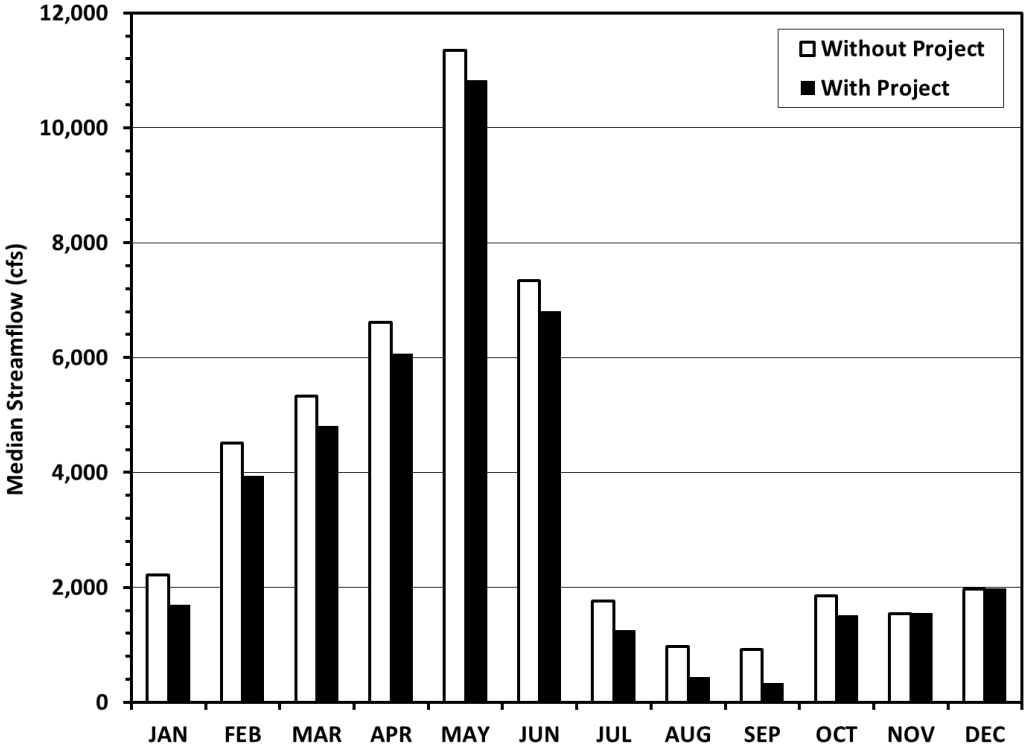
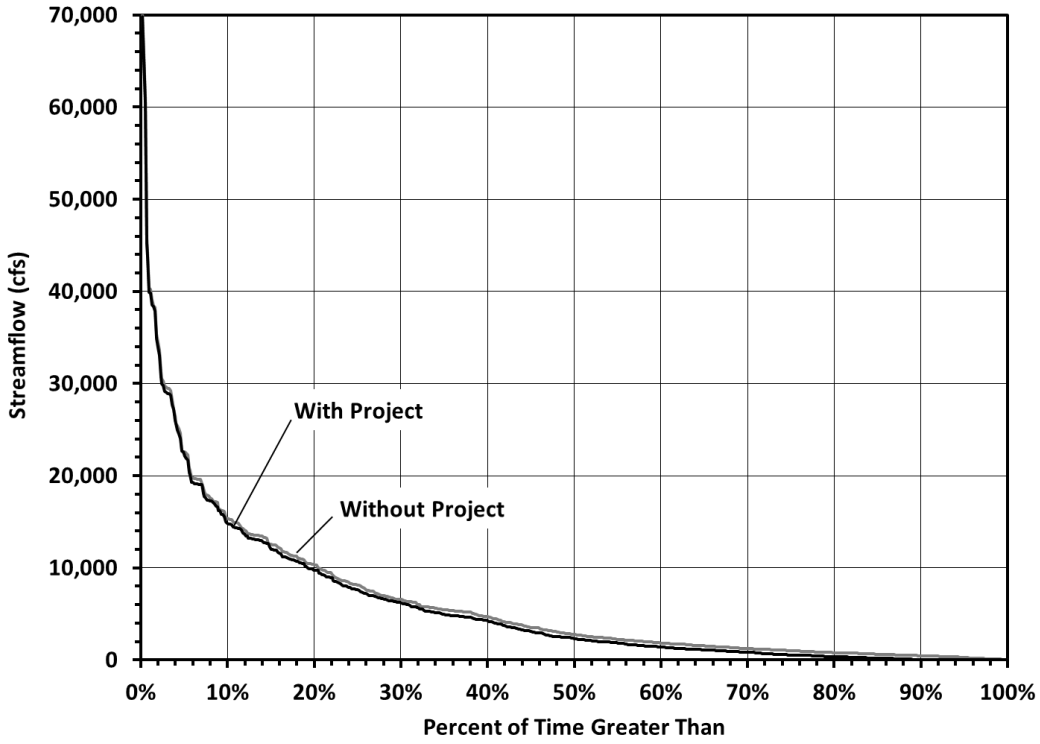


Figure 4.8-6. Red River at Arthur City Streamflow Frequency Comparison



Diversion from the Red River would also need to comply with all provisions included in the Red River Compact[1]. The diversion at Arthur City would be located in Reach II, Subbasin 5 of the Red River Compact. Under Section 5.05 of the Compact, the main stem of the Red River within Reach II (i.e. subbasin 5) is defined as "that portion of the Red River, together with its tributaries, from Denison Dam down to the Arkansas-Louisiana State boundary, excluding all tributaries included in the other four subbasins of Reach II."

Water availability analyses performed as part of the LRWSP estimate the amount of available flow in accordance with the Compact is about 2 million acft/yr less than the average annual available flow calculated in the TCEQ Red River WAM. The discrepancy in available flow is a result of the TCEQ Red River WAM including only a portion of the Red River Compact stipulations and not including inflows into the main stem of the Red River from Oklahoma tributaries or Oklahoma water rights and reservoirs. In addition, the TCEQ WAM and gaged flows used to estimate water availability in the LRWSP do not have similar periods of record. The gaged flows at the Arkansas-Louisiana boundary were only available after the WAM period of record and contain several drought periods including the drought of 2011 – 2015.

As a result of the analyses performed as part of the LRWSP, it is assumed that provision in the Compact will not significantly reduce the yield of project.

4.8.3 Environmental Issues

The following environmental section focuses on providing a high level summary of environmental issues consistent with other water management strategies evaluated as part of the 2021 Brazos G Plan.

Existing Environment

The proposed project occurs within the Post Oak Savannah, Blackland Prairie, and Crosstimbers physiographic regions of Texas and is within the Texan biotic province[2]. The project components are within areas defined as crops, Bluestem Grassland, Live Oak – Ashe Juniper Parks, Post Oak Parks/Woods, and Post Oak Woods/Forest vegetation types[3]. Crops include cultivated cover or row crops providing food or fiber and also may include grassland associated with crop rotations. Ecological Mapping Systems of Texas (EMST) data, more detailed vegetation data recently produced by the Texas Parks and Wildlife Department (TPWD)[4], show the area containing barren land and disturbed/tame grasslands.

[1] http://www.statutes.legis.state.tx.us/Docs/WA/htm/WA.46.htm
[2] Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950.

[3] McMahan, C.A., R.G. Frye, and K.L. Brown, 1984. The Vegetation Types of Texas. Accessed online https://tpwd.texas.gov/publications/pwdpubs/pwd_bn_w7000_0120/ March 22, 2019.
[4] TPWD, Ecological Mapping Systems of Texas, High Plains. Accessible to download online https://tpwd.texas.gov/gis/programs/landscape-ecology/by-ecoregion-vector

Potential Impacts

Aquatic Environments including Bays & Estuaries

The proposed pipeline spans seven counties and crosses areas of 100-year floodplain (Zones A and AE) associated with several rivers and streams. The National Wetland Inventory (NWI) maps were reviewed and the proposed pipeline has the potential to cross numerous creeks, streams, and wetland areas. Impacts to waters of the U.S. should be minimized to the extent practical during project design. Impacts to waters of the U.S. would need to be permitted through the U.S. Army Corps of Engineers. Several surface waters were identified on the TCEQ Surface Water Quality Viewer within the proposed project area, or within 5 miles. According to the draft 2020 Texas Integrated Report – Texas 303(d) List[1], the following surface water segments located within five miles of the proposed project pipelines were fully supporting of their uses and were not impaired: Little Elm Creek (0823A), Sister Grove Creek (0821B), North Sulpher River (0305), Rowdy Creek (0305A), Auds Creek (0305B), Six Mile Creek (0202P), Pine Creek (0202D), Red River below Lake Texoma (0202), Elm Fork Trinity River below Ray Roberts Lake (0839), Denton Creek (0826A), and Big Sandy Creek (0810A). The following stream segments were listed as impaired for bacteria in water (recreational use) [2]: East Fork Trinity River (0821D), Choctaw Creek (0202F), Clear Creek (0823C), Martin Branch (0810C), West Fork Trinity River below Bridgeport Reservoir (0810), Beans Creek (0811B), Upper South Sulpher River (0306) (this segment was also impaired for pH), Bois D'Arc Creek (0202A), Honey Grove Creek (0202L), Smith Creek (0202G), and Hicks Creek (0202N).

Threatened & Endangered Species

The Texas Parks and Wildlife Department (TPWD) maintains a list of Rare, Threatened, and Endangered Species of Texas by County. This list includes the federal and state listing status and a habitat description for each species which may be a resident or migrant through the county. TPWD regularly updates the listing status, range data, and habitat descriptions on their published county lists, based on the most recently available data. The current list of rare, threatened and endangered species for Palo Pinto, Jack, Wise, Denton, Grayson, Fannin, and Lamar counties can be found at https://tpwd.texas.gov/gis/rtest/.

According to the Information for Planning and Consultation (IPaC) website[5] maintained by the U.S. Fish & Wildlife Service (USFWS), the golden-cheeked warbler, least tern, whooping crane, sharpnose shiner, smalleye shiner, Texas fawnsfoot, American burying beetle, and *Geocarpon minimum* need to be considered for the proposed project. The

[1] TCEQ, 2020. Draft 2020 Texas Integrated Report – Texas 303(d) List (Category 5). Accessed online https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/20txir/2020_303d.pdf February 5, 2020.

[2] TCEQ, 2020. Draft 2020 Texas Integrated Report – Texas 303(d) List (Category 5). Accessed online https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/20txir/2020_303d.pdf February 5, 2020.

[5] USFWS, 2020. Information for Planning and Consultation. Accessed online https://ecos.fws.gov/ipac/location/2CDHNRFRWZBEFN2BCFV527IIXM/resources February 5, 2020.

piping plover and red knot were also mentioned, but only need to be considered for wind energy projects. There are no critical habitats in the project area.

Texas Natural Diversity Data (TXNDD) from the TPWD was revealed 87 documented occurrences (including several reported occurrences of the golden-cheeked warbler, Brazos watersnake, colonial wading bird colony, chub shiner, silver chub, blackspot shiner, orangebelly darter, eastern spotted skunk, timber rattlesnake, southern crawfish frog, bald eagle, American burying beetle, Ouachita rock pocketbook, Hall's prairie clover, vertisol blackland prairie, mollisol blackland prairie, Gammagrass – Switchgrass tallgrass prairie, little bluestem – indiangrass series, *Silveanus* Dropseed series, sShortleaf pine-oak series, Texas oak series and *Schizachyrium scoparium – Bouteloua curtipendula – Nassella leucotricha* herbaceous vegetation) of threatened, endangered, or rare species or natural communities within five miles of the limited review area. No other documented occurrences of threatened, endangered or rare species or natural communities were reported within five miles of the project area.

Cultural Resources

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (P196-515), and the Archeological and Historic Preservation Act (PL93-291). The City, as the owner or controller of the project, would be required to comply with the Antiquities Code. Based on the review of publically-available Geographic Information System (GIS) datasets from the Texas Historical Commission, many cemeteries were in proximity to the proposed pipeline routes (within a one-mile buffer). In Jack County, the cemeteries include: Joplin Fairview, Fairview, Barton Chapel, Wood, and Halsell Ranch cemeteries. In Wise County, the cemeteries included: Oaklawn, Eternal Oaks, Hyde, Sweetwater, and Allison Family cemeteries. In Denton County the cemeteries included: unknown (Plainview, McGill, Blue Mound, unknown (Gribble Springs), unknown (Green Valley), Wilson-Black Jack, Belew, Skinner, Pilot Point Community, St. Thomas, Pilot Point Memorial, and Craven cemeteries. In Fannin County cemeteries within one-mile of the proposed pipeline routes included: Providence Cemetery, Oak Hill #1, Pig Branch, Carlisle-Wolfe, Smyrna, Cedar Hill, Oakwood, Onstott-Stewart, White Rock, McCraws, and Allen cemeteries. In Lamar County the cemeteries within one mile of the proposed pipeline routes included: Pleasant Hill, unknown (Hopewell), Jackson and Restlawn cemeteries. In Grayson County, cemeteries within one mile of the proposed pipeline routes included Bethel Baptist and White Mound cemeteries.

The Thomas and Katherine Trout House (Fannin County), Pilot Point Downtown Historic District (Denton), Texas Tourist Camp (Wise County), Wassover Mansion (Wise County), and Wise County Courthouse were listed on the National Register of Historic Places and were within one-mile of the proposed pipeline routes. No historical markers or State Historic Sites were located within a one-mile buffer of the proposed project area. A review of archeological resources in the proposed project area should be conducted during project planning and be in compliance with the Texas Antiquities Code, if required.

4.8.4 Engineering and Costing

The Red River OCR Project requires a 750 cfs river intake and pumping facility to be constructed on the Red River and a 2 mile, 132-in transmission pipeline to deliver the supplies to three OCRs. A 535 cfs OCR intake facility and a 144-in, 100-mile transmission pipeline would need to be constructed to deliver supplies to Lake Ray Roberts. The cost estimate assumes a Brazos G sponsor would split costs of these facilities with Dallas based on annual supply amounts.

Delivery of the remaining supplies to Possum Kingdom Reservoir would require a 120-inch, 107-mile transmission pipeline. The delivery system is designed with a 1.25 peaking factor to allow for over pumping to compensate for delivery shortages during periods when diversions from the OCR are not available.

A summary of project and annual costs for the Red River OCR strategy with delivery to Possum Kingdom Reservoir is presented in Table 4.8-1. Annual costs include estimates for periodic dredging of the sedimentation basins and chemical addition for zebra mussel control. The costs presented in Table 4.8-1 do not include delivery or treatment of the supplies from Possum Kingdom Reservoir to water users in Brazos G.

Table 4.8-1. Cost Estimate Summary for Red River Off-Channel Reservoir

Item	Estimated Cost for Facilities
CAPITAL COST	
Off-Channel Storage Reservoir (32,000 acft, 800 acres; BRA Portion)	$104,523,000
Red River Intake and Pump Station (485 MGD; BRA Portion)	$49,750,000
Transmission Pipeline from Red River to Off-Channel Reservoir (132-in dia., 2 mile; Brazos G Portion)	$22,106,000
Off-Channel Reservoir Intake and Pump Stations to Lake Ray Roberts (346 MGD; BRA Portion)	$93,074,000
Transmission Pipeline from Off-Channel Reservoir to Lake Ray Roberts (144-in, 100-mile; BRA Portion)	$667,996,000
Pump Stations to Possum Kingdom Reservoir (219 MGD)	$146,607,000
Transmission Pipeline from Lake Ray Roberts to Possum Kingdom Reservoir (120-in dia., 107-mile)	$865,043,000
TOTAL COST OF FACILITIES	**$1,949,099,000**
OTHER PROJECT COSTS	
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$604,427,000
Environmental & Archaeology Studies and Mitigation	$10,372,000
Land Acquisition and Surveying (3,286 acres)	$14,359,000
Interest During Construction (4% for 2 years with a 1% ROI)	$212,707,000
TOTAL COST OF PROJECT	**$2,790,964,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$185,935,000
Reservoir Debt Service (5.5 percent, 40 years)	$6,948,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$15,551,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$7,236,000
Dam and Reservoir (1.5% of Cost of Facilities)	$1,419,000
Zebra Mussel Treatment	$5,952,000
Pumping Energy Costs (0.08 $/kW-hr)	$48,241,000
Sediment Dredging	$1,419,000
TOTAL ANNUAL COST	**$272,701,000**
Available Project Yield (acft/yr)	**196,000**
Annual Cost of Water ($ per acft), based on PF=1.25	**$1,391**
Annual Cost of Water After Debt Service ($ per acft), based on PF=1.25	**$407**
Annual Cost of Water ($ per 1,000 gallons), based on PF=1.25	**$4.27**
Annual Cost of Water After Debt Service ($ per 1,000 gallons), based on PF=1.25	**$1.25**

4.8.5 Implementation Issues

Several key issues would need to be overcome to make the project feasible. These issues include bank stability for the intake structure along the Red River, water quality and sediment control, invasive species, and regulatory and permitting issues considering the Red River Compact.

