3.4.12 George Parkhouse II Lake

3.4.12.1 Description

George Parkhouse II Lake (North) would be located on the North Sulphur River in Lamar and Delta Counties, about 15 miles southeast of the City of Paris. Figure 3.4.12-1 shows the location of the reservoir. The proposed conservation pool is at elevation 410 feet, with a conservation capacity of 330,871 acft. The inundated area at the top of conservation pool is 14,387 acres. The reservoir has a total drainage area of 421 square miles.

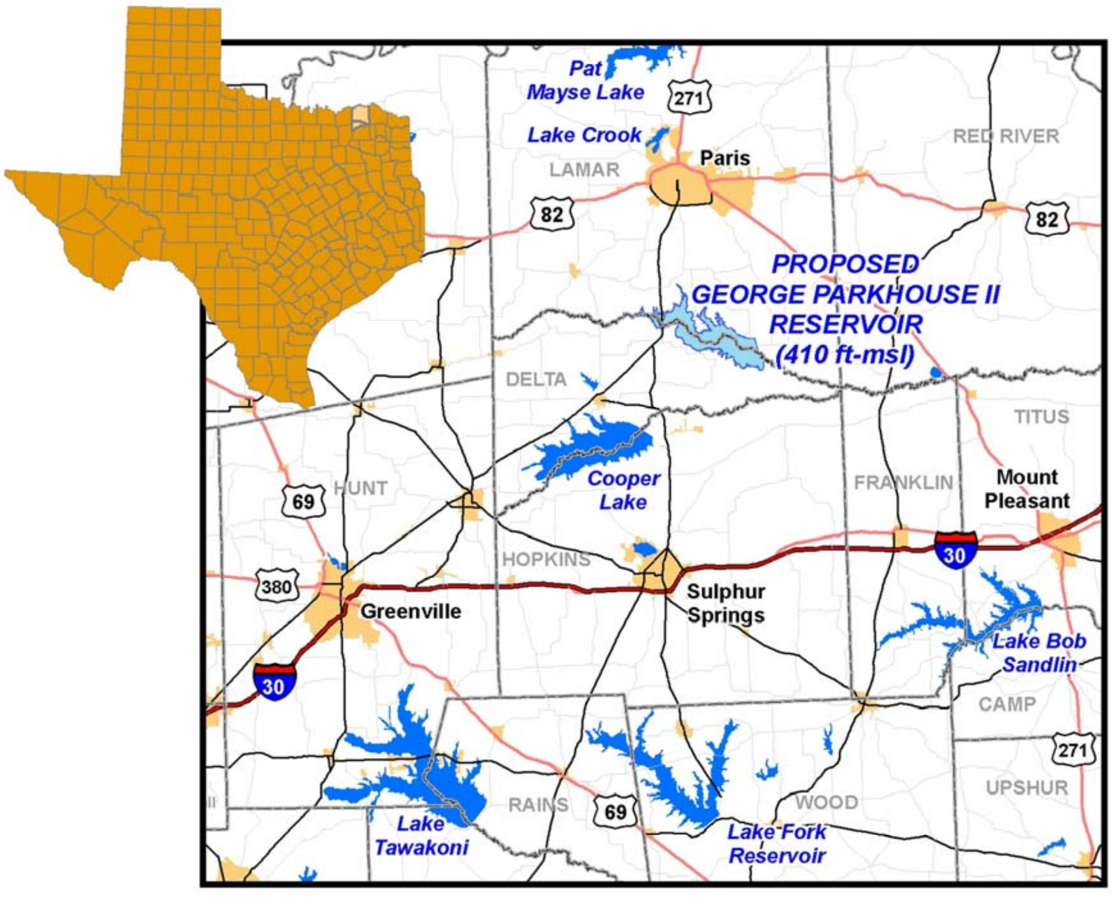

Figure 3.4.12-1 Location Map of George Parkhouse II Lake

This reservoir has been previously studied by Freese and Nichols (1990, 1996, 2000 and 2006). The Region C Water Plan (Freese and Nichols *et al*., 2006) lists George Parkhouse II Lake as an alternate water management strategy for Dallas, the North Texas Municipal Water District, Tarrant Regional Water District, and the Upper Trinity Municipal Water District.

The George Parkhouse II Lake site is not a recommended unique reservoir site in the 2006 regional water plans, but it is one of several potential reservoir sites in the Sulphur River Basin. The projected needs within 50 miles of the proposed reservoir site are 473,850 acft/yr. Much of this need is associated with Region C, located west of the proposed reservoir site. The nearest major demand center is the Dallas-Fort Worth metroplex, which is located approximately 94 miles southwest of the reservoir site.

3.4.12.2 Reservoir Yield Analysis

The elevation-area-capacity relationship is included in Table 3.4.12-1 and shown in Figure 3.4.12-2. The data in Table 3.4.12-1 were developed by Freese and Nichols (2000) by measurement from U.S. Geological Survey topographic quadrangle maps with scale 1:24,000 and 10-foot contour interval. Figure 3.4.12-3 shows the inundation map at different elevations in a 10-foot interval, including the elevation with the probable maximum flood at 418 ft-msl.

Table 3.4.12-2 includes the environmental flows needs calculated using the Consensus Criteria for Environmental Flow Needs (TWDB, 1997). For the yield analyses, it was assumed that the reservoir will have to pass the lesser of the inflow and the values in Table 3.4.12-2.

The firm yield of Parkhouse II Lake was calculated with the full authorization scenario (Run 3) of the Water Availability Model of the Sulphur River Basin (dated July 15, 2004) obtained from TCEQ (Brandes, 1999 and TCEQ, 2006). A control point was added on the Sulphur River at the dam location.

The naturalized flows at the reservoir sites were calculated using the drainage area ratio method with the existing series naturalized flows at gaged location and drainage areas obtained from the USGS, similarly to Parkhouse I and Marvin Nichols (see Section 3.4.8). For Parkhouse II Lake, the naturalized flows were calculated using the incremental flow between the South Sulphur River near Cooper (Control Point A10), the North Sulphur River near Cooper (Control Point B10), and the South Sulphur River near Talco (Control Point C10).

Net evaporation rates were calculated from TWDB quadrangle data of precipitation and gross lake evaporation. Evaporation at the reservoir site was based on data from the Quadrangle 412. Net evaporation rates entered in the Sulphur WAM were adjusted to remove the portion of the precipitation on the reservoir surface area that has been accounted for in the natural inflow.

Table 3.4.12-1.
Elevation-Area-Capacity Relationship for George Parkhouse II Lake

Elevation (feet)	Area (acres)	Capacity (acft)
340.0	0	0
345.0	49	121
350.0	99	490
355.0	162	1,142
360.0	226	2,113
365.0	1,334	5,997
370.0	2,442	15,432
375.0	3,532	30,364
380.0	4,621	50,744
385.0	6,097	77,536
390.0	7,573	111,707
395.0	9,255	153,773
400.0	10,937	204,252
405.0	12,662	263,249
410.0	14,387	330,871

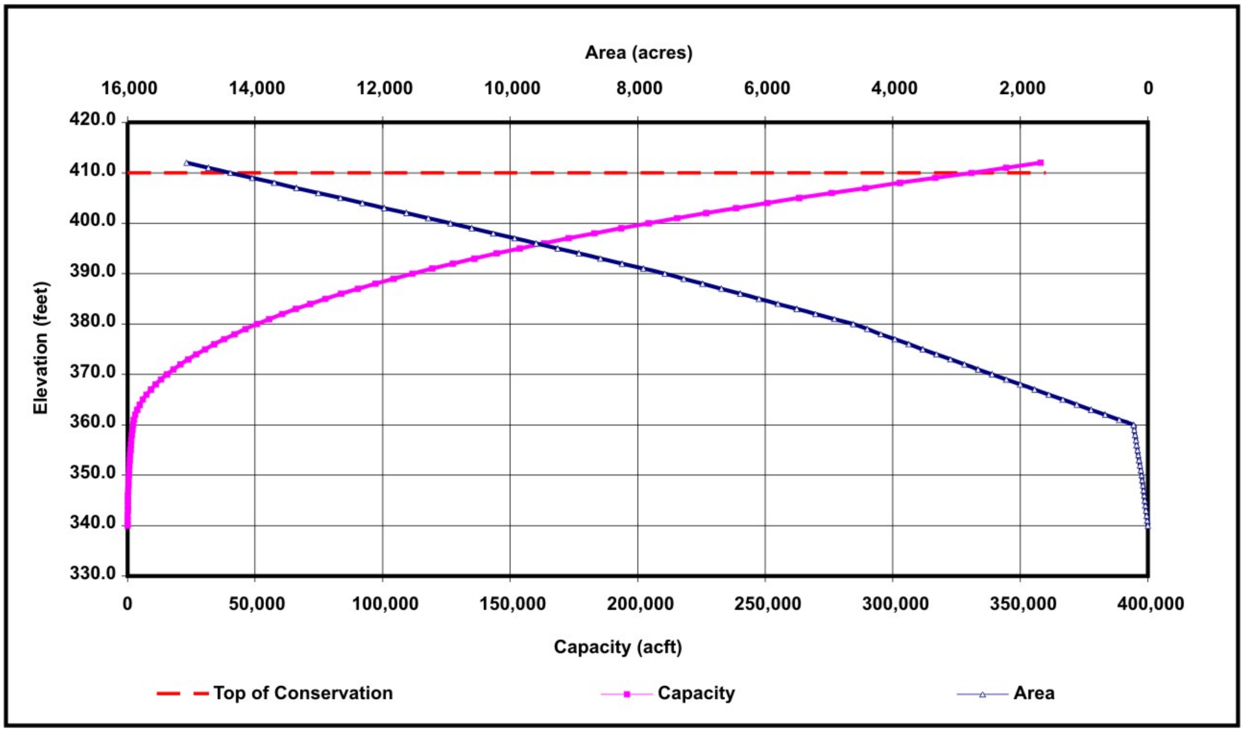

Figure 3.4.12-2. Elevation-Area-Capacity Relationship for George Parkhouse II Lake

Table 3.4.12-2.
Consensus Criteria for Environmental Flow Needs for George Parkhouse II Lake

	Median		25th Percentile		7Q2	
	acft	cfs	acft	cfs	acft	cfs
Jan	2,396	39.0	532	8.6	0	0.0
Feb	3,266	58.3	1,096	19.6	0	0.0
Mar	3,333	54.2	1,045	17.0	0	0.0
Apr	3,129	52.6	1,049	17.6	0	0.0
May	3,289	53.5	874	14.2	0	0.0
Jun	1,175	19.7	205	3.4	0	0.0
Jul	183	3.0	12	0.2	0	0.0
Aug	50	0.8	0	0.0	0	0.0
Sep	66	1.1	0	0.0	0	0.0
Oct	174	2.8	3	0.1	0	0.0
Nov	920	15.4	73	1.2	0	0.0
Dec	2,068	33.6	243	4.0	0	0.0
Total	20,046		5,132		0	
Average	1,671	27.8	428	7.2	0	0.0