This water supply option has been compared to the plan development criteria, as shown in Table 4.8-2, and the option meets each criterion.

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality Water Right and Storage permit;
- Texas Commission on Environmental Quality Interbasin Transfer permit;
- U.S. Army Corps of Engineers Permit will be required for discharges of dredge or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act) (pending at the USACE-SWF);
- Texas Commission on Environmental Quality administered Texas Pollutant Discharge Elimination System Storm Water Pollution Prevention Plan;
- Texas General Land Office Easement if State-owned land or water is involved;
- Texas Parks and Wildlife Department Sand, Shell, Gravel and Marl permit if state-owned streambed is involved; and
- Compliance with the Red River Compact.

State and Federal Permits may require the following studies and plans:

- Environmental impact or assessment studies;
- Wildlife habitat mitigation plan that may require acquisition and management of additional land;
- Flow releases downstream to maintain aquatic ecosystems;
- Assessment of impacts on Federal- and State-listed endangered and threatened species;
- Aquatic Resource Relocation Plan (ARRP) and a relocation permit may be required from TPWD if a dewatering event is required during construction; and
- Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resource recovery and cataloging; requires coordination with the Texas Historical Commission.

Land Acquisition Issues:

- Land acquired for reservoir and/or mitigation plans could include market transactions or other local landowner agreements;
- Additional acquisition of rights-of-way and/or easements may be required; and
- Relocations or removal of residences, utilities, roads, or other structures.

Table 4.8-2. Comparison of Red River Off-Channel Reservoir to Plan Development Criteria

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet needs
2. Reliability	2. High reliability
3. Cost	3. High
B. Environmental factors	
1. Environmental Water Needs	1. Moderate impact
2. Habitat	2. Moderate impact
3. Cultural Resources	3. Moderate impact based on surveys of site
4. Bays and Estuaries	4. Low impact due to distance from coast
5. Threatened and Endangered Species	5. Possible moderate 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	Potential impact on bottomland farms and habitat in reservoir area
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	Yes
G. Third Party Social and Economic Impacts from Voluntary Redistribution	None

4.9 South Bend Reservoir

4.9.1 Description of Option

The South Bend Reservoir is a proposed reservoir with the dam located in Young County immediately downstream from the confluence of the main stem Brazos River and the Clear Fork of the Brazos River, as shown in Figure 4.9-1. The reservoir would capture flow from both streams, with an estimated capacity of up to 771,604 acft from the 13,168 square mile drainage area. The dam would be an earthfill embankment that would extend approximately 2.8 miles across the Brazos River at an elevation of 1,090 ft-msl and inundate 29,877 surface acres.

There are some water-short entities in the area that could benefit from the construction of the reservoir but supplies from the reservoir would provide the greatest benefit as part of the BRA System.

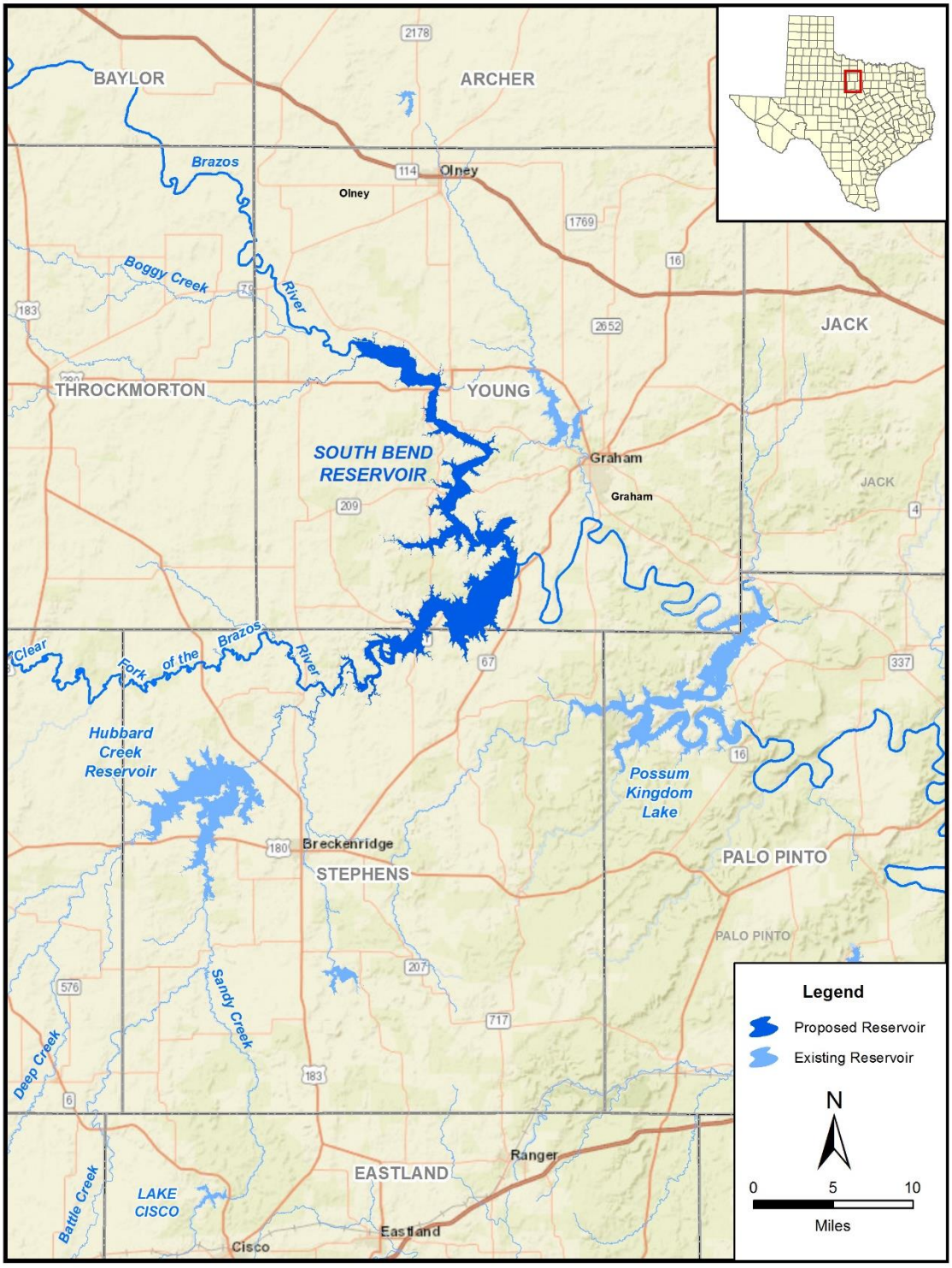
4.9.2 Available Yield

Water potentially available for impoundment in the proposed South Bend Reservoir was estimated using the TCEQ Brazos WAM Run 3. The TCEQ WAM assumes no return flows and permitted storages and diversions for all water rights in the basin. The model utilized a January 1940 through December 1997 hydrologic period of record and computed the streamflow available from the Brazos River for impoundment in the South Bend Reservoir without causing increased shortages to downstream rights. Firm yield was computed subject to the reservoir and Brazos River depletions having to pass inflows to meet environmental flow standards associated with Senate Bill 3 (SB3).

Since the South Bend Reservoir is of a significant size and geographically close to Possum Kingdom Reservoir, it was analyzed both as a stand-alone reservoir and acting as part of the BRA system. The stand-alone firm yield of South Bend Reservoir is calculated to be only 14,800 acft/yr as a result of the BRA System Operations permit appropriating most of the remaining available streamflow upstream of Possum Kingdom Reservoir. If South Bend Reservoir is operated as part of the BRA System, preliminary analyses indicate that the reservoir could increase the system yield by up to 65,000 acft/yr. Because the stand-alone operations would result in a yield that is insufficient to make the project feasible, results presented in the remainder of this section are for the BRA System yield scenario of South Bend Reservoir.

When the reservoir is operated as part of the BRA System, streamflows are impounded during wet periods when unappropriated streamflow are available and held in reserve until being released during drought periods when downstream contract holders begin to experience supply shortages. Figure 4.9-2 shows the annual releases from South Bend Reservoir. Figure 4.9-3 illustrates simulated South Bend Reservoir storage levels for the 1940 to 1997 historical period and Figure 4.9-4 shows the storage frequency. The figures show that the reservoir releases all available storage during the 1950s drought to help meet downstream needs of the BRA system.

Figure 4.9-1. South Bend Reservoir Location



Document Path: \\dalctxsrv01\Texas_GIS_Projects\10029705_036_Brazos_G_2021_Plan\Map_Docs\MXDs\Reservoir_Strategy\South_Bend_Reservoir.mxd

Figure 4.9-2. South Bend Reservoir Releases as Part of BRA System Operations

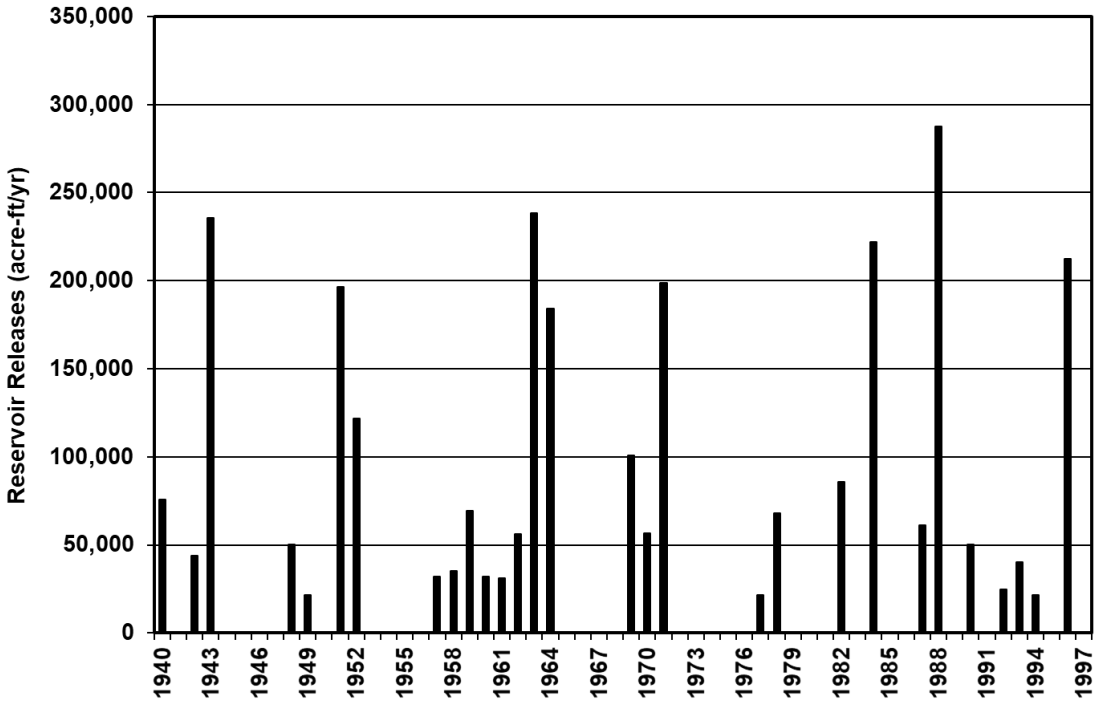


Figure 4.9-3. South Bend Reservoir System Operations Storage Trace

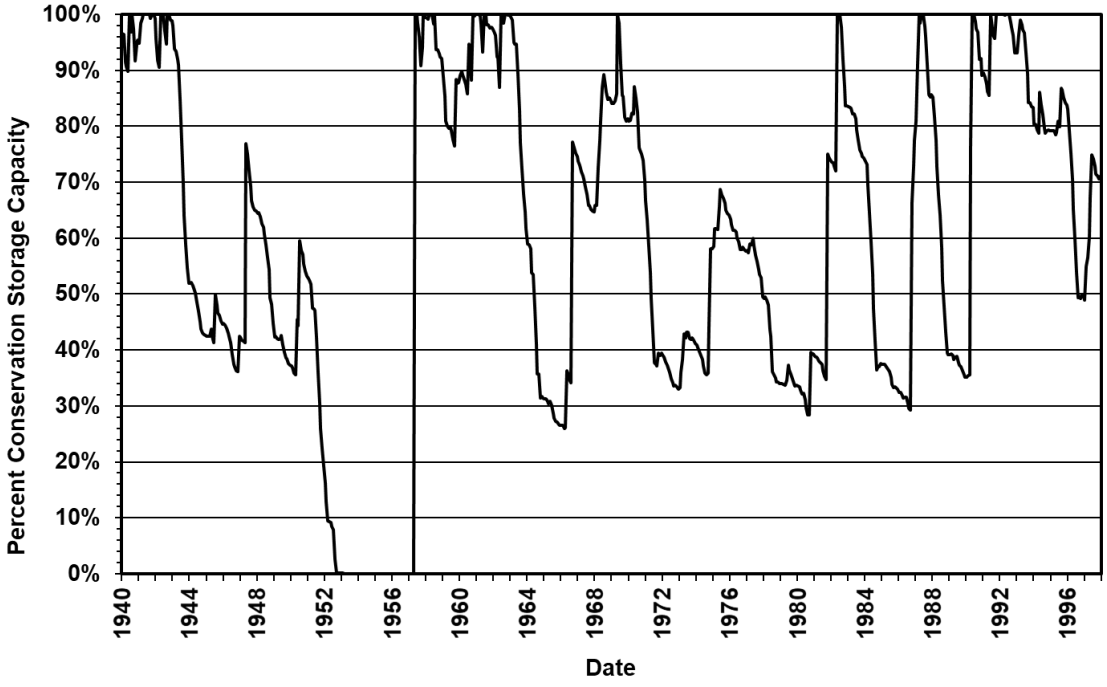


Figure 4.9-4. South Bend Reservoir Storage Frequency at Firm Yield

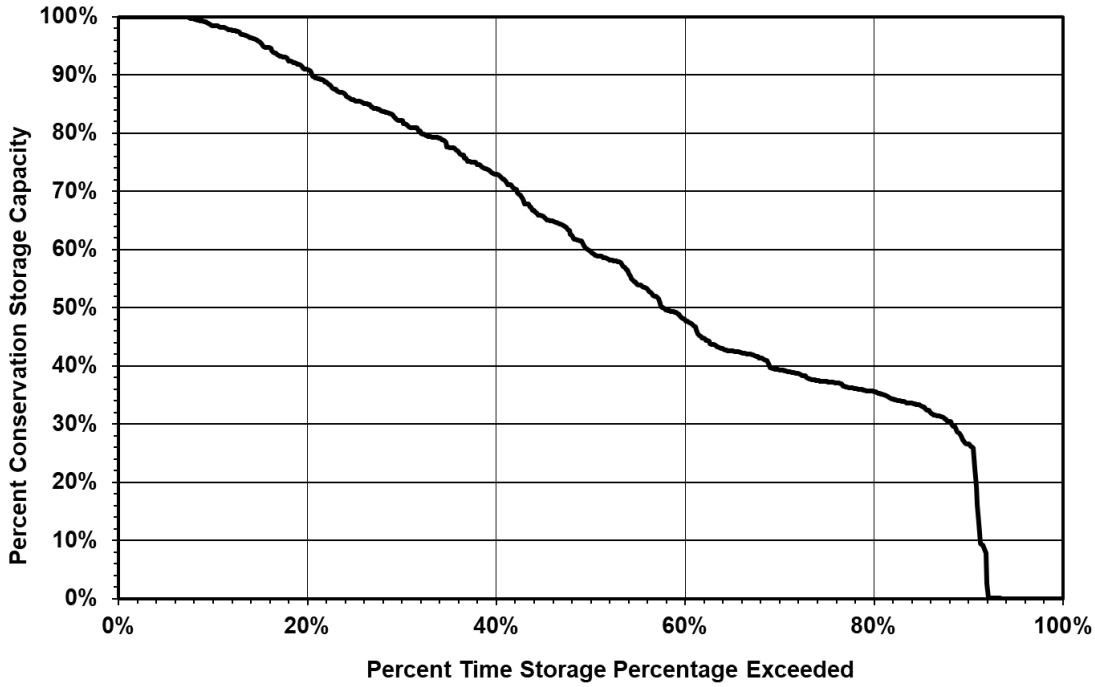


Figure 4.9-5 illustrates the changes in Brazos River median streamflows at the South Bend Reservoir Dam resulting from the project and Figure 4.9-6 compares the streamflow frequency with and without the project. The greatest reduction in flow would occur in the spring and summer months of May and June. The largest decline occurs in June, where the median streamflow is reduced by 33 cfs. During the months outside of April-Jun, the reservoir is typically not able to impound flows in excess of those required for downstream senior water rights and environmental needs and releases of stored water from the reservoir increase flows in many months. Comparison of the frequency of streamflow demonstrates how the reservoir reduces streamflow through impoundments during higher flow periods (flows typically greater than 7,500 cfs) and increases streamflow through reservoir releases during drought periods.