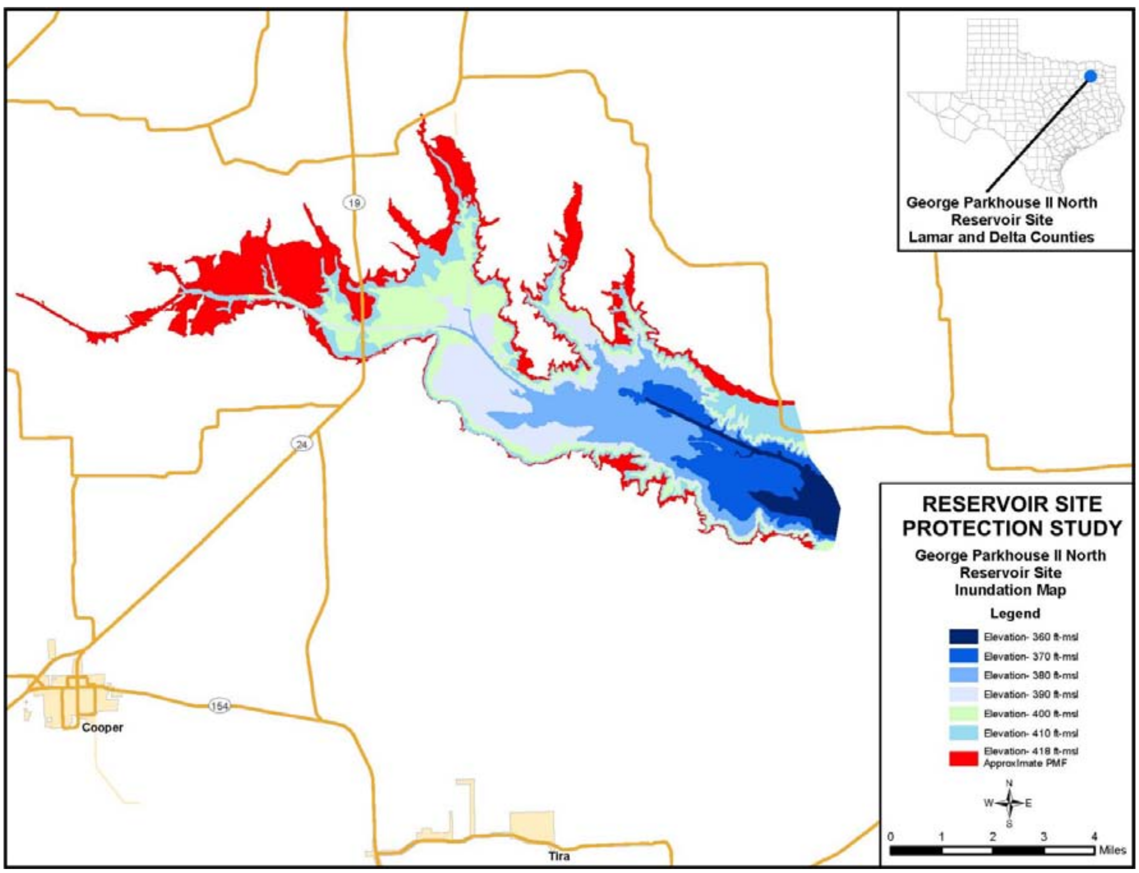

Figure 3.4.12-3. Inundation Map for George Parkhouse II Lake

Yields were calculated for elevations 410, 402, 396, and 390 feet, subject to bypass for environmental flow needs and assuming stand-alone reservoir operations with no minimum reserve content. Results of firm yield at these elevations are included in Table 3.4.12-3 and Figure 3.4.12-4. At the conservation pool level of 410 feet, the firm yield is 144,300 acft/yr. Environmental flow requirements reduce the firm yield of the reservoir by 2,500 acft.

Table 3.4.12-3.
Firm Yield vs. Conservation Storage for George Parkhouse II Lake

Conservation Pool Elevation (ft-msl)	*Conservation Storage (acft)*	*Environmental Bypass Criteria*	*Yield (acft/yr)*	*Critical Period*
390.0	111,707	CCEFN	71,900	8/77-12/78
396.0	163,196	CCEFN	98,600	5/77-12/78
402.0	226,816	CCEFN	120,100	5/54-1/57
410.0*	330,871	CCEFN	144,300	6/51-1/57
		None	146,800	
*Proposed Conservation Storage				

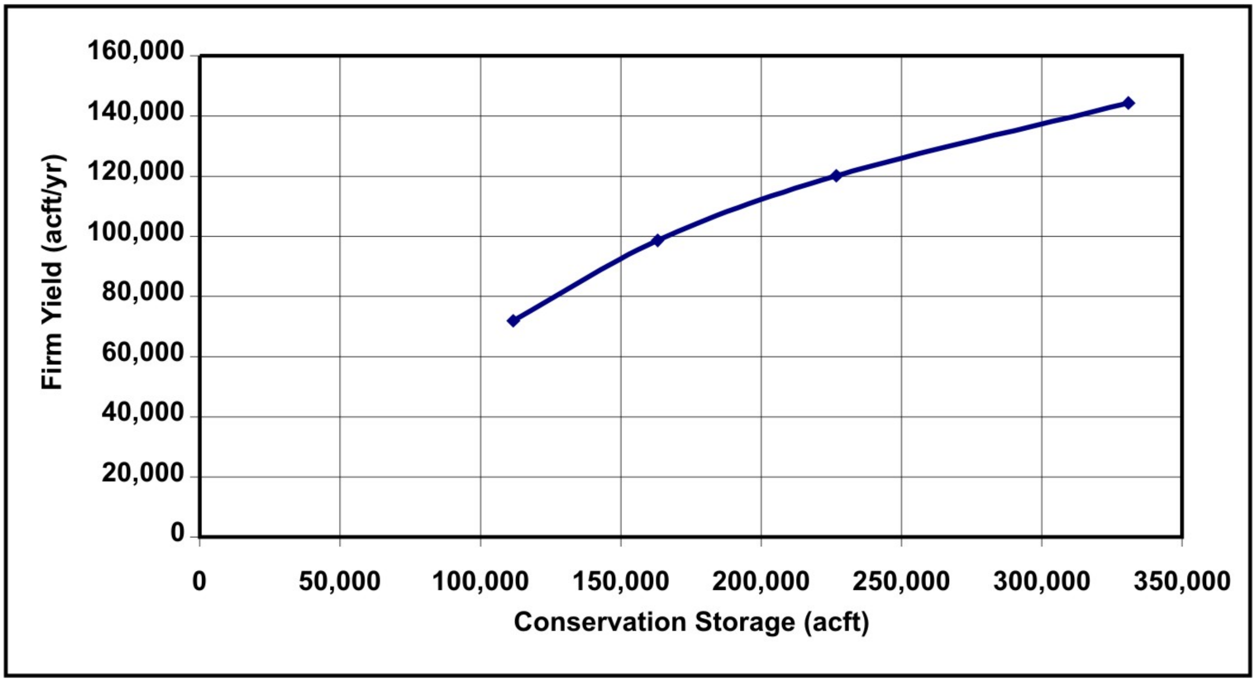

Figure 3.4.12-4. Firm Yield vs. Conservation Storage for George Parkhouse II Lake

The firm yield of Parkhouse II Lake will decrease if one or more of the proposed reservoirs in the Sulphur Basin (Ralph Hall, Parkhouse I, and/or Marvin Nichols) are built and Parkhouse II Lake has a junior priority to any of these reservoirs. As of November 2006, Ralph

Hall Lake is in the permitting process and likely would be senior to Parkhouse II. Yield analysis determined that Ralph Hall Lake would reduce the firm yield of Parkhouse II by 26,900 acft/yr, which is 18 percent of the stand-alone yield. If Parkhouse II is junior to all of the other proposed reservoirs in the Sulphur Basin, its yield would be 32,100 acft/yr, which is 112,200 acft/yr less than the stand-alone yield (or a reduction of 78 percent). Appendix A is a memorandum describing the sensitivity of firm yield to the development of other reservoirs.

Freese and Nichols (1990, 1996, 2000, and 2006) has performed previous evaluations of this reservoir. The 2000 study shows that the firm yield (without restrictions due to environmental flows) is 152,500 acft/yr. The 2006 Region C Water Plan (Freese and Nichols et al., 2006) shows that yield of Parkhouse II is 148,700 acft/yr, which is 4,400 (or 3 percent) more than the yield of this study. Differences between the Region C estimate and this study are due to assumptions for drainage areas for estimating flow. The Region C yield used the Sulphur WAM methodology for calculating drainage areas while this study used calculations from USGS data. The 2000 study shows a higher yield because it does not consider environmental flows.

The simulated storage trace and frequency curve for storage content for George Parkhouse II Lake with an annual diversion of 144,300 acft are shown in Figure 3.4.12-5. At the conservation pool of 410 feet, assuming full diversion, the reservoir would be full about 23 percent of the time and would be below 50 percent of the conservation storage about 8 percent of the months.