Figure 4.9-5. Monthly Median Streamflow at Proposed South Bend Reservoir Dam

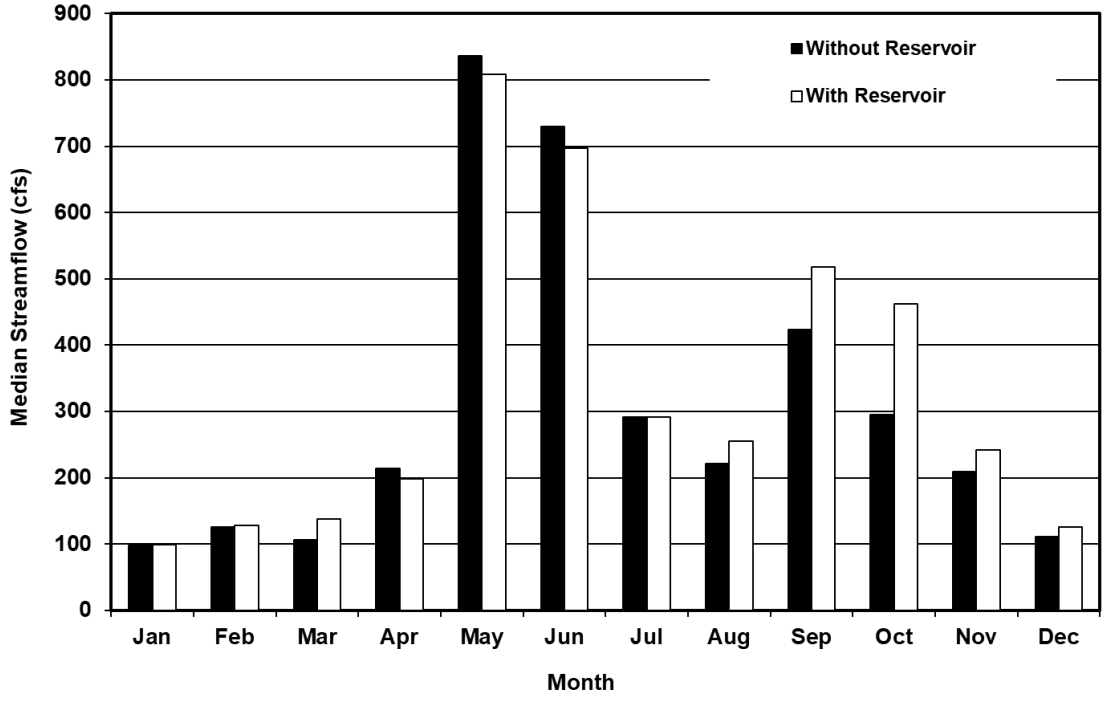
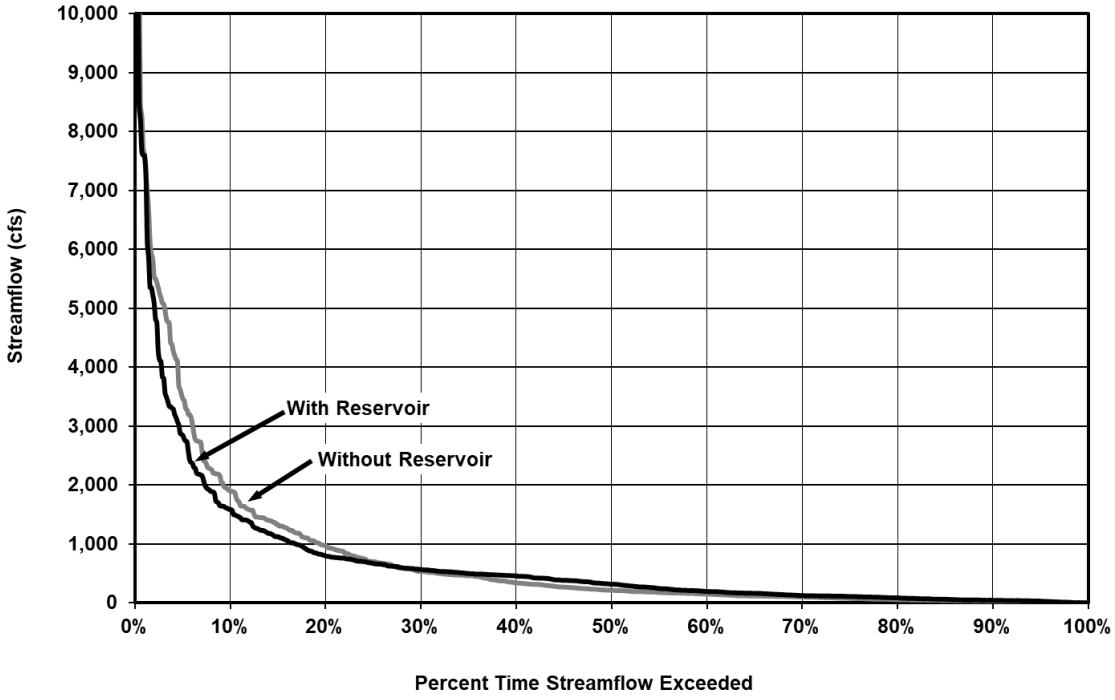


Figure 4.9-6. Streamflow Frequency at Proposed South Bend Reservoir Dam



4.9.3 Environmental Issues

Existing Environment

The South Bend Reservoir site in Stephens and Young counties is within the Cross Timbers and Prairies Ecological Region, a complex transitional area of prairie dissected by two parallel timbered strips extending from north to south.[1] This region is located in north-central Texas west of the Blackland Prairies, east of the Rolling Plains, and north of the Edwards Plateau and Llano Uplift. The physiognomy of the region is oak and juniper woods and mixed grass prairie. Much of the native vegetation has been displaced by agriculture and development, and range management techniques—including fire suppression—have contributed to the spread of invasive woody species and grasses. Farming and grazing practices have also reduced the abundance and diversity of wildlife in the region.[2] The climate is characterized as subtropical subhumid, with hot summers and dry winters. Average annual precipitation ranges between 26 and 32 inches.[3] The project area lies between the Seymour and Trinity major aquifers, but is underlain by no major or minor aquifers.[4]

The region lies within the North-Central Plains physiographic region which includes elevations between 900 and 3,000 feet above sea level. Bedrock includes limestones, sandstones, and shales. Where shale bedrock prevails, meandering rivers traverse stretches of local prairie. In areas of harder bedrock, hills and rolling plains dominated. Local areas of hard sandstones and limestones cap steep slopes severly dissected near rivers. [5] The predominant soil associations in the project area are the Shatruce-Exray-Loving, Lincoln-Westola-Padgett, and Clearfork-Wheatwood associations in Young County[6] and the Clearfork-Clairemont and Bastrop-Minwells, associations in Stephens County[7]. The Shatruce-Exray-Loving association ranges from very shallow to moderately deep soils on ridges. These soils, primarily support rangeland, typically have a surface of fine, sandy loam underlain by clay, clay loam, and sandstone. The Lincoln-Westola-Padgett association consists of very deep loamy and clayey soils formed in alluvial sediments on the Brazos River flood plain. Soils in this map unit are generally used as

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[1] Gould, F.W., G.O. Hoffman, and C.A. Rechenthin, Vegetational Areas of Texas, Texas A&M University, Texas Agriculture Experiment Station Leaflet No. 492, 1960.

[2] Telfair, R.C., "Texas Wildlife Resources and Land Uses," University of Texas Press, Austin, Texas, 1999.

[3] Larkin, T.J., and G.W. Bomar, "Climatic Atlas of Texas," Texas Department of Water Resources, Austin, Texas, 1983.

[4] Texas Water Development Board (TWDB), *Aquifers*, http://www.twdb.texas.gov/groundwater/aquifer/index.asp accessed December 1, 2014.

[5] Wermund, E.G., Physiographic Map of Texas, Bureau of Economic Geology, University of Texas, Austin, Texas, 1996. Accessed online at http://www.beg.utexas.edu/UTopia/images/pagesizemaps/physiography.pdf on November 25, 2014.

[6] NRCS, 2009. Soil Survey of Young County, Texas. Accessed online http://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/texas/TX503/0/Young.pdf December 2, 2014.

[7] NRCS, 1994. Soil Survey of Stephens County, Texas. Accessed online http://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/texas/TX429/0/stephens_texas.pdf December 2, 2014.

pasture, rangeland or cropland. The Clearfork-Wheatwood soil association very deep loamy soils formed in alluvium on the Clearfork of the Brazos River flood plain. These soils are typically used as cropland and pasture. The Clearfork-Clairemont association consists of very deep, nearly level and very gently sloping, loamy soils underlain by clayey and loamy alluvial sediments, on flood plains. The Bastrop-Minwells association consists of very deep, nearly level and very gently sloping, loamy soils underlain by loamy and gravelly alluvial sediments, on stream terraces.

Four major vegetation types occur within the general vicinity of the proposed project: Mesquite (*Prosopis glandulosa*)-Lotebush (*Ziziphus obtusifolia*) Shrub (and Mesquite brush), Post Oak (*Quercus stellata*) Parks/Woods, Live Oak (*Q. virginiana*)-Mesquite-Ashe Juniper (*Juniperus ashei*) Parks, and crops.[8] Variations of these primary types may occur based on changes in the composition of woody and herbaceous species and the physiognomy of localized conditions and specific range sites.

Mesquite-Lotebush Brush/Shrub could include the following commonly associated plants: yucca (*Yucca* spp.), skunkbush sumac (*Rhus trilobata*), agarito (*Berberis trifoliolata*), elbowbush (*Forestiera pubescens*), juniper, tasajillo (*Opuntia leptocaulis*), cane bluestem (*Bothriochloa barbinodis*), silver bluestem (*Bothriochloa saccharoides*), little bluestem (*Schizachyrium scoparium*), sand dropseed (*Sporobolus cryptandrus*), Texas grama (*Bouteloua rigidiseta*), sideoats grama (*Bouteloua curtipendula*), hairy grama (*Bouteloua hirsuta*), red grama (*Bouteloua trifida*), tobosagrass (*Pleuraphis mutica*), buffalograss (*Buchloe dactyloides*), Texas wintergrass (*Nasella leucotricha*), purple three-awn (*Aristida purpurea*), Engelmann daisy (*Engellmania pinnatifida*), broom snakeweed (*Gutierrezia sarothrae*), and bitterweed (*Hymenoxys odorata*).

Commonly associated plants of Post Oak Parks/Woods are blackjack oak (*Q. marilandica*), eastern redcedar (*J. virginiana*), mesquite, black hickory (*Carya texana*), live oak, sandjack oak (*Q. incana*), cedar elm (*Ulmus crassifolia*), hackberry (*Celtis* spp.), yaupon (*Ilex vomitoria*), poison oak (*Toxicodendron pubescens*), American beautyberry (*Callicarpa americana*), hawthorn (*Crataegus* spp.), supplejack (*Berchemia scandens*), trumpet creeper (*Campsis radicans*), dewberry (*Rubus* sp.), coralberry (*Symphoricarpos orbiculatus*), little bluestem, silver bluestem, sand lovegrass (*Eragrostis trichodes*), beaked panicum (*Panicum anceps*), three-awn (*Aristida* spp.), sprangle-grass (*Chasmanthium sessiliflorum*), and tickclover (*Desmodium* spp.).

Commonly associated plants of Live Oak-Mesquite-Ashe Juniper, found chiefly on level to gently rolling uplands and ridge tops of the Edwards Plateau, are Texas oak, shin oak (*Q. havardii*), cedar elm, netleaf hackberry (*Celtis laevigata*), flameleaf sumac (*Rhus lanceolata*), agarito, Mexican persimmon (*Diospyros texana*), Texas pricklypear (*Opuntia engelmannii*), kidneywood (*Eysenhardtia texana*), saw greenbrier (*Smilax bona-nox*), Texas wintergrass, little bluestem, curly mesquite (*Hilaria belangeri*), Texas grama, Hall's panicgrass (*Panicum hallii*), purple three-awn, hairy tridens (*Erioneuron pilusum*), cedar sedge (Carex *planostachys*), two-leaved senna (*Senna roemeriana*), mat euporbia (*Chamaesyce serpens*), and rabbit tobacco (*Evax prolifera*).

[8] McMahan, C.A., R.F. Frye, and K.L. Brown, "The Vegetation Types of Texas," Texas Parks and Wildlife Department, Wildlife Division, Austin, Texas, 1984.

Crops consist of cultivated cover crops or row crops providing food and/or fiber for either man or domestic animals. This vegetation type may also portray grassland associated with crop rotations.

Potential Impacts

Aquatic Environments including Bays & Estuaries

The anticipated impact of this project would be minimal influence on the variability of monthly flows but substantial reductions in quantity of median monthly flows at the project site. The minimal reduction in variability of monthly flow values would probably not have much impact on the instream biological community or riparian species. The decrease in monthly median flow values would range from 0 cfs (0 percent) in July to 33 cfs (5 percent) in June, as shown in Table 4.9-1. The highest reductions would occur in April and June. Despite relatively large differences in median flow values, this project would have no effect on the frequency of low-flow conditions; the 65 percent exceedance value would be approximately 115 cfs without the proposed reservoir in place and 129 cfs with the proposed reservoir. The reductions in flow that would occur with this project in place may have moderate impacts on the instream biological community since the highest reductions would occur in the summer when water temperatures are high.

Because this site is in the upper portion of the watershed, there would be a greater probability of impacts in the Brazos River than with a similar-sized project further downstream where flows are higher. However, additional downstream inflows would limit the extent of such impacts from this project. Alone, this project would not be expected to have a substantial influence on freshwater inflows to the Brazos River estuary, but the cumulative impact of multiple projects may reduce freshwater inflows to the estuary. As a new reservoir without a current operating permit, the South Bend Reservoir would likely be required to meet environmental flow requirements determined by site-specific studies.

Table 4.9-1. Median Monthly Streamflow at South Bend Reservoir Dam

Month	Without Project (cfs)	With Project (cfs)	Difference (cfs)	Percent Reduction
January	97.19	98.79	-1.61	-2%
February	125.33	127.62	-2.29	-2%
March	106.04	138.13	-32.09	-30%
April	213.73	198.22	15.51	7%
May	836.47	808.24	28.23	3%
June	729.90	696.75	33.15	5%
July	291.99	291.99	0.00	0%
August	221.41	255.19	-33.78	-15%
September	423.08	517.40	-94.32	-22%
October	294.78	461.57	-166.79	-57%
November	209.50	241.37	-31.87	-15%
December	111.60	125.80	-14.21	-13%

Threatened & Endangered Species

The Texas Parks and Wildlife Department (TPWD) maintains a list of Rare, Threatened, and Endangered Species of Texas by County. This list includes the federal and state listing status and a habitat description for each species which may be a resident or migrant through the county. TPWD regularly updates the listing status, range data, and habitat descriptions on their published county lists, based on the most recently available data. The current list of rare, threatened and endangered species for Stephens and Young counties can be found at https://tpwd.texas.gov/gis/rtest/.

A search of the Texas Natural Diversity Database [9] maintained by the Texas Parks and Wildlife Department (TPWD) revealed the documented occurrence of two colonial water bird rookeries within the vicinity of the proposed South Bend Reservoir (as noted on representative 7.5-minute quadrangle maps that include the project site). One rookery is located less than one mile north of the project site; the other is located within five miles east of the proposed reservoir site. These data are not a representative inventory of rare resources or sensitive sites. Although based on the best information available to TPWD, these data do not provide a definitive statement as to the presence, absence, or condition of special species, natural communities, or other significant features in the project area. On-site evaluations would be required by qualified biologists to confirm the occurrence of sensitive species or habitats.

Wildlife Habitat

Approximately 29,877 acres are estimated to be inundated by the reservoir. Based on TPWD's Ecological Mapping Systems of Texas data[10], the largest habitat components that would be affected include approximately 9,850 acres of mesquite shrubland, approximately 7,300 acres of floodplain hardwood forest, 3,500 acres of cropland, 1,850 acres of savanna grassland and 1,900 acres of post oak woodland. The remaining affected acreage is divided among a variety of vegetation types.

A number of vertebrate species would be expected to occur within the vicinity of the South Bend Reservoir site as indicated by county occurrence records.[11] These include 11 species of frogs and toads, seven species of turtles, 12 species of lizards and skinks, and 24 species of snakes. Additionally, 78 species of mammals could occur within the site or surrounding region[12] in addition to an undetermined number of bird species. A variety of fish species would be expected to inhabit streams and ponds within the site, but with distributions and population densities limited by the types and quality of habitats available.

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[9] Texas Parks and Wildlife Department (TPWD), Texas Natural Diversity Database, *Element of Occurrence Records*, 06/06/2019.

[10] TPWD, 2014. Ecological Mapping Systems of Texas – Great Plains and Cross Timbers Ecological Areas.

[11] Texas A&M University (TAMU), "County Records for Amphibians and Reptiles," http://wfscnet.tamu.edu/tcwc/Herps_online/CountyRecords.htm accessed September 2, 2009.