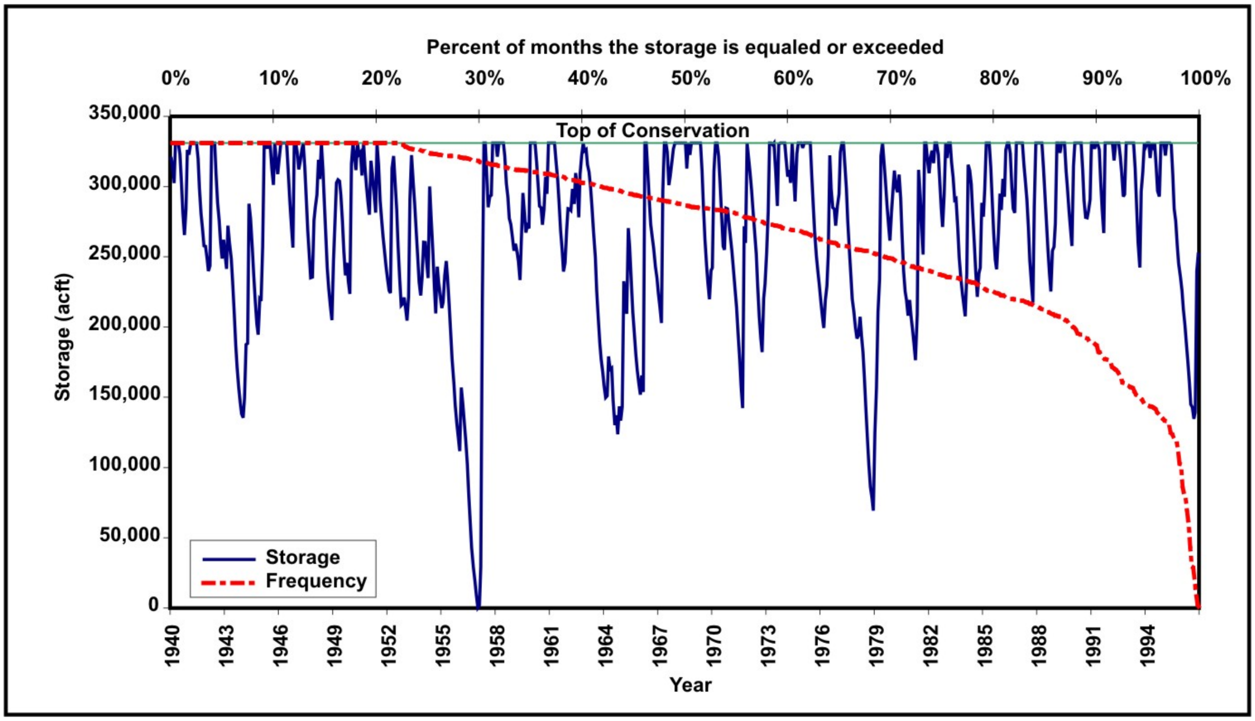

Figure 3.4.12-5. Simulated Storage in George Parkhouse II Lake (Conservation Elevation = 410 ft-msl, Diversion = 144,300 acft/yr)

3.4.12.3 Reservoir Cost

The quantities used for the costs for the George Parkhouse II Dam are based on data developed from previous studies (Freese and Nichols, 2000). The dam and spillway costs assume a zoned earthen embankment with a gated spillway structure. The length of the dam is estimated at 24,760 feet with a maximum elevation of 420 ft-msl. The service spillway includes a gated ogee-type weir constructed of concrete, ten tainter gates, a stilling basin and discharge channel.

The conflicts identified at the site include electrical lines, roads (including State Highway 19), oil and gas wells, one water well, and two 30-inch parallel gas lines. A list of the potential conflicts is provided in Table 3.4.12-4. Quantities for these conflict resolutions are based on data obtained from the Railroad Commission and TNRIS. Figure 3.4.12-6 shows the conflicts as mapped by TNRIS.