[12] Davis, W.B., and D.J. Schmidly, "The Mammals of Texas – Online Edition," Texas Tech University, http://www.nsrl.ttu.edu/tmot1/Default.htm, 1997.

Construction of the reservoir would inundate habitat identified as critical to the Smalleye Shiner and Sharpeye Shiner, and further fragment the upper Brazos River stream channel upstream of Possum Kingdom Reservoir.

Cultural Resources

A search of the Texas Historical Commission's online database for the 2011 Regional Water Plan indicated that one historical marker for Old Donnell Mill is located within the footprint for the proposed reservoir. At least two cemeteries, the Hill Cemetery and the Peveler Cemetery, are mapped within the proposed reservoir site.

A search of the Texas Archeological Sites Atlas database indicated that approximately 700 archeological sites have been documented within or in close proximity to the proposed reservoir. In 1987-88, Texas A&M University conducted a survey of South Bend Reservoir as it was then proposed, recording 673 archeological sites. The investigators recommended that 18 percent of the prehistoric sites and 21 percent of the historic sites warranted further testing to determine their eligibility for inclusion in the National Register of Historic Places or as State Archeological Landmarks. Prior to reservoir inundation, these sites must be reassessed relative to their eligibility for inclusion in the National Register of Historic Places or as State Archeological Landmarks. Additionally, the project must be coordinated with the Texas Historical Commission and a cultural resources survey must be conducted for any areas within the proposed reservoir that were not included in the previous survey to determine if cultural resources are present. Any cultural resources identified during survey will need to be assessed for eligibility for inclusion in the National Register of Historic Places or as State Archeological Landmarks. Cultural resources that occur on public lands or within the Area of Potential Effect of publicly funded or permitted projects are governed by the Texas Antiquities Code (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archeological and Historic Preservation Act (PL93-291).

Threats to Natural Resources

Threats to natural resources include lower streamflows, declining water quality, and reduced inflows to reservoirs. This project would contribute to seasonally lower streamflows downstream of the reservoir site and potentially affect water quality through decreased flows.

Agricultural Impacts

The South Bend Reservoir site contains approximately zero acres of Pasture/Hay fields and 3,034 acres of cropland. These two agricultural land uses account for roughly 10 percent of the reservoir footprint.

4.9.4 Engineering and Costing

The cost estimate summary for the South Bend Reservoir strategy is presented in Table 4.9-2. The total project costs are estimated to be $623,882,000. The cost for the estimated increase in system yield of 65,000 acft/yr, translates to an annual unit cost of raw water at the reservoir of $1.65 per 1,000 gallons, or $538 per acft. The annual

project costs are estimated to be $35.0 million; this includes annual debt service, and operation and maintenance costs.

Table 4.9-2. Cost Estimate Summary for South Bend Reservoir

Item	Estimated Costs for Facilities
Dam and Reservoir (Conservation Pool 771,604 acft, 29,877 acres)	$204,833,000
Integration, Relocations, & Other	$60,701,000
TOTAL COST OF FACILITIES	**$265,534,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$92,937,000
Environmental & Archaeology Studies and Mitigation	$107,438,000
Land Acquisition and Surveying (59,754 acres)	$110,425,000
Interest During Construction (3% for 3 years with a 0.5% ROI)	$47,548,000
TOTAL COST OF PROJECT	**$623,882,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$6,242,000
Reservoir Debt Service (3.5 percent, 40 years)	$25,061,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$607,000
Dam and Reservoir (1.5% of Cost of Facilities)	$3,072,000
TOTAL ANNUAL COST	**$34,982,000**
Available Project Yield (acft/yr)	65,000
Annual Cost of Water ($ per acft), based on a Peaking Factor of 1	$538
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$1.65

4.9.5 Implementation Issues

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality Water Right and Storage permits;
- U.S. Army Corps of Engineers Permits will be required for discharges of dredge or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act);
- Texas Commission on Environmental Quality administered Texas Pollutant Discharge Elimination System Storm Water Pollution Prevention Plan;

- General Land Office Easement if State-owned land or water is involved; and,
    - Texas Parks and Wildlife Department Sand, Shell, Gravel and Marl permit if state-owned streambed is involved.
    - Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resource recovery and cataloging; requires coordination with the Texas Historical Commission.

State and Federal Permits may require the following studies and plans:

- Environmental impact or assessment studies;
    - Wildlife habitat mitigation plan that may require acquisition and management of additional land;
    - Flow releases downstream to maintain aquatic ecosystems; and
    - Assessment of impacts on Federal- and State-listed endangered and threatened species.

Land Acquisition Issues:

- Land acquired for reservoir and/or mitigation plans could include market transactions and/or eminent domain;
- Additional acquisition of rights-of-way and/or easements may be required; and
- Possible relocations or removal of residences, utilities, roads, or other structures.

This water supply option has been compared to the plan development criteria, as shown in Table 4.9-3, and the option meets each criterion.

Table 4.9-3. Evaluations of South Bend Reservoir Option to Enhance Water Supplies

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet needs
2. Reliability	2. High reliability
3. Cost	3. Reasonable (moderate to high)
B. Environmental factors	
1. Environmental Water Needs	1. Negligible impact
2. Habitat	2. Negligible impact
3. Cultural Resources	3. Low impact
4. Bays and Estuaries	4. Negligible impact
5. Threatened and Endangered Species	5. Low impact
6. Wetlands	6. Negligible 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	• None
E. Equitable Comparison of Strategies Deemed Feasible	• Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	• Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	• None

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4.10 New Throckmorton Reservoir

4.10.1 Description of Option

A potential water management strategy for the City of Throckmorton is a new reservoir located approximately 3 miles northwest of the city as shown in Figure 4.10-1. The proposed reservoir will be located on the North Elm Creek and will contain approximately 15,900 acft of conservation storage and inundate 1,161 acres at the full conservation storage level of 1,345 ft-msl. The contributing drainage area is approximately 82 square miles.

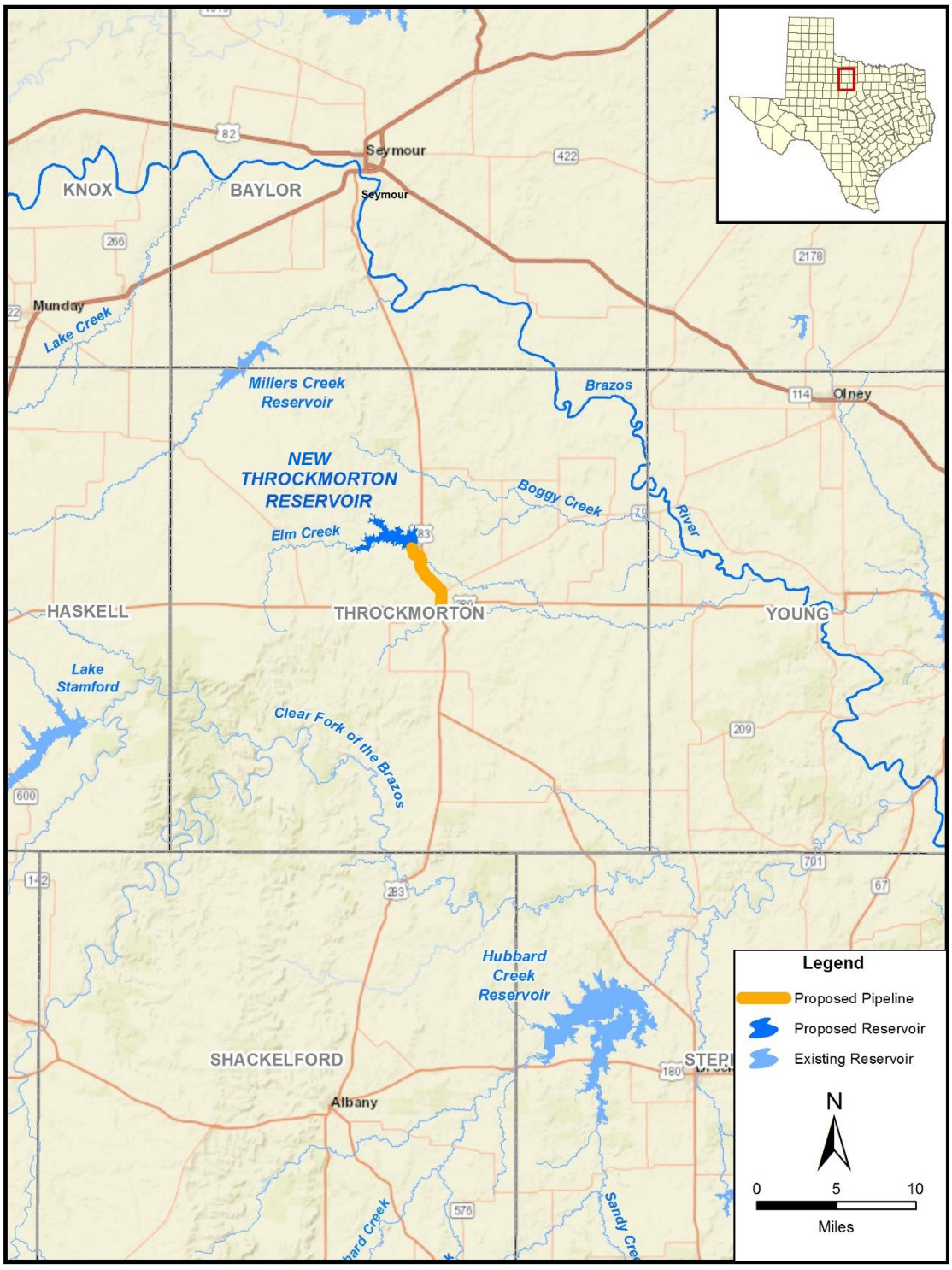
4.10.2 Available Yield

Water potentially available for impoundment in the proposed New Throckmorton Reservoir was estimated using the TCEQ Brazos WAM Run 3. The model includes a January 1940 through December 1997 hydrologic period of record and computes streamflow available from North Elm Creek without causing increased shortages to existing downstream rights. The safe yield of the project was computed subject to the reservoir and North Elm Creek diversion having to pass inflows to meet TCEQ environmental flow standards.

This strategy would require a subordination agreement with BRA for Possum Kingdom Reservoir. The calculated safe yield of New Throckmorton Reservoir is 3,500 acft/yr, assuming subordination of Possum Kingdom Reservoir. The estimated impact to the Possum Kingdom firm yield from the subordination is 2,390 acft/yr. Currently, BRA indicates that no subordination agreement is likely to be possible.

Figure 4.10-2 illustrates the simulated New Throckmorton Reservoir storage levels for the 1940 to 1997 historical period, subject to the safe yield of 3,500 acft/yr. Figure 4.10-3 shows that simulated reservoir contents remain above 80 percent capacity about 64 percent of the time and above 50 percent capacity above 96 percent of the time. Figure 4.10-4 illustrates the changes in North Elm Fork streamflows caused by impounding unappropriated water. Median streamflow would be reduced to zero in all months from implementation of the project. The largest changes would be declines in median streamflow of 24 cfs during May and 21.8 cfs during June. Figure 4.10-5 also illustrates the North Elm Creek streamflow frequency characteristics with New Throckmorton Reservoir in place.

Figure 4.10-1. New Throckmorton Reservoir



Document Path: \\dalctxsrv01\Texas_GIS_Projects\10029705_036_Brazos_G_2021_Plan\Map_Docs\MXDs\Reservoir_Strategy\Throckmorton_Reservoir.mxd