Table 3.4.12-4. List of Potential Conflicts for George Parkhouse II Lake

Gas Pipelines	Power Transmission Lines
Roads	Wells

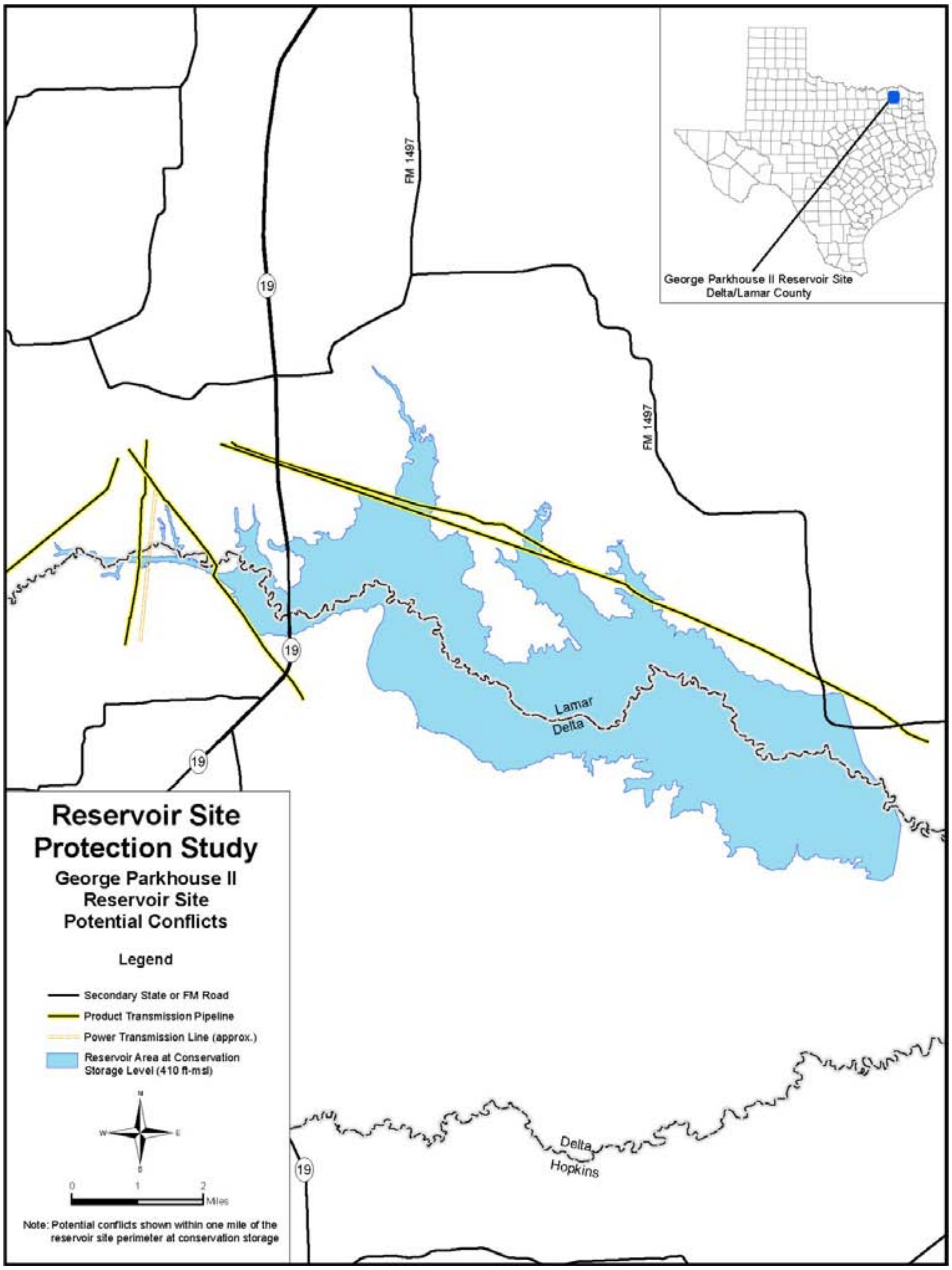

Figure 3.4.12-6. Potential Major Conflicts for George Parkhouse II Lake

Table 3.4.12-5 shows the estimated capital costs for the George Parkhouse II Lake Project, including construction costs, engineering, permitting, and mitigation. Unit costs for the dam and reservoir are based on the unit cost assumptions used in this study. The total estimated cost of the project is $210 million (2005 prices). Assuming a yield of 144,300 acft/yr, raw water from the project will cost approximately $107 per acft ($0.33 per 1,000 gallons) during the debt service period.

3.4.12.4 Environmental Considerations

The George Parkhouse II Lake is not located on an identified ecologically significant stream segment. The Region D Water Planning Group did not identify the Sulphur River as ecologically unique in the 2006 water plan. The reservoir site is located some distance upstream of a Priority 1 bottomland hardwood preservation site identified as Sulphur River Bottoms West (USFWS, 1985).

George Parkhouse II Lake will inundate approximately 14,400 acres of land at conservation storage capacity. Table 3.4.12-6 and Figure 3.4.12-7 summarize existing landcover for the George Parkhouse II Lake site as determined by TPWD using methods described in Appendix C. Existing landcover within this reservoir site is dominated by grassland (49 percent) with sizeable areas of upland deciduous forest (26 percent) and agricultural land (16 percent). Only about 1.4 percent of this site is classified as bottomland hardwood forest.

Table 3.4.12-5.
Cost Estimate - George Parkhouse II Reservoir @ Elevation 410 ft-msl
(page 1 of 2)

	Quantity	Unit	Unit Price	Cost
Dam & Reservoir				
Excavation	802,200	CY	$2.50	$2,005,500
Fill				
Random Compacted Fill	3,173,100	CY	$2.50	$7,932,800
Impervious Fill	786,000	CY	$3.00	$2,358,000
Structural Fill	8,600	CY	$12.00	$103,200
Filter Drain	296,300	CY	$35	$10,370,500
Bridge	490	LF	$1,300	$637,000
Roadway	60,520	SY	$20	$1,210,400
Slurry Trench	1,078,000	SF	$15	$16,170,000
Soil Cement	208,100	CY	$65	$13,526,500
Barrier Warning System	490	LF	$100	$49,000
Gates				
Gate & Anchor	10,000	SF	$275	$2,750,000
Stop Gate & Lift	490	LF	$2,000	$980,000
Hoist	10	EA	$250,000	$2,500,000
Electrical	1	LS	$550,000	$550,000
Power Drop	1	LS	$250,000	$250,000
Spillway Low-Flow System	1	LS	$400,000	$400,000
Stop Gate Monorail System	490	LF	$1,000	$490,000
Guardrail	780	LF	$30	$23,400
Grassing	100	AC	$4,500	$450,000
Concrete (mass)	79,700	CY	$150	$11,955,000
Concrete (reinforced)	24,100	CY	$475	$11,447,500
Subtotal				***$86,158,800***
Mobilization (5% of subtotal)				$4,307,900
Care of water (3% of subtotal)				$2,584,800
Clearing and Grubbing	150	AC	$4,000	$600,000
Land Clearing	3,600	AC	$1,000	$3,600,000
Engineering and Contingencies (35%)				$34,038,000
Subtotal for Dam & Reservoir				**$131,289,500**
Conflicts				
Highways				
State Highways (S.H.19)	8,400	LF	$900	$7,560,000
F.M.	11,100	LF	$150	$1,665,000
Gas pipelines				
30-inch (2 pipelines)	33,800	LF	$98	$3,312,000
Oil & Gas wells	9	EA	$25,000	$225,000
Water Wells	1	EA	$49,000	$49,000
Power Transmission lines	610	LF	$450	$275,000
Engineering and Contingencies (35%)				$4,580,000
Subtotal of Conflicts				**$17,666,000**
	Quantity	**Unit**	**Unit Price**	**Cost**
Land Acquisition	15,826	AC	$1,201	$19,007,000
Environmental Studies and Mitigation Lands	15,826	AC	$1,201	$19,007,000
Total Reservoir Construction Cost				**$186,969,500**
Interest During Construction (36 months)				**$22,749,000**
TOTAL COST				**$209,718,500**

Table 3.4.12-5.
Cost Estimate - George Parkhouse II Reservoir @ Elevation 410 ft-msl
(page 2 of 2)

ANNUAL COSTS	
Debt Service (6% for 40 years)	$13,938,000
Operation & Maintenance	$1,551,000
Total Annual Costs	**$15,489,000**
UNIT COSTS	
Per Acre-Foot	$107
Per 1,000 Gallons	$0.33
Units: AC = Acre; CY = Cubic Yard; EA = Each; LB = Pound; LF = Linear Foot; LS = Lump Sum; SF = Square Foot; and SY = Square Yard.	

Table 3.4.12-6.
Acreage and Percent Landcover for George Parkhouse II Reservoir

Landcover Classification	*Acreage[1]*	*Percent*
Bottomland Hardwood Forest	208	1.4%
Seasonally Flooded Shrubland	170	1.1%
Swamp	31	0.2%
Evergreen Forest	9	0.0%
Upland Deciduous Forest	4,003	26.0%
Grassland	7,605	49.5%
Shrubland	672	4.4%
Agricultural Land	2,424	15.8%
Urban / Developed Land	45	0.3%
Open Water	200	1.3%
Total	15,367	100.0%

[1] Acreage based on approximate GIS coverage rather than calculated elevation-area-capacity relationship.