Figure 4.10-2. New Throckmorton Reservoir Firm Yield Storage Trace

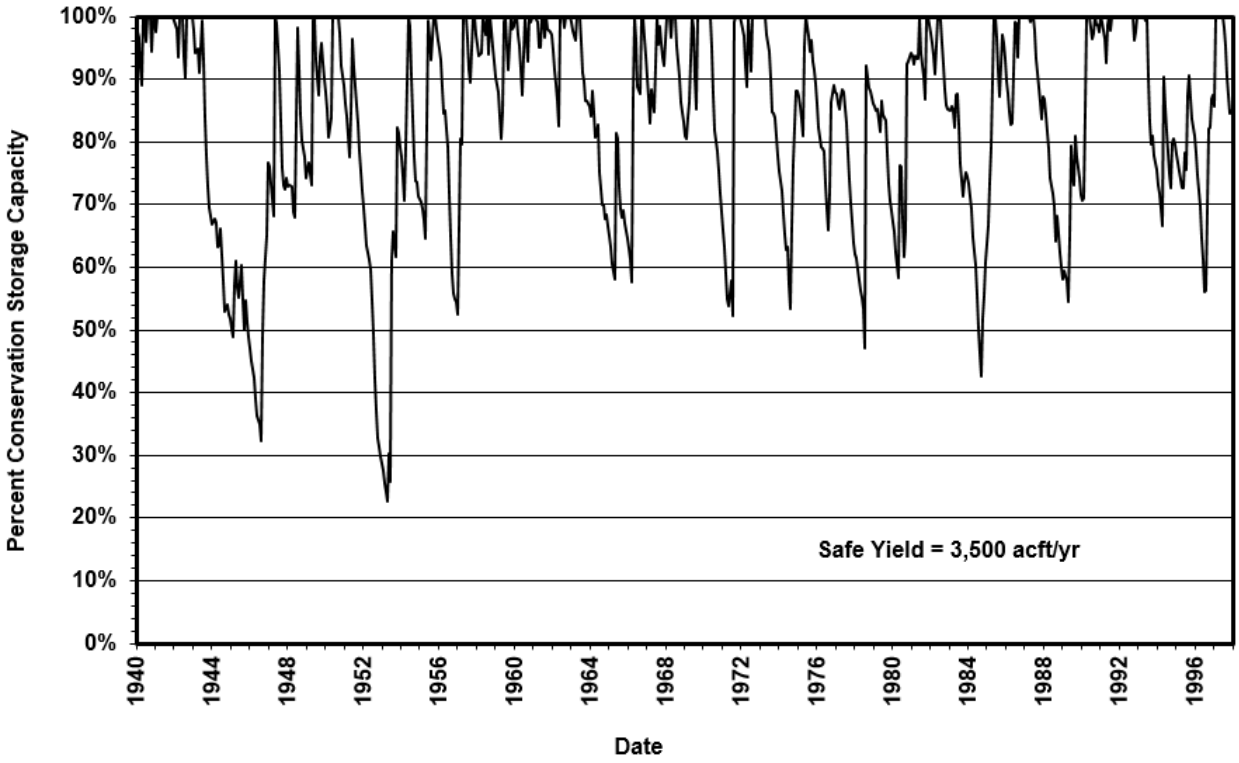


Figure 4.10-3. New Throckmorton Reservoir Storage Frequency at Safe Yield

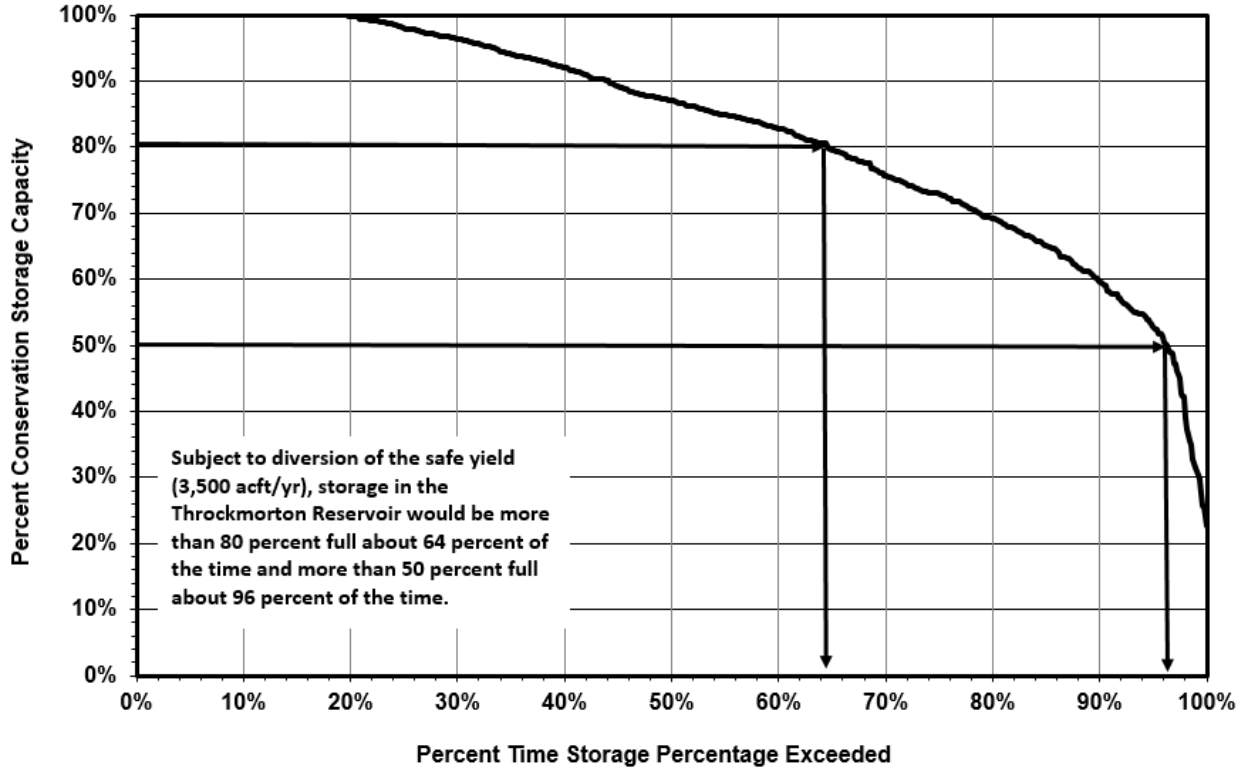


Figure 4.10-4. North Elm Fork Diversion - Median Streamflow Comparison

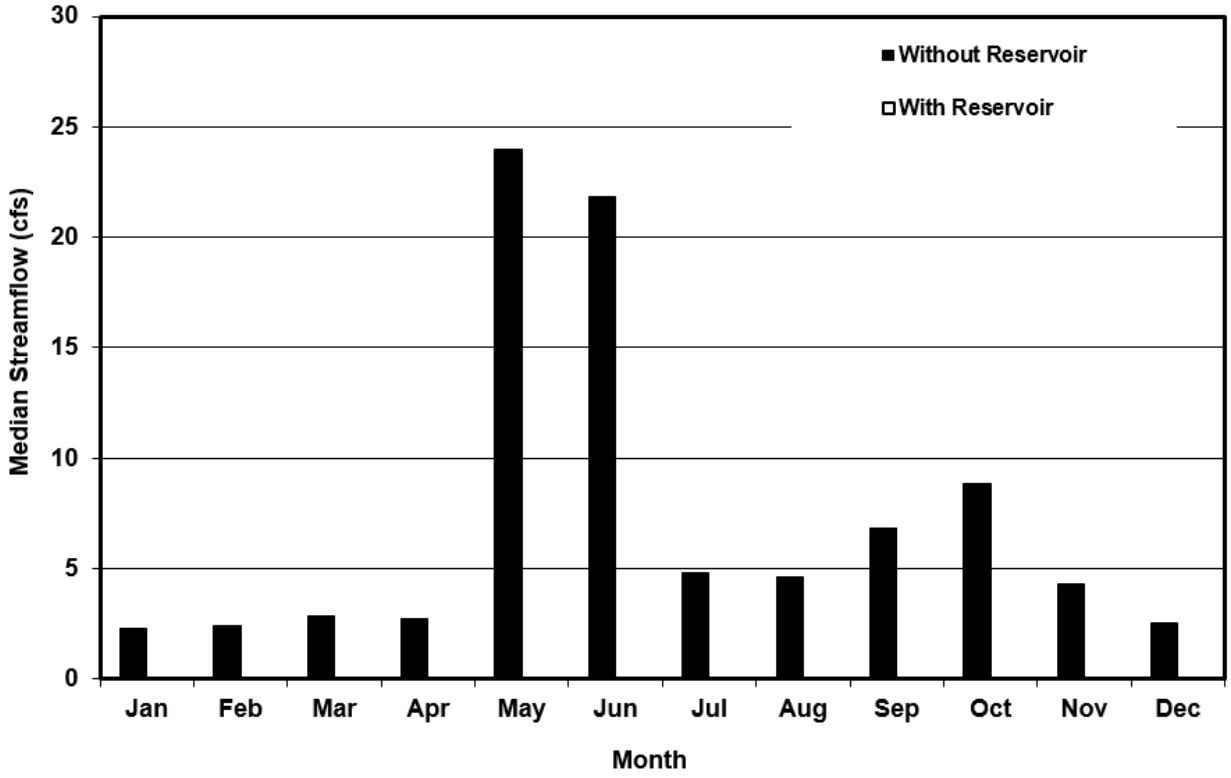
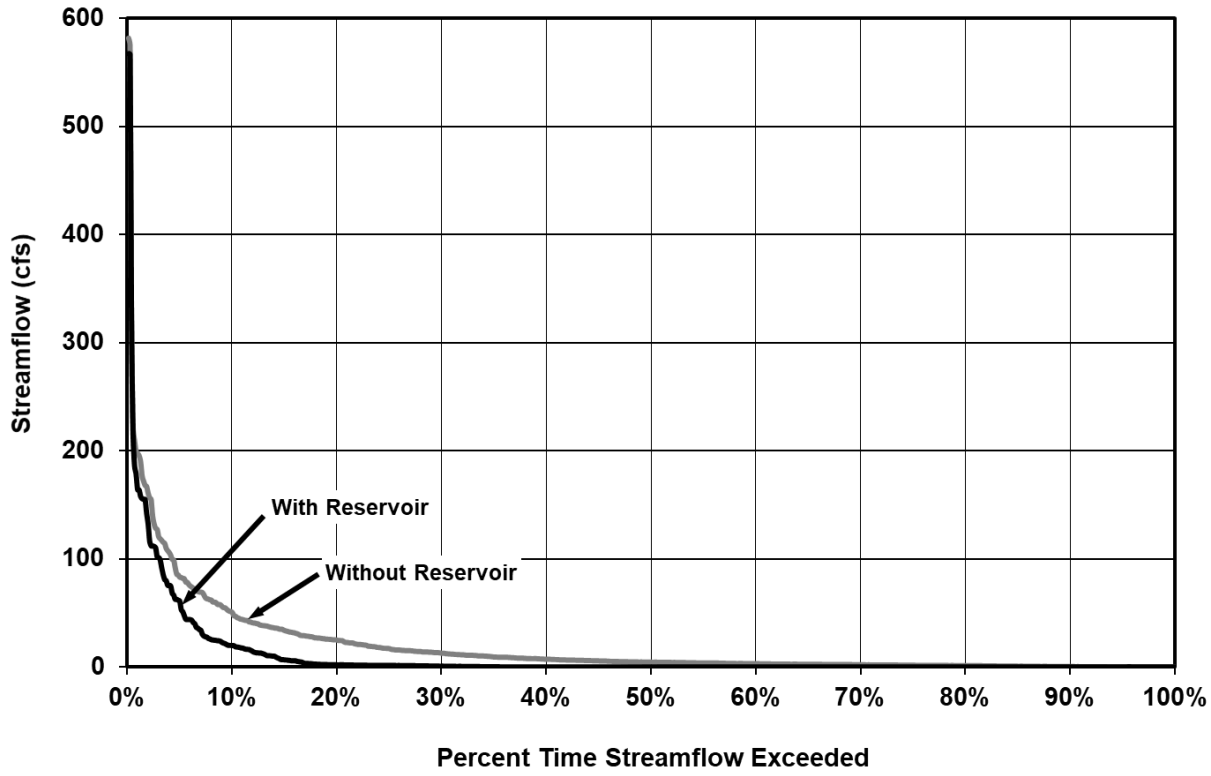


Figure 4.10-5. North Elm Fork Diversion- Streamflow Frequency Comparison



4.10.3 Environmental Issues

Existing Environment

The New Throckmorton Reservoir site in Throckmorton County is within the Rolling Plains Ecological Region[1]. This region is located east of the High Plains, west of the Cross Timbers and Prairies, and north of the Edwards Plateau. It is characterized by nearly level to rolling topography, soft prairie sands and clays, and alternating woodlands and prairies. The physiognomy of the region varies from open, short to tall, scattered to dense grasslands to savannahs with bunch grasses. Most of the plains are rangeland, but cultivated crops are important in certain localities. Poor range management practices of the past have increased the density of invasive woody plant species and have decreased the value of the land for cattle production. Farming and grazing practices have also reduced the abundance and diversity of wildlife in the region[2]. The climate is characterized as subtropical subhumid, with hot summers and dry winters. Average annual precipitation is approximately 27 inches.[3]

The Seymour aquifer, an unconsolidated sand and gravel aquifer, is the only major aquifer in the county, but does not underlie the proposed reservoir site.[4] The aquifer consists of Quaternary-age, alluvial sediments unconformably overlying Permian-age rocks. Water is contained in isolated patches of alluvium as much as 360 feet thick. Water ranges from fresh to slightly saline. Most of the groundwater pumped from the aquifer (about 90%) is used for irrigation, with the remainder used primarily for municipal supply.[5]

The region lies within the North-Central Plains physiographic region which includes elevations between 900 and 3,000 feet above sea level. Bedrock includes limestones, sandstones, and shales. Where shale bedrock prevails, meandering rivers traverse stretches of local prairie. In areas of harder bedrock, hills and rolling plains dominated. Local areas of hard sandstones and limestones cap steep slopes severly dissected near rivers.[6] The predominant soil types in the project area are the Clearfork silty clay loam, occasionally flooded and Lueders-Throck complex, 1-8 percent slopes, extremely stony. The Clearfork silty clay loams are very deep, well drained soils present on floodplains on draws. These soils are considered prime farmland soils. The Lueders-Throck complex soils are soils are generally found on hillslopes on ridges and are derived from gravelly residuum weathered from limestone. These soils are well drained and are not considered prime farmland. Other soils comprise a smaller portion of the project area. These include Leeray clay, 0 to 1 percent slopes, Lueders cobbly loam, 1 to 5 percent slopes, Lueders-Springcreek complex, 1 to 8 percent slopes, very stony, Nukrum clay

[1] Gould, F.W., G.O. Hoffman, and C.A. Rechenthin, Vegetational Areas of Texas, Texas A&M University, Texas Agriculture Experiment Station Leaflet No. 492, 1960.
[2] Telfair, R.C., *Texas Wildlife Resources and Land Uses*, University of Texas Press, Austin, Texas, 1999.
[3] Texas Almanac, 2008. Texas Almana 2008-2009. The Dallas Morning News Inc., Dallas, TX 2008.
[4] Texas Water Development Board (TWDB), *Major and Minor Aquifers of Texas*, Maps online at http://www.twdb.texas.gov/groundwater/aquifer/major.asp, accessed November 25, 2004.
[5] TWDB, *Seymour Aquifer*, http://www.twdb.texas.gov/groundwater/aquifer/majors/seymour.asp, accessed November 25, 2014.
[6] Wermund, E.G., *Physiographic Map of Texas*, Bureau of Economic Geology, University of Texas, Austin, Texas, 1996. Accessed online at http://www.beg.utexas.edu/UTopia/images/pagesizemaps/physiography.pdf on November 25, 2014.

loam, 1 to 3 percent slopes, Nuvalde clay loam, 0 to 1 percent slopes, Nuvalde clay loam, 1 to 3 percent slopes, Owens-Harpersville complex, 8 to 45 percent slopes, extremely bouldery, Owens-Lueders complex, 5 to 30 percent slopes, extrememly bouldery, Rowden clay loam, 0 to 2 percent slopes, Rowena clay loam, 0 to 1 percent slopes, Sagerton clay loam, moist, 1 to 3 percent slopes, Speck silty clay loam, 0 to 2 percent slopes, Springcreek clay loam, 1 to 3 percent slopes, and Throck silty clay loam, 1 to 5 percent slopes. Of these soils, approximately 46 percent are considered to be prime farmland soils.[7]

Two major vegetation types occur within the general vicinity of the proposed project: Mesquite (*Prosopis glandulosa*)–Lotebush Shrub, and crops.[8] Variations of these primary types occur involving changes in the composition of woody and herbaceous species and physiognomy according to localized conditions and specific range sites. Mesquite-Lotebush Shrub could include the following commonly associated plants: yucca (*Yucca* spp.), skunkbush sumac (*Rhus trilobata*), agarito (*Berberis trifoliolata*), elbowbush (*Forestiera angustifolia*), juniper, tasajillo (*Opuntia leptocaulis*), cane bluestem (*Bothriochloa barbinodis*), silver bluestem (*Bothriochloa saccharoides*), little bluestem (*Schizachyrium scoparium*), sand dropseed (*Sporobolus cryptandrus*), Texas grama (*Bouteloua rigidiseta*), sideoats grama (*Bouteloua curtipendula*), hairy grama (*Bouteloua hirsuta*), red grama (*Bouteloua trifida*), tobosagrass (*Pleuraphis mutica*), buffalograss (*Buchloe dactyloides*), Texas wintergrass (*Nasella leucotricha*), purple three-awn (*Aristida purpurea*), Engelmann daisy (*Engellmania peristena*), broom snakeweed (*Gutierrezia sarothrae*), and bitterweed (*Hymenoxys odorata*). Crops include cultivated cover crops or row crops providing food and/or fiber for either man or domestic animals and may also include grassland associated with crop rotations and hay production.

Potential Impacts

Aquatic Environments including Bays and Estuaries

The anticipated impact of this project would be minimal reduction in variability and substantial reductions in quantity of median monthly flows. The reduction in variability of monthly flow values would probably not have much impact on the instream biological community or riparian species. However, there would be a reduction in the quantity of median monthly flows downstream of the project ranging from 2.3 cfs in January to 24 cfs in May, as shown in Table 4.10-1. The highest reductions (>10 cfs) would occur in May and June, and all months would have significant reductions in flow. This project would also result in a higher frequency of low-flow conditions. Without the project, the monthly flow would be less than 0.72 cfs only 15 percent of the time (85 percent exceedance value) and would be less than 0.72 cfs 70 percent of the time with the project in place. These reductions in flow would have substantial impacts on the instream biological community, especially since the greatest reductions are predicted for

[7] Natural Resources Conservation Service, *Custom Soil Resource Report for Throckmorton County, Texas*, United States Department of Agriculture, Natural Resources Conservation Service, in cooperation with Texas Agricultural Experiment Station, November 25, 2014.
[8] McMahan, C.A., R.F. Frye, and K.L. Brown, *The Vegetation Types of Texas*, Texas Parks and Wildlife Department, Wildlife Division, Austin, Texas, 1984.

the summer months when flows are already historically low and water chemistry conditions are the most stressful for aquatic species (e.g., high temperatures and high nutrient growth).

Although there would be biological impacts in the immediate vicinity of the project site and downstream, it is not likely that this project, alone, would have a substantial influence on total discharge in the Brazos River or to freshwater inflows to the Brazos River estuary. However, the cumulative impact of multiple projects may reduce freshwater inflow to the estuary. As a new reservoir without a current operating permit, the New Throckmorton Reservoir would likely be required to meet environmental flow requirements determined by site-specific studies.

Table 4.10-1. Median Monthly Streamflow: North Elm Creek Diversion Site

Month	Without Project (cfs)	With Project (cfs)	Difference (cfs)	Percent Reduction
January	2.26	0.00	2.26	100%
February	2.44	0.00	2.44	100%
March	2.88	0.00	2.88	100%
April	2.74	0.00	2.74	100%
May	23.95	0.00	23.95	100%
June	21.84	0.00	21.84	100%
July	4.82	0.00	4.82	100%
August	4.65	0.00	4.65	100%
September	6.82	0.00	6.82	100%
October	8.87	0.00	8.87	100%
November	4.31	0.00	4.31	100%
December	2.52	0.00	2.52	100%

Threatened & Endangered Species

The Texas Parks and Wildlife Department (TPWD) maintains a list of Rare, Threatened, and Endangered Species of Texas by County. This list includes the federal and state listing status and a habitat description for each species which may be a resident or migrant through the county. TPWD regularly updates the listing status, range data, and habitat descriptions on their published county lists, based on the most recently available data. The current list of rare, threatened and endangered species for Throckmorton County can be found at https://tpwd.texas.gov/gis/rtest/.

No documented occurrences of any state or federally listed threatened, endangered, or candidate species or species of concern were revealed within at least 2.5 miles of the proposed New Throckmorton Reservoir during a search of the Texas Natural Diversity Database[9] maintained by TPWD (as noted on representative 7.5 minute quadrangle map(s) that include the project site). This data is not a representative inventory of rare resources or sensitive sites. Although based on the best information available to TPWD, these data do not provide a definitive statement as to the presence, absence, or condition of special species, natural communities, or other significant features in the project area. On-site evaluations will be required by qualified biologists to confirm the occurrence of sensitive species or habitats.

Wildlife Habitat

Approximately 1,160 acres are estimated to be inundated by the reservoir. Utilizing Ecological Mapping Systems of Texas data[10], the projected wildlife habitat that will be impacted includes dominantly mixed grass prairie (approximately 760 acres), mesquite shrubland (approximately 470 acres), native invasive mesquite shrubland (approximately 430 acres), floodplain herbaceous vegetation (approximately 255 acres), and row crops (approximately 250 acres). Other wildlife habitat types that would be impacted include riparian herbaceous vegetation, native invasive juniper shrubland, floodplain hardwood forest, native invasive juniper woodland, marsh and barren land.

A number of vertebrate species would be expected to occur within Throckmorton County near the proposed reservoir site including many game and non-game animals. These include 11 species of frogs and toads, 6 species of turtles, 10 species of lizards and skinks, and 24 species of snakes. Additionally, 78 species of mammals could occur within the site or surrounding region [11] in addition to an undetermined number of bird species. A variety of fish species would be expected to inhabit streams and ponds within the site, but with distributions and population densities limited by the types and quality of habitats available.

Cultural Resources

A search of the Texas Historical Commission's online database for the 2011 Regional Water Plan identified no mapped cemeteries, historical markers, National Register of Historic Places sites or districts or State historic sites within the proposed reservoir site. A search of the Texas Archeological Sites Atlas database indicated that no archeological sites have been documented within the general vicinity of the proposed reservoir. However, the area has never been surveyed by a professional archeologist and the absence of documented sites may reflect the lack of investigation rather than the absence of archeological sites. Prior to reservoir inundation the project must be

[9] Texas Parks and Wildlife Department (TPWD), Texas Natural Diversity Database, *Element of Occurrence Records*, November 24, 2014.

[10] Texas Parks & Wildlife Department (TPWD), "Ecological Mapping Systems of Texas," https://drive.google.com/folderview?id=0B32g5sG2VKbgbl9oOGlneUdMZjA&usp=sharing accessed November 21, 2014.

[11] Davis, W.B., and D.J. Schmidly, *The Mammals of Texas – Online Edition*, Texas Tech University, http://www.nsrl.ttu.edu/tmot1/Default.htm, 1997.

coordinated with the Texas Historical Commission and a cultural resources survey must be conducted to determine if any cultural resources are present within the conservation pool. Any cultural resources identified during survey will need to be assessed for eligibility for inclusion in the National Register of Historic Places (NRHP) or as State Archeological Landmarks (SAL). Cultural resources that occur on public lands or within the Area of Potential Effect of publicly funded or permitted projects are governed by the Texas Antiquities Code (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archeological and Historic Preservation Act (PL93-291).

Threats to Natural Resources

Threats to natural resources include lower stream flows, declining water quality, and reduced inflows to reservoirs. This project would likely have increased adverse effects on stream flow below the reservoir site as a reduction in the quantity of median monthly flow is projected downstream, but the reservoir would also trap sediment and/or dilute pollutants, providing some positive benefits to water quality immediately downstream. These benefits could be offset by declines in dissolved oxygen through decreased flows and higher temperatures during summer periods. The project is expected to have negligible impacts to total discharge downstream and overall water quality in the Brazos River.

Agricultural Impacts

The New Throckmorton Reservoir site contains approximately 180 acres of Pasture/Hay fields and zero acres of cropland. These two agricultural land uses account for roughly 8 percent of the reservoir footprint.

4.10.4 Engineering and Costing

Construction of the New Throckmorton Reservoir project will cost approximately $68.1 million. This includes the construction of the dam, land acquisition, resolution of conflicts, environmental permitting and mitigation, and technical services. The annual project costs are estimated to be $5.91 million; this includes annual debt service and operation and maintenance. The cost for the available project safe yield of 3,500 acft/yr translates to an annual unit cost of raw water of $5.18 per 1,000 gallons, or $1,687/acft. A summary of the cost estimate is provided in Table 4.10-2. Costs shown herein are for raw water supply at the reservoir and do not include transmission, local distribution, or treatment costs. These costs include compensation to BRA for impacts of subordination of Possum Kingdom Reservoir to New Throckmorton Reservoir. Note that any subordination agreement would need to be negotiated with BRA.

Table 4.10-2. Cost Estimate Summary for New Throckmorton Reservoir

Item	Estimated Costs for Facilities
Dam and Reservoir (Conservation Pool 15,900 acft; 1,161 acres)	$17,506,000
Intake Pump Station (3.3 MGD)	$5,603,000
Transmission Pipeline (12in. dia., 5 miles)	$2,957,000
Water Treatment Plant (3.3 MGD)	$15,440,000
TOTAL COST OF FACILITIES	**$41,506,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$14,379,000
Environmental & Archaeology Studies and Mitigation	$4,306,000
Land Acquisition and Surveying (2,357 acres)	$4,361,000
Interest During Construction (3% for 2 years with a 0.5% ROI)	$3,551,000
TOTAL COST OF PROJECT	**$68,103,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$2,409,000
Reservoir Debt Service (3.5 percent, 40 years)	$1,586,000
Operation and Maintenance	
Dam and Reservoir (1.5% of Cost of Facilities)	$263,000
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$30,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$140,000
Water Treatment Plant	$1,220,000
Pumping Energy Costs (0.08 $/kW-hr)	$75,000
Purchase of Water (2,390 acft/yr @ 76.50 $/acft)	$183,000
TOTAL ANNUAL COST	**$5,906,000**
Available Project Yield (acft/yr)	3,500
Annual Cost of Water ($ per acft), based on a Peaking Factor of 1	$1,687
Annual Cost of Water ($ per 1,000 gallons), based on a Peaking Factor of 1	$5.18

Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 4.10-3, and the option meets each criterion.

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality Water Right and Storage permits;
- U.S. Army Corps of Engineers Permits will be required for discharges of dredge or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act);
- Texas Commission on Environmental Quality administered Texas Pollutant Discharge Elimination System Storm Water Pollution Prevention Plan;
- General Land Office Easement if State-owned land or water is involved; and
- Texas Parks and Wildlife Department Sand, Shell, Gravel and Marl permit if state-owned streambed is involved.

State and Federal Permits may require the following studies and plans:

- Environmental impact or assessment studies;
- Wildlife habitat mitigation plan that may require acquisition and management of additional land;
- Flow releases downstream to maintain aquatic ecosystems;
- Assessment of impacts on Federal- and State-listed endangered and threatened species;
- Aquatic Resource Relocation Plan (ARRP) and a relocation permit may be required from TPWD if a dewatering event is required during construction; and
- Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resource recovery and cataloging; requires coordination with the Texas Historical Commission.

Land Acquisition Issues:

- Land acquired for reservoir and/or mitigation plans could include market transactions and/or eminent domain;
- Additional acquisition of rights-of-way and/or easements may be required; and
- Possible relocations or removal of residences, utilities, roads, or other structures.

Table 4.10-3. Evaluations of New Throckmorton Reservoir Option to Enhance Water Supplies

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet needs
2. Reliability	2. High reliability
3. Cost	3. Reasonable
B. Environmental factors	
1. Environmental Water Needs	1. Moderate impact
2. Habitat	2. High impact
3. Cultural Resources	3. High impact
4. Bays and Estuaries	4. Negligible 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	• Potential impact on bottomland farms and habitat in the reservoir area
E. Equitable Comparison of Strategies Deemed Feasible	• Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	• Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	• None

4.11 Turkey Peak Dam – Lake Palo Pinto Enlargement

4.11.1 Description of Option

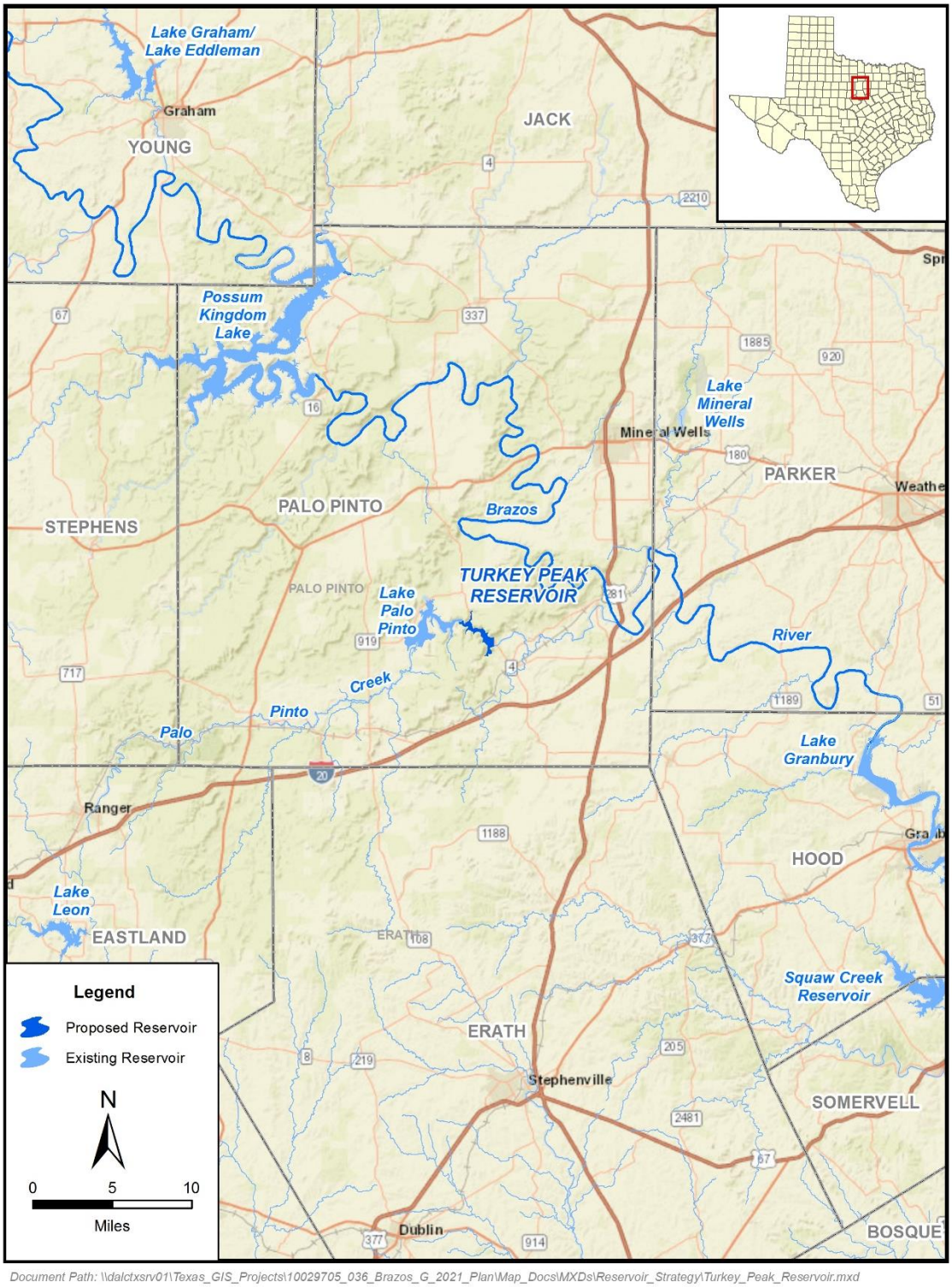
The Lake Palo Pinto (LPP) dam was initially constructed in 1963 and 1964 with a conservation pool level of 863.0 feet above mean sea level (ft-msl) and deliberate impoundment began in April 1964. In 1966 the conservation storage level was raised four feet to 867.0 ft-msl. The Palo Pinto County Municipal Water District No. 1 (District) operates LPP by making releases through the reservoir outlet works for subsequent diversion downstream. Additionally, the District's water right allows for the diversion of intervening streamflow entering Palo Pinto Creek downstream of LPP. As a result, the District is able to conserve storage in LPP by ceasing releases from LPP during wet periods and meeting demands by diverting the intervening streamflow.

In the early 1980s, the District became concerned about the capacity of LPP and in 1985, a volumetric survey of the reservoir was performed. This survey determined the reservoir's conservation capacity to be 27,650 acft, about 63 percent of its authorized storage. In 2007, an additional volumetric survey was performed by the Texas Water Development Board and this survey determined the reservoir's capacity to be 27,215 acft (about 62 percent of its authorized storage of 44,100 acft). Based on the June 2007 TWDB survey, the LPP conservation pool currently inundates 2,176 acres at its conservation level and has an average depth of only 12.5 feet. The construction of the Turkey Peak Dam is currently being pursued by the District to expand LPP and recover the storage authorized under Certificate of Adjudication 12-4031.

The proposed Turkey Peak Dam is located on Palo Pinto Creek immediately downstream of LPP, as shown in Figure 4.11-1. The proposed dam is located approximately 2 miles northwest of the City of Santo, just upstream from the bridge over Palo Pinto Creek on FM4. The conservation capacity of the expanded portion of LPP is 22,577 acft and covers 648 acres, resulting in an average reservoir depth of 35 ft.

The normal pool elevation of the expanded LPP will be 867.0 ft-msl, the same as the existing LPP. A portion of the existing dam and spillway at LPP will be removed and the two reservoir pools will be connected above an elevation of 863.0 ft-msl. Below this elevation a pipe will connect both pools and the two pools can be operated either as a single reservoir or as separate reservoirs. The expanded LPP will contain approximately 49,792 acft of conservation storage and inundate 2,824 acres at its conservation storage level of 867 ft-msl.

Figure 4.11-1. Location of Turkey Peak Dam – Lake Palo Pinto Enlargement



Document Path: \\dalctxsrv01\Texas_GIS_Projects\10029705_036_Brazos_G_2021_Plan\Map_Docs\MXDs\Reservoir_Strategy\Turkey_Peak_Reservoir.mxd

The Turkey Peak Dam will increase storage by 83 percent (as compared to the existing LPP), while only inundating an additional 20 percent of the surface area of the existing LPP. Because the expanded portion of the reservoir is significantly deeper than the existing LPP, the surface area of the combined reservoirs is 695 acres less (20 percent) when compared to raising the conservation level of LPP by 5.5 feet (and storing 44,100 acft, its current permit authorization). This results in a significant reduction in reservoir evaporation between the two alternative configurations.

The District has been granted an amendment to their surface water permit for LPP (Certificate of Adjudication 12-4031A) for the expansion of the reservoir and has obtained the required Section 404 permit of the Clean Water Act for construction of the Turkey Peak Dam. The District is currently in the final design phase of the project and is beginning to acquire property. The District anticipates construction to begin in 2025.

4.11.2 Available Yield

Water potentially available for impoundment in the expanded LPP was estimated using the TCEQ Brazos WAM Run 3 which assumes no return flows and permitted storages and diversions for all water rights in the basin. The model utilizes a January 1940 through December 1997 hydrologic period of record. Estimates of water availability were derived subject to the reservoir having to pass inflows to meet TCEQ environmental flow standards.

Because this project is being pursued to recover lost storage in LPP and to increase the reliability of the supply as currently authorized by the District's water right, the additional storage provided by Turkey Peak Dam was modeled at the LPP priority date of July 3, 1962, which is consistent with Certificate of Adjudication 12-4031A. When the expanded LPP is simulated with the TCEQ Brazos WAM Run 3 and diversions of released water from the reservoir taken at the downstream diversion point, the full authorized diversion amount of 18,500 acft/yr is firm.

However, during the recent 2015 drought, storage levels in LPP were reduced to critical levels, signifying a new drought of record for the Palo Pinto Creek watershed. As a result, the District adopted a 12-month safe yield for planning purposes. The recent drought is not included in the TCEQ Brazos WAM hydrologic period of record. Analyses performed by HDR considering the recent drought indicates the safe yield of the existing LPP is 4,700 acft/yr. With the expanded LPP, the safe yield is increased by 6,000 acft/yr to 10,700 acft/yr.

Figure 4.11-2 shows the simulated expanded LPP storage levels for the 1940 to 1997 period included in the TCEQ Brazos WAM, subject to the safe yield demand of 10,700 acft/yr. Figure 4.11-3 illustrates the storage frequency of the combined reservoir under the same safe yield demand. Simulated contents remain full over 20 percent of the time and above 90 percent full more than half of the time. Figure 4.11-4 shows the annual releases from storage for subsequent diversion downstream. For years in which releases are less than the safe yield amount of 10,700 acft, intervening streamflow downstream of the Turkey Peak Dam is utilized to meet portions of the safe yield demand.