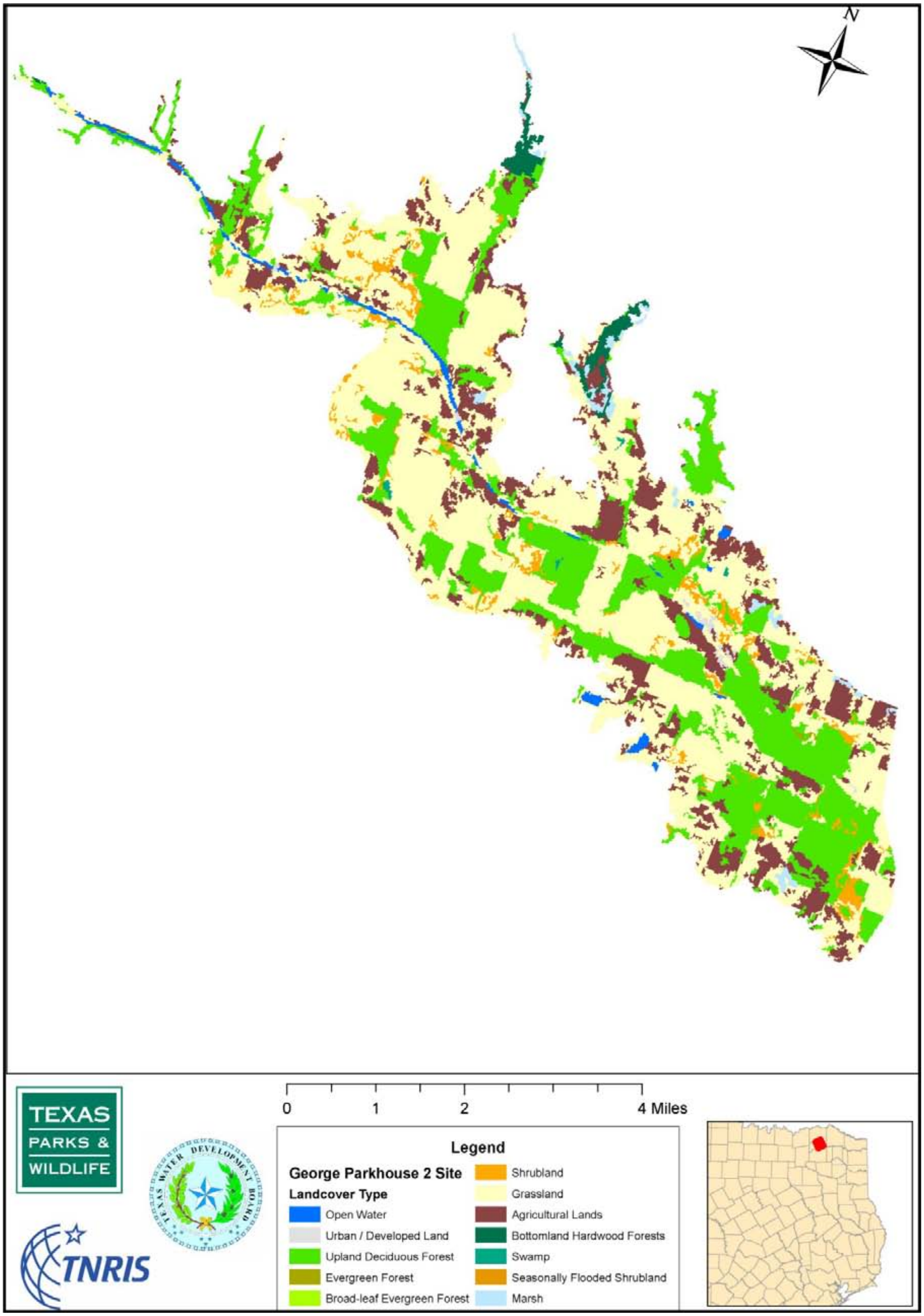

Figure 3.4.12-7. Existing Landcover for George Parkhouse II Lake

3.4.13 Lake Ralph Hall

3.4.13.1 Description

Lake Ralph Hall is proposed by the Upper Trinity Regional Water District (UTRWD) on the North Sulphur River in the Sulphur River Basin in Fannin County, as illustrated in Figure 3.4.13-1. The reservoir is recommended as a water management strategy in the 2006 Region C Water Plan and the 2007 State Water Plan (Texas Water Development Board, 2006). The primary purpose of the project is to provide a municipal water supply source to meet future water demands within that portion of Fannin County that lies within the Sulphur Basin and future demands within the service area of the UTRWD in the Trinity River Basin. A water rights permit application for the project is pending review and approval at the Texas Commission on Environmental Quality (TCEQ). An application for a Section 404 permit has also been submitted to the U. S. Army Corps of Engineers.

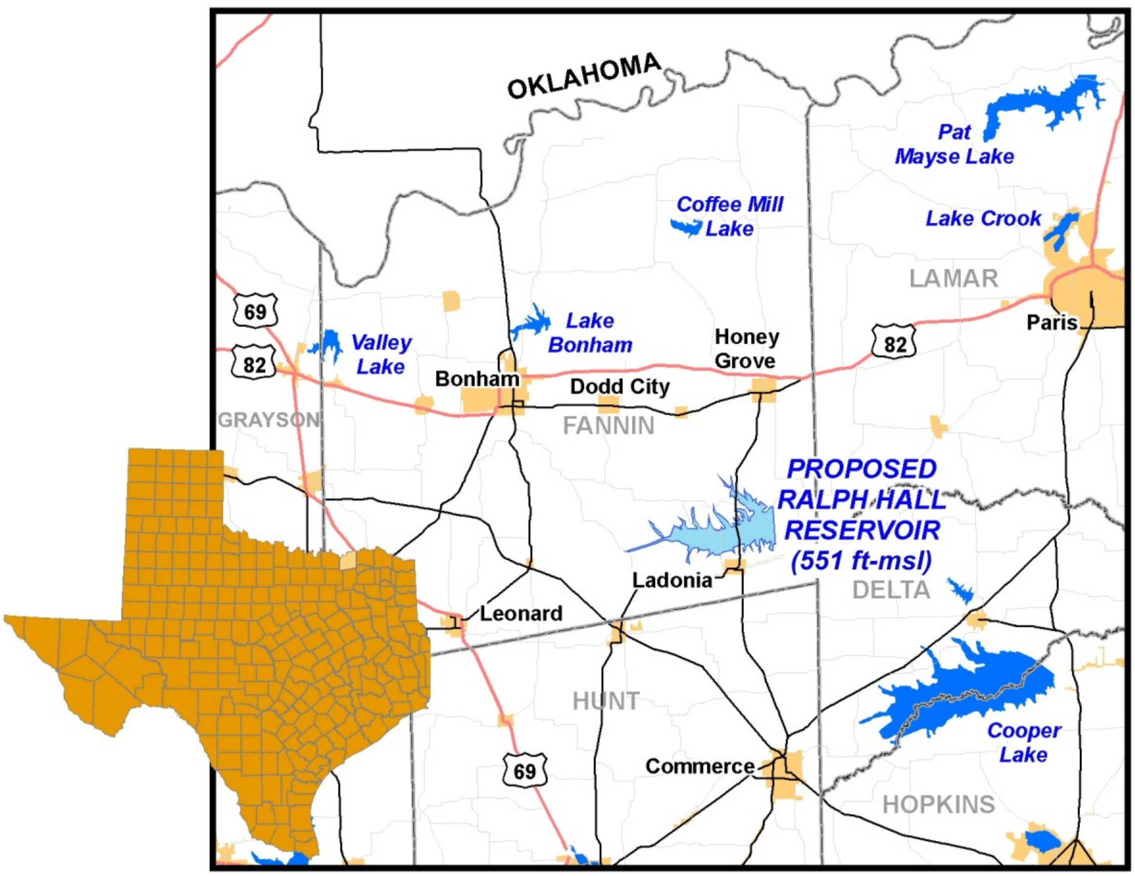

Figure 3.4.13-1. Location Map of Lake Ralph Hall

The maximum storage capacity of the project is proposed to be 160,235 acft at an elevation of 551 ft-msl. The firm yield is estimated to be approximately 32,940 acft/yr; however, annual withdrawals from the reservoir may be as much as 45,000 acft/yr as the project is operated in a systems mode with other UTRWD sources of water in order to maximize UTRWD's overall available water supply. The projected water needs within 50 miles of the proposed reservoir site by 2060 are approximately 419,000 acft/yr. The nearest major demand center is the Dallas/Fort Worth metroplex, which is located approximately 70 miles west of the project site.

The upstream drainage area of the project is approximately 101 square miles. The reach of the North Sulphur River, where Lake Ralph Hall is to be located, is unique because of the deep, incised, and eroded river channel that lies within a fairly broad, flat floodplain. While the depth and width of the river channel vary in the vicinity of the proposed project, at the proposed dam site, it is a steep-walled, deep gorge approximately 40 feet deep and 300 feet wide, with the capacity to fully contain and convey the 100-year flood. The existing river channel has been formed over the years by extensive erosion of a relatively small man-made drainage ditch that was constructed in the late 1920's and early 1930's along the valley of the North Sulphur River to protect and drain agricultural fields. With the impoundment of Lake Ralph Hall, the ongoing erosional processes in the river channel within the reservoir and for some distance downstream will be curtailed.

The proposed structure will consist of an earth-filled embankment across the valley of the North Sulphur River with a crest elevation of 562 ft-msl. An ungated concrete principal spillway will be constructed within the channel of the river near the center of the embankment, and a concrete-capped emergency spillway will be located within the embankment on the northern floodplain of the river.

3.4.13.2 Reservoir Yield Analysis

The water supply capabilities of the proposed reservoir site were previously investigated by R. J. Brandes Company as part of the original planning for the project, and results from that study formed the basis for the water rights permit application that has been submitted to the TCEQ. Additional yield analyses have not been undertaken since the physical features of the dam and reservoir for Lake Ralph Hall already have been established and included in the pending application.

The elevation-area-capacity relationship and the corresponding conservation storage capacity for the proposed reservoir, as determined from a two-foot contour map of the reservoir site prepared specifically for the project, are presented in Table 3.4.13-1 and depicted graphically in Figure 3.4.13-2. Figure 3.4.13-3 shows the reservoir inundation area at different water surface elevations.

Table 3.4.13-1.
Elevation-Area-Capacity Relationship for Lake Ralph Hall

Elevation (ft-msl)	*Area (acres)*	*Capacity (acft)*
460.0	0	0
470.0	18	57
480.0	50	397
500.0	208	2,357
510.0	941	7,521
520.0	2,003	21,849
530.0	3,307	47,989
540.0	5,189	90,104
550.0	7,345	152,630
551.0	7,605	160,235
560.0	9,914	238,693
564.0	10,985	280,506