Figure 4.11-2. Expanded Lake Palo Pinto Storage Trace

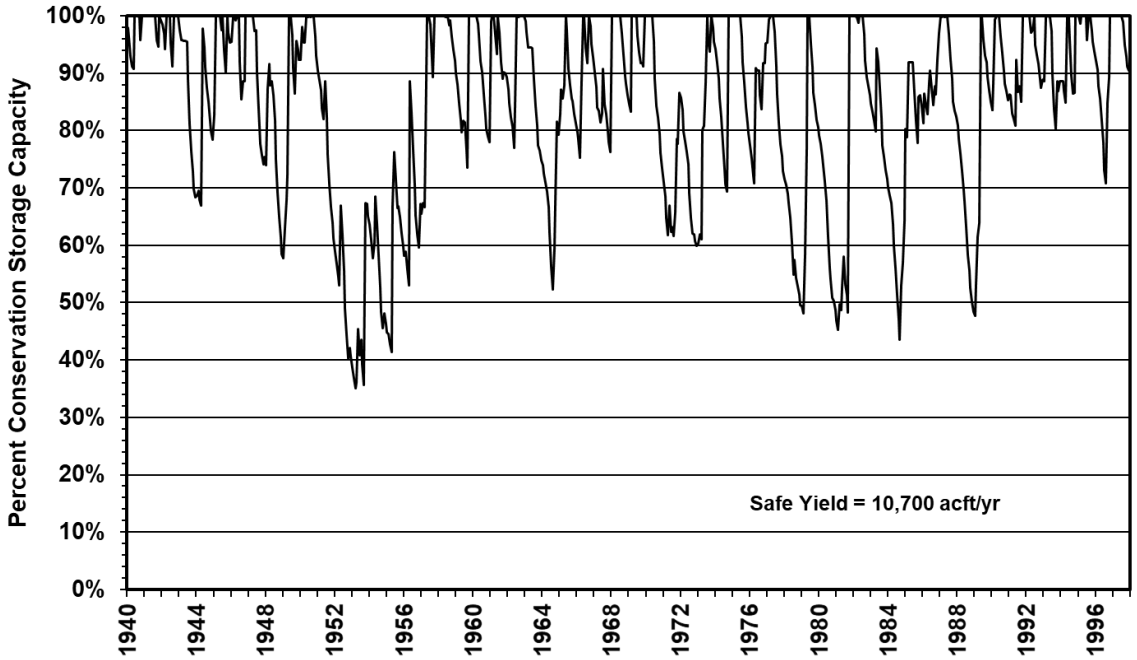


Figure 4.11-3. Expanded Lake Palo Pinto Reservoir Storage Frequency

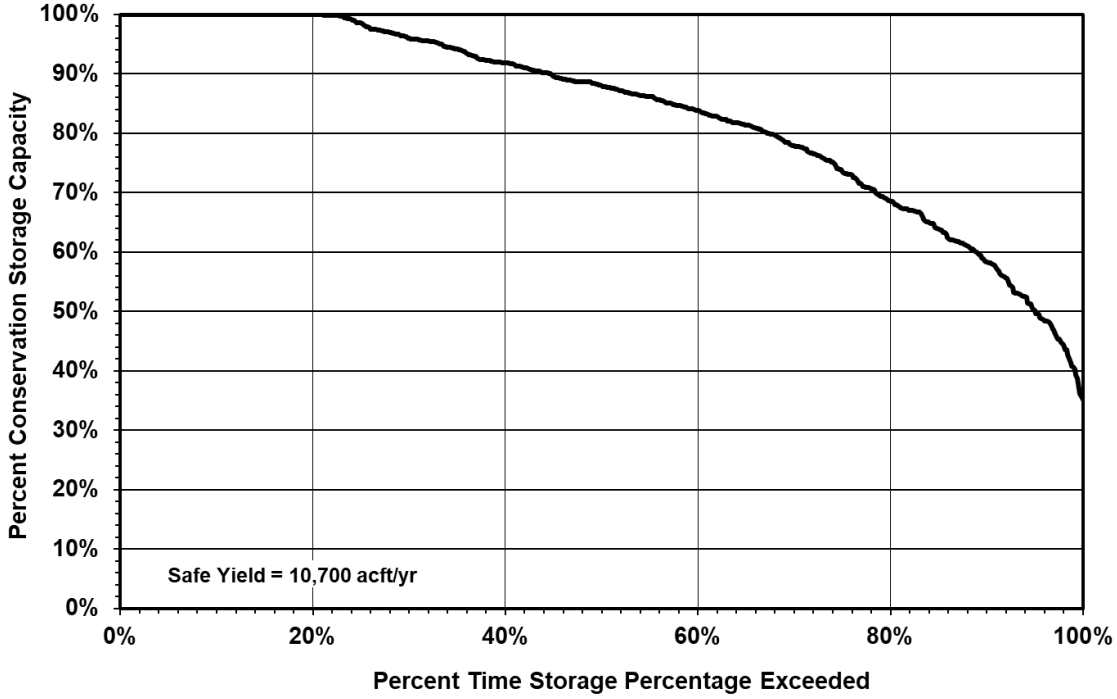


Figure 4.11-4. Releases from Expanded LPP for Water Supply

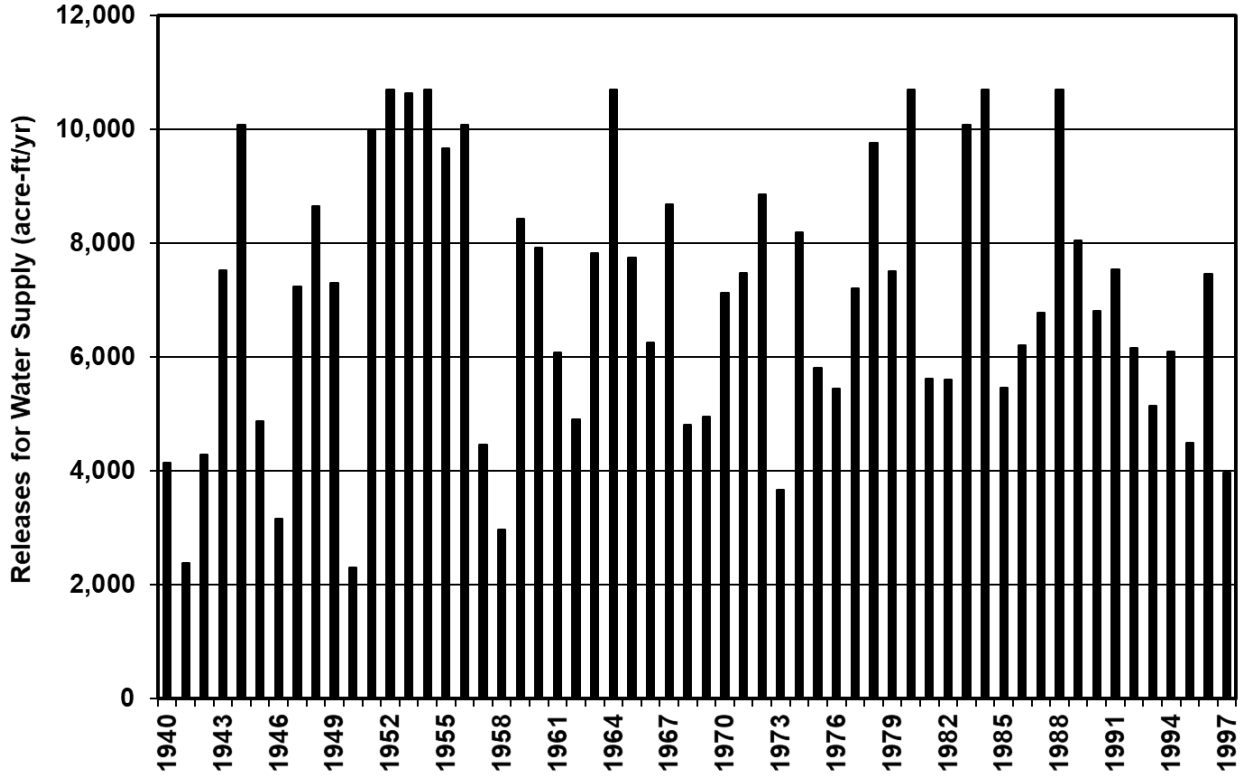


Figure 4.11-5 illustrates the changes in Palo Pinto Creek streamflows as a result of the Turkey Peak dam construction. The median streamflows are reduced in May and June as a result of the expanded reservoir impounding a greater amount of available streamflow. Median streamflows are increased in all other months of the project due to the expanded reservoir being able to release additional water for subsequent diversion downstream. Figure 4.11-6 compares the streamflow frequency at the Proposed Turkey Peak Dam with and without the project. The figure shows that streamflow will not be significantly impacted from implementation of the project.

Figure 4.11-5. Monthly Median Streamflow near Proposed Turkey Peak Reservoir Dam

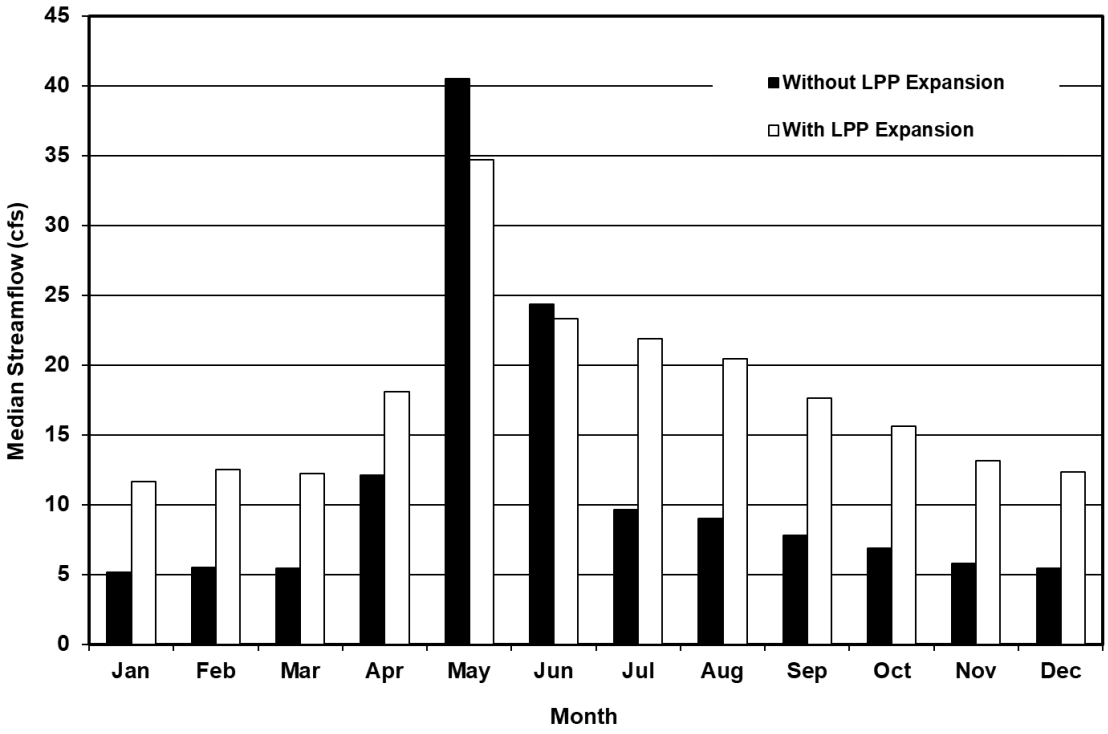
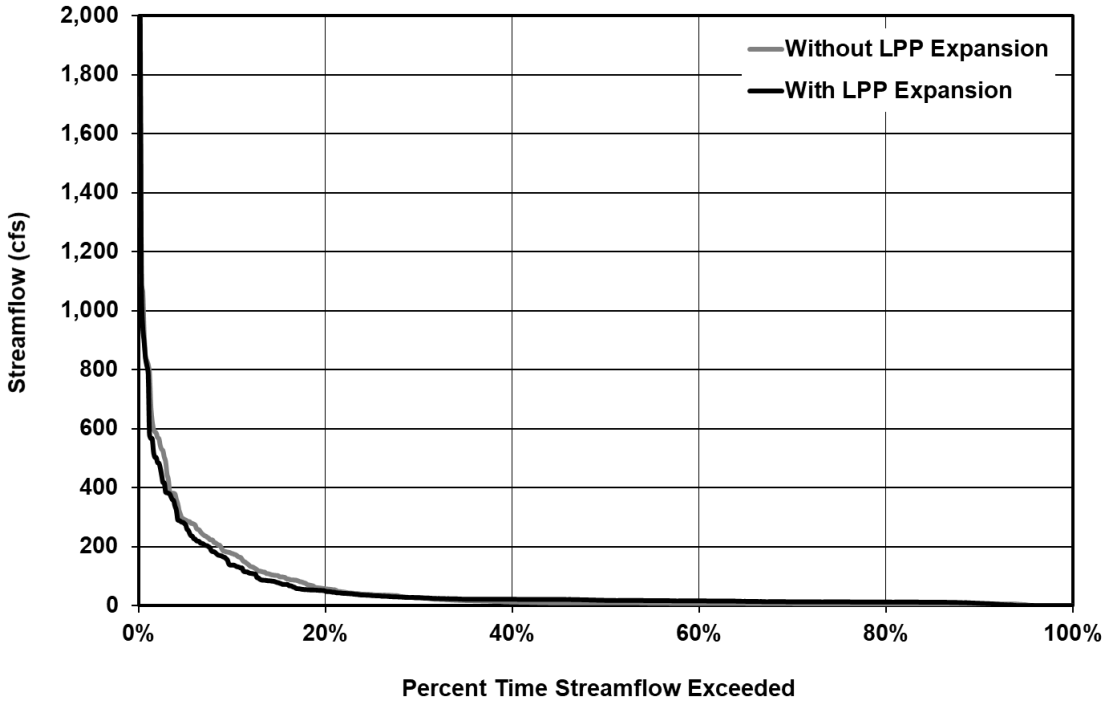


Figure 4.11-6. Streamflow Frequency Comparison at Turkey Peak Dam



4.11.3 Environmental Issues

Existing Environment

The Turkey Peak Project site in Palo Pinto County is within the Cross Timbers Ecoregion.1 This complex transitional area of prairie dissected by parallel timbered strips is located in north-central Texas west of the Texas Blackland Prairies Ecoregion, east of the Central Plains Ecoregion and north of the Edwards Plateau Ecoregion. The physiognomy of the Cross Timbers Ecoregion is oak and juniper woods, and mixed grass prairie. Much of the native vegetation has been displaced by agriculture and development. Range management techniques, including fire suppression, have contributed to the spread of invasive woody species and grasses within this area. Farming and grazing practices have also reduced the abundance and diversity of wildlife in the region.[2] The climate within this area is characterized as subtropical subhumid, with hot summers and dry winters. Average annual precipitation ranges between 28 and 32 inches.[3] No major or minor aquifers underlie the project area, however the Trinity Aquifer, a major aquifer consisting of interbedded sandstone, sand, limestone, and shale of Cretaceous Age, lies east and south of the project area.[4]

The physiography of the region includes hard sandstone, mud, and mudstone (undifferentiated), ceramic clay and lignite/coal, terraces, and flood-prone areas. The topography ranges from flat to rolling, and from steeply to moderately sloped, with local shallow depressions in flood-prone areas along waterways.[5] The predominant soil associations in the project area are the Bosque-Santo and Bonti-Truce-Shatruce associations. Bosque-Santo soils are deep, nearly level to gently sloping, loamy soils, typically found on flood plains. Bonti-Truce-Shatruce soils are moderately deep and deep, gently sloping to steep, loamy, stony, and bouldery upland soils.[6]

The dominant vegetation types found within the project area as mapped by the TPWD are Ashe Juniper Parks/Woods and Oak-Mesquite-Juniper Parks/Woods.[7] Variations of these primary types occur within the region, which reflect changes in the composition of woody and herbaceous species and physiognomy. Ashe Juniper Parks/Woods, which occur principally on the slopes of hills in Palo Pinto County, usually include the following

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[1] Griffith, G.E., Bryce, S.A., Omernik, J.M., Comstock, J.A., Rogers, A.C., Harrison, B., Hatch, S.L., and Bezanson, D., 2004, Ecoregions of Texas (color poster with map, descriptive text, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:2,3000,000).

[2] Telfair, R.C., "Texas Wildlife Resources and Land Uses," University of Texas Press, Austin, Texas, 1999.

[3] Larkin, T.J., and G.W. Bomar, "Climatic Atlas of Texas," Texas Department of Water Resources, Austin, Texas, 1983.

[4] Texas Water Development Board (TWDB), Major and Minor Aquifers of Texas; Maps online at http://www.twdb.state.tx.us/mapping/index.asp, 2004.

[5] Kier, R.S., L.E. Garner, and L.F. Brown, Jr., "Land Resources of Texas." Bureau of Economic Geology, University of Texas, Austin, Texas, 1977.

[6] Moore, J.D., *Soil Survey of Palo Pinto County, Texas*, United States Department of Agriculture, Soil Conservation Service, in cooperation with Texas Agricultural Experiment Station, 1981.

[7] McMahan, C.A., R.F. Frye, and K.L. Brown, "The Vegetation Types of Texas," Texas Parks and Wildlife Department, Wildlife Division, Austin, Texas, 1984.

commonly associated plants: live oak (*Quercus virginiana*), Texas oak (*Q. texana*), cedar elm (*Ulmus crassifolia*), mesquite (*Prosopis glandulosa*), agarito (*Mahonia trifoliolata*), tasajillo (*Opuntia leptocaulis*), western ragweed (*Ambrosia cumanensis*), scurfpea (*Psoralea* spp.), little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), Texas wintergrass (*Nasella leucotricha*), silver bluestem (*Bothriochloa saccharoides*), hairy tridens (*Erioneuron pilosum*), tumblegrass (*Schedonnardus paniculatus*), and red three-awn (*Aristida purpurea* var. *longiseta*).

Oak-Mesquite-Juniper Parks/Woods, which occur as associations or as a mixture of individual (woody) species stands on uplands, generally include the following commonly associated plants: post oak (*Q. stellata*), Ashe juniper (*Juniperus ashei*), shin oak (*Q. sinuata* var. *breviloba*), Texas oak, blackjack oak (Q. marilandica), live oak, cedar elm, agarito, soapberry (*Sapindus saponaria*), sumac (*Rhus* spp.), hackberry (*Celtis* spp.), Texas pricklypear (*Opuntia engelmannii* var. *lindheimeri*), Mexican persimmon (*Diospyros texana*), purple three-awn (*Aristida purpurea*), hairy grama (*Bouteloua hirsuta*), Texas grama (*B. texana*), curly mesquite (*Hilaria belangeri*), and Texas wintergrass (*Nassella leucotricha*).

Potential Impacts

Aquatic Environments including Bays & Estuaries

Currently there is no requirement for pass throughs of environmental flows from Lake Palo Pinto. However, the permit issued by TCEQ for the Turkey Peak project requires pass through of inflows originating in the intervening drainage area between the dams of 1 cfs for subsistence flow and between 1 and 4 cfs for base flows in Palo Pinto Creek. Additionally, the USACE 404 permit requires the District to maintain a minimum 1 cfs flow downstream of the Turkey Peak dam by passing inflows or releasing stored water when the reservoir is greater than 50% full. Therefore, only minimal differences in streamflow frequencies in Palo Pinto Creek are anticipated. This project will not have a substantial influence on total discharge in downstream locations on the Brazos River including freshwater inflows to the Brazos River estuary.

Threatened & Endangered Species

The Texas Parks and Wildlife Department (TPWD) maintains a list of Rare, Threatened, and Endangered Species of Texas by County. This list includes the federal and state listing status and a habitat description for each species which may be a resident or migrant through the county. TPWD frequently updates the listing status, range data, and habitat descriptions on their published county lists, based on the most recently available data. The current list of rare, threatened and endangered species for Palo Pinto County can be found at https://tpwd.texas.gov/gis/rtest/. On-site evaluations by qualified biologists are required to confirm the occurrence of sensitive species or habitats.

The Migratory Bird Treaty Act protects most bird species, including, but not limited to, cranes, ducks, geese, shorebirds, hawks, and songbirds. Migratory bird pathways, stopover habitats, wintering areas, and breeding areas may occur within and adjacent to the project area, and may be associated with wetlands, ponds, shorelines, riparian corridors, fallow fields and grasslands, and woodland and forested areas. Although reservoir construction would remove some habitats utilized by certain migratory bird

species, it would create more habitats for others. It is anticipated that the reservoir would reach its full capacity in one to three years. This transition from terrestrial to aquatic habitat would allow time for migratory species to acclimate to the altered condition within the project area and movement of non-aquatic species to similar areas nearby.

Three bird species federally listed as threatened or endangered may occur in the project vicinity. These include the golden-cheeked warbler (*Dendroica chrysoparia*), interior least tern (*Sterna antillarum athalassos*), and whooping crane (Grus americana). Two of these bird species are seasonal migrants that could pass through the project area. The interior least tern typically nests on bare or sparsely vegetated areas associated with streams or lakes, such as sand and gravel bars, beaches, islands, and salt flats. Unvegetated bars within wide river channels or open flats along lake or reservoir shorelines are preferred and provide nesting habitat and access to adjacent open water for foraging for this tern. The main whooping crane flock nests in Canada and migrates annually to their wintering grounds in and around the Aransas National Wildlife Refuge near Rockport on the Texas coast. Whooping cranes occasionally utilize wetlands as an incidental rest stop during this migration. Habitat elements particularly attractive to the interior least tern and whooping crane do not appear to be present on or adjacent to the proposed reservoir site, although migrants are possible.

The golden-cheeked warbler is the only federally-listed avian species with potential to utilize the proposed reservoir site for nesting. Juniper-oak woodlands found on canyon slopes may provide the isolated woodland habitat of deciduous oaks and mature junipers required by this migratory songbird. A detailed field survey for this species was conducted by qualified personnel in March–May 2006, and no sightings or detections of the warbler were documented.[8] This survey and habitat assessment concluded that the Turkey Peak study area lacked the appropriate habitat for the golden-cheeked warbler, and that the Turkey Peak Project area was not likely to support this species.[9]

Avian species listed by the State of Texas as endangered or threatened include the bald eagle (*Haliaeetus leucocephalus*). Bald eagles are listed as threatened in Texas and occur as winter migrants. The majority of nesting bald eagle pairs currently reported are found along major rivers and near reservoirs in eastern Texas. Bald eagles are opportunistic predators, feeding primarily on fish captured in the shallow water of both lakes and streams or scavenged food sources. These birds may utilize tall trees near perennial water as roosting or nesting sites. Although the bald eagle could use either Lake Palo Pinto or Possum Kingdom Reservoir for foraging or nesting, the species has not been reported in the region. It is not expected that the bald eagle would be directly affected by the proposed reservoir construction at the Turkey Peak site.

The Texas horned lizard (*Phrynosoma cornutum*), Texas fawnsfoot mussel (*Truncilla macrodon*), and Brazos water snake (*Nerodia harteri*), three state threatened species, and the plains spotted skunk (*Spilogale putorius interrupta*), Texas garter snake (*Thamnophis sirtalis annectens*), and granite spiderwort (*Tradescantia pedicellata*), three species of concern, are possible inhabitants of the reservoir site or its adjacent upland pastures. Texas horned lizards inhabit deserts and grasslands in semi-arid to arid

[8] Ladd, Clifton and Amanda Aurora. Endangered Species Survey Summary for the Golden-Cheeked Warbler. Loomis Austin, 2006.

[9] Ibid.

landscapes with sparse vegetation and gravelly soils. Their habitat must contain a stable population of harvester ants, the primary prey of the horned lizard, which make up the majority of its diet. Patchy environments that contain bare areas mixed with patches of vegetation are ideal to attract harvester ants and Texas horned lizards. This species could be displaced within the areas that will be gradually inundated. Relocation would then be possible into similar and acceptable habitat available adjacent to the project area.

Several species of freshwater mussels including the Texas fawnsfoot (*Truncilla macrodon*) have been listed as threatened by the state of Texas. This species is currently considered a candidate by the USFWS. The Texas fawnsfoot has been documented within the Brazos River Basin although it is generally thought to prefer large to medium streams or rivers which are not representative of Palo Pinto Creek. No Texas fawnsfoot specimens (live or dead) were identified during mussel surveys conducted in 2009 of the project reach downstream of the existing Lake Palo Pinto dam.

The Brazos water snake (*Nerodia harteri*) is limited in range to the Brazos River drainage and is usually found in riffle areas along the riverbank. Possible suitable habitat for this species occurs along Palo Pinto Creek within the reservoir area; however, comparable habitat occurs downstream of the proposed dam site. Occurrences of the endemic Brazos water snake have been documented by TPWD near Palo Pinto Creek. Surveys for the Brazos water snake along Palo Pinto Creek within the Turkey Peak Project site and downstream were undertaken in 2009 and there were no sightings of this species. Adverse impacts to this snake are not anticipated as it has been documented to persist along rocky shorelines in reservoirs, such as in Possum Kingdom.

The plains spotted skunk (*Spilogale putorius interrupta*) is generally found in open fields, prairies, and croplands. Vegetation within the project area generally consists of moderately dense mixed deciduous woodlands in the canyons, with pastures or pecan orchards in the floodplains. It is expected that if the plains spotted skunk is present in the project area, the gradual transition to an aquatic system could displace these species. However, the project area is rural, and similar suitable habitats exist adjacent to the project area; therefore, it is anticipated that the spotted skunk could relocate to those areas if necessary.

The sharpnose shiner (*Notropis oxyrhynchus*) and the smalleye shiner (*Notropis buccula*) are two small, slender minnows endemic to the Brazos River Basin that are federally listed as endangered. Historically, these sympatric fish existed throughout the Brazos River and several of its major tributaries. The population of each species within the Upper Brazos River drainage which occurs upstream of Possum Kingdom Reservoir is apparently stable, while the population within the middle and lower segments of the Brazos River Basin may exist only in remnant areas of suitable habitat. General habitat associations for both species include relatively shallow water of moderate currents flowing through broad and open sandy channels. Typical habitat is similar for both species and includes the often saline and turbid water of the Upper Brazos River. The last documented occurrence of the smalleye shiner within the lower segment of the Brazos River was recorded near the confluence of Palo Pinto Creek and the Brazos River in 1953. The stored water released from the existing Lake Palo Pinto is fresh and does not provide the saline water quality conditions needed by both species. Additionally, the existing channel dam constructed in the mid 1960's would likely restrict upstream

movement of these minnows. The study area lies downstream of any recently recorded occurrences for these species; therefore, the occurrence of either cyprinid species is unlikely. The Guadalupe bass (*Micropterus treculii*) is endemic to the perennial streams of the Edwards Plateau region and is considered introduced in the Nueces River system. It is possible, but unlikely, that this species will be found within project area.

Information received from the TPWD Texas Natural Diversity Database[10] revealed no documented occurrences of endangered or threatened species within or near the proposed Turkey Peak Project. Although based on the best information available to TPWD, these data do not provide a definitive statement as to the presence, absence, or condition of special species, natural communities, or other significant features in the project area.

Based on the lack of suitable habitat for listed endangered or threatened species, the degree of previous land modification, and the anticipated gradual transition of the area into an aquatic system, this project is unlikely to have an adverse effect on any listed threatened or endangered species.

Wildlife Habitat

Palo Pinto County is included in the Texan Biotic Province as delineated by Blair and modified by TPWD. [11] This province includes bands of prairie and woodland that begin in South Central Texas and run north to Kansas. The Texan Biotic Province constitutes a broad ecotone between the forests in the eastern portion of this region and the western grasslands. Although varied, the vertebrate community within the area of the proposed reservoir includes no true endemic species. The wildlife habitat types of the study area coincide closely with the major plant community types present. The mountains and associated vegetation areas within Palo Pinto County are similar to that of the Edwards Plateau; therefore, the wildlife habitats and species of the study area represent a mixture of those typical of the surrounding areas.

Within this province, western species tend to encroach into open habitats, and eastern species intrude along the many wooded drainageways extending through the landscape. Mammals typical of this province include the Virginia opossum (*Didelphis virginiana*), eastern mole (*Scalopus aquaticus*), fox squirrel (Sciurus niger), Louisiana pocket gopher (*Geomys breviceps*), fulvous harvest mouse (*Reithrodontomys fulvescens*), white-footed mouse (*Peromyscus leucopus*) and swamp rabbit (*S. aquaticus*). Animals typical of grasslands of this province include the thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), hispid pocket mouse (*Chaetodipus hispidus*), and black-tailed jackrabbit (*Lepus californicus*).

Typical anuran species to the Texan Biotic Province include the Hurter's spadefoot (*Scaphiopus holbrookii hurteri*), Gulf Coast toad (*Bufo valliceps*), green treefrog (*Hyla cinerea*), bullfrog (*Rana catesbeiana*), southern leopard frog (*Rana sphenocephala*) and eastern narrowmouth toad (*Microhylla carolinensis*).

[10] Texas Parks and Wildlife Department (TPWD), Texas Natural Diversity Database, Received 10/04/2014.

[11] Blair, W. Frank. 1950. “The Biotic Provinces of Texas,” Texas Journal of Science 2 (1):93-117, modified by TPWD GIS lab.

According to TPWD geographic information system (GIS) data, 84 percent of the habitat which will be inundated by the project includes forest or woodland areas, 6 percent is grassland, approximately 4 percent is shrubland, and the remaining 6 percent includes herbaceous vegetation, open water and urban areas.[12]

Cultural Resources

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available GIS datasets provided by the Texas Historical Commission (THC), there are no National Register Properties, National Register Districts, State Historic Sites, cemeteries or historical markers located within or near the reservoir project area. The owner or controller of the project would be required to coordinate with the Texas Historical Commission regarding potential impacts to cultural resources.

The Texas Archeological Sites Atlas online database of the Texas Historical Commission (THC) was also consulted and background research was conducted to determine any previous cultural resources survey efforts as well as the locations of previously recorded historic and archaeological resources in the project area. Records indicate that eight previously recorded prehistoric archaeological sites were located within a 1-mile radius of the reservoir area.

In addition, a Phase IA cultural resource assessment was conducted for the proposed development of the Turkey Peak Project site in January 2009. This research revealed that there were no previously documented archeological sites found within the proposed reservoir area. Phase 1B surveys, including trenching at selected alluvial terrace locations, were initiated in 2010. The findings of the Phase 1B surveys were provided to the USACE and THC in support of Section 404 Permit coordination in accordance with the requirements of Section 106 of the National Historic Preservation Act (NHPA). The District will also coordinate the findings of the archeological surveys with the THC and TCEQ in conjunction with the review of the project under the Antiquities Code of Texas.

The Phase 1B investigations recorded two prehistoric localities, 13 prehistoric sites, and one historic site. Nine sites are recommended for further testing to determine eligibility for listing in the National Register of Historic Places (NRHP) and designation as a State Archeological Landmark (SAL). Five sites are recommended as not eligible for NRHP listing or SAL designation. The evaluation of the pre-historic and historic resources in the area of potential effect of the reservoir will be conducted and documented in accordance with standard practices for determination of NRHP and SAL eligibility and mitigation measures will be implemented, if necessary.

Threats to Natural Resources

The Turkey Peak Project will have little adverse effect on stream flow below the reservoir site and will meet TCEQ environmental flow requirements included in the water rights permit. In addition, the reservoir would trap and/or dilute pollutants, providing some

[12] TPWD. 2014. Texas Ecological Systems GIS mapping layers.

positive benefits to water quality immediately downstream. Dissolved oxygen levels on Palo Pinto Creek are expected to be slightly improved as the project includes plans to construct a multi-level outlet tower which will always release water to Palo Pinto Creek from the top 10 to 15 feet of the reservoir pool. Current conditions include an existing outlet pipe at Lake Palo Pinto at a fixed elevation of 835 ft-msl which is 32 feet below conservation level. The project is expected to have negligible impacts to total discharge downstream and overall water quality in the Brazos River or Brazos River estuary.

Agricultural Impacts

The Turkey Peak Reservoir site includes hay fields and a pecan orchard. As a result, some impacts are expected for agricultural land use.

4.11.4 Engineering and Costing

An opinion of probable construction costs (OPCC) is currently being developed as part of the final design of the project. However, the final OPCC was not available at the time of completion of this Initially Prepared Plan. If the OPCC becomes available during the IPP review period, costs shown here will be updated to reflect the OPCC.

As a result, cost estimates for the Turkey Peak/Palo Pinto Reservoir were indexed to current September 2018 dollars from those originally prepared by HDR, Inc. in 2013 as part of a preliminary design study. The estimated capital cost of $56.4 million includes costs associated with the relocation of FM 4, the construction of a new bridge and road at the existing dam and spillway at Lake Palo Pinto and the construction of the new dam and spillways along with modifications to the existing dam and spillway. The total project cost is approximately $102.5 million (Table 4.11-1). This includes the costs for construction, land acquisition, resolution of conflicts, environmental permitting and mitigation, engineering, mapping and surveying, utility relocations, design, TxDOT plan review, and construction phase services. Since the project is currently being implemented, the District has already financed a portion of the permitting, planning and design activities as well as legal assistance associated with permit acquisitions. The 12-month safe yield increase of 6,000 acft/yr from the project would provide raw water to the District at a unit cost of $972 per acft or $2.98 per 1,000 gallons.

Table 4.11-1. Cost Estimate for Turkey Peak Project

Item	Estimated Costs for Facilities
Capital Cost	
Dam and Reservoir	$46,347,000
Integration, Relocation, & Other	$10,083,000
Total Cost of Facilities	**$56,430,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$19,751,000
Environmental & Archaeological Studies and Mitigation	$10,252,000
Land Acquisition and Surveying (9,978 acres)	$10,751,000
Interest During Construction (3% for 2 years with a 0.5% ROI)	$5,346,000
Total Cost Of Project	**$102,530,000**
Debt Service (3.5 percent, 20 years)	$1,010,000
Reservoir Debt Service (3.5 percent, 40 years)	$4,129,000
Operation and Maintenance	
Dam and Reservoir	$695,000
Pumping Energy Costs ($0.09 kwh)	$0
Total Annual Cost	**$5,834,000**
Available Project Yield (acft/yr), based on a Peaking Factor of 1	**6,000**
Annual Cost of Water ($ per acft)	**$972**
Annual Cost of Water ($ per 1,000 gallons)	**$2.98**

4.11.5 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 4.11-2, and the option meets each criterion.

The District is actively implementing this project with plans to begin construction in 2020. A summary of the planned implementation steps for the project follows.

- Complete final design of the project.
- Complete land acquisition for the project.
- Secure additional state funding to implement the project.
- Begin construction of the project.

Remaining Regulatory Requirements:

- None

Table 4.11-2. Comparison of Turkey Peak Project to Plan Development Criteria

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet needs
2. Reliability	2. High reliability
3. Cost	3. Reasonable
B. Environmental factors	
1. Environmental Water Needs	1. Low impact
2. Habitat	2. Low impact
3. Cultural Resources	3. Low impact
4. Bays and Estuaries	4. Low impact due to distance from coast
5. Threatened and Endangered Species	5. Low impact
6. Wetlands	6. Low impact
C. Impact on Other State Water Resources	Low to none
D. Threats to Agriculture and Natural Resources	Low to none
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	None
G. Third Party Social and Economic Impacts from Voluntary Redistribution	None

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