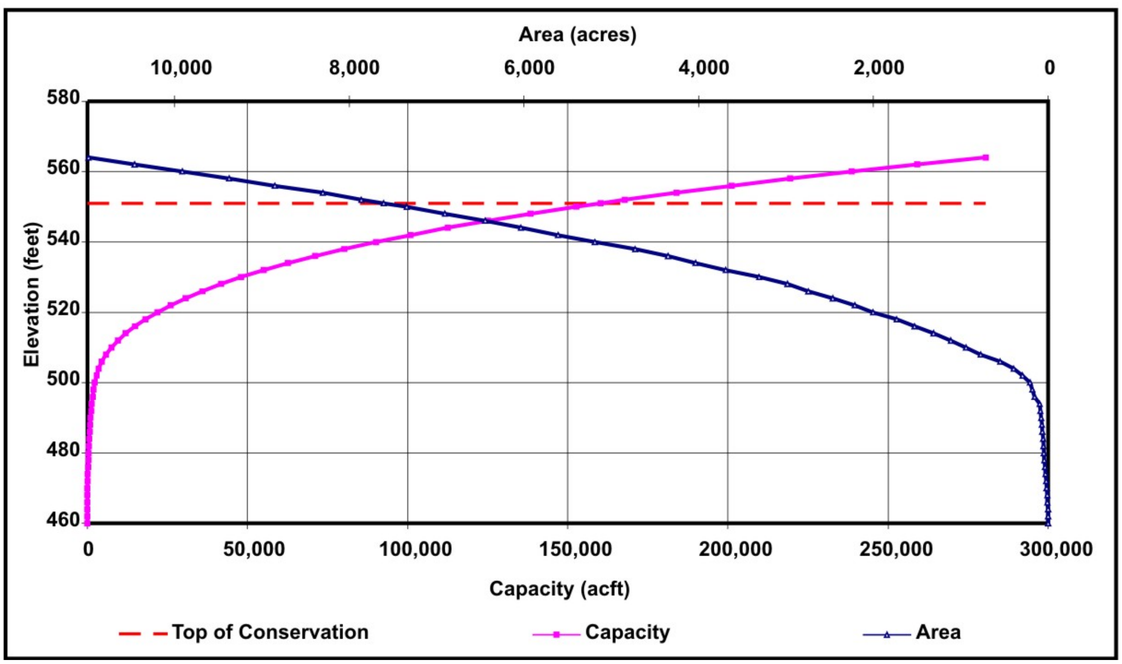

Figure 3.4.13-2. Elevation-Area-Capacity Relationship for Lake Ralph Hall

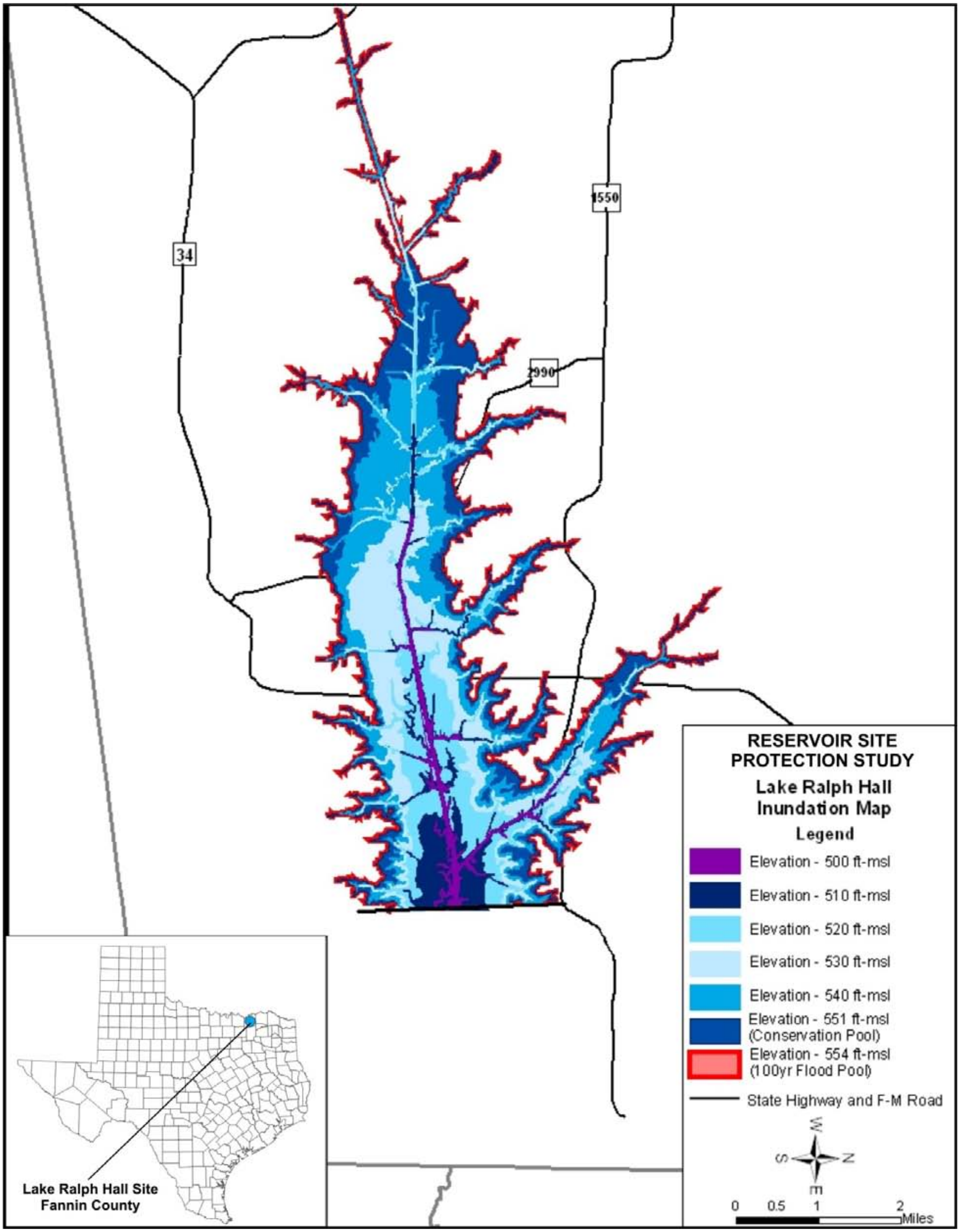

Figure 3.4.13-3. Inundation Map for Lake Ralph Hall

For purposes of the pending water rights permit application for Lake Ralph Hall, the Lyons Method was used for estimating environmental flow requirements as a placeholder until field studies could be undertaken to provide a more scientific basis for establishing appropriate river flows for protecting downstream biological resources. This method basically assumes that 40 percent of the median daily flow for each of the months of October through February and 60 percent of the median daily flow for each of the months of March through September are adequate to protect existing riverine aquatic resources. For the North Sulphur River at the project site, this calculated environmental flow was adjusted to a minimum of the seven-day average low flow with a two-year recurrence interval, or 0.1 cfs for this reach of the North Sulphur River. The resulting environmental flow values that were used in the original yield analyses are presented in Table 3.4.13-2.

Table 3.4.13-2.
Lyons Criteria for Environmental Flow Needs for Lake Ralph Hall

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median	acft/mo	584	818	812	607	541	238	37	6	12	37	202	449
	cfs	9.5	14.6	13.2	10.2	8.8	4.0	0.6	0.1	0.2	0.6	3.4	7.3
Lyons	acft/mo	211	325	486	365	324	144	22	6	7	14	81	180
	cfs	3.4	5.8	7.9	6.1	5.3	2.4	0.4	0.1	0.1	0.2	1.4	2.9
7Q2	acft/mo	6	6	6	6	6	6	6	6	6	6	6	6
	cfs	0.1											
Note: The 7Q2 value is used when it exceeds the value of the median and/or quartile.													

Simulations using the TCEQ Sulphur Basin Water Availability Model, appropriately modified to incorporate Lake Ralph Hall and its associated environmental flow requirements as described above, were made during the initial planning investigations for the project to evaluate its potential yield. These firm yield analyses were performed assuming stand-alone reservoir operations with no minimum reserve content. Results from these simulations, considered in conjunction with various topographic, environmental and physiographic factors regarding the reservoir site, culminated in the decision to establish the conservation pool level for the reservoir at elevation 551 ft-msl, which provided the adopted total conservation storage capacity of 160,235 acft. The firm yield at this reservoir capacity was determined to be 32,940 acft/yr. As noted previously, Lake Ralph Hall is to be operated as part of the overall water supply system for the UTRWD; therefore, the pending water rights permit application stipulates that up to 45,000 acft/yr may be withdrawn from the reservoir. Figure 3.4.13-4 presents a graph of the simulated storage trace for Lake Ralph Hall operated under firm yield conditions and the corresponding storage frequency curve. Subject to firm yield diversions, the reservoir is expected to be full about 10 percent of the time and more than half full about 85 percent of the time.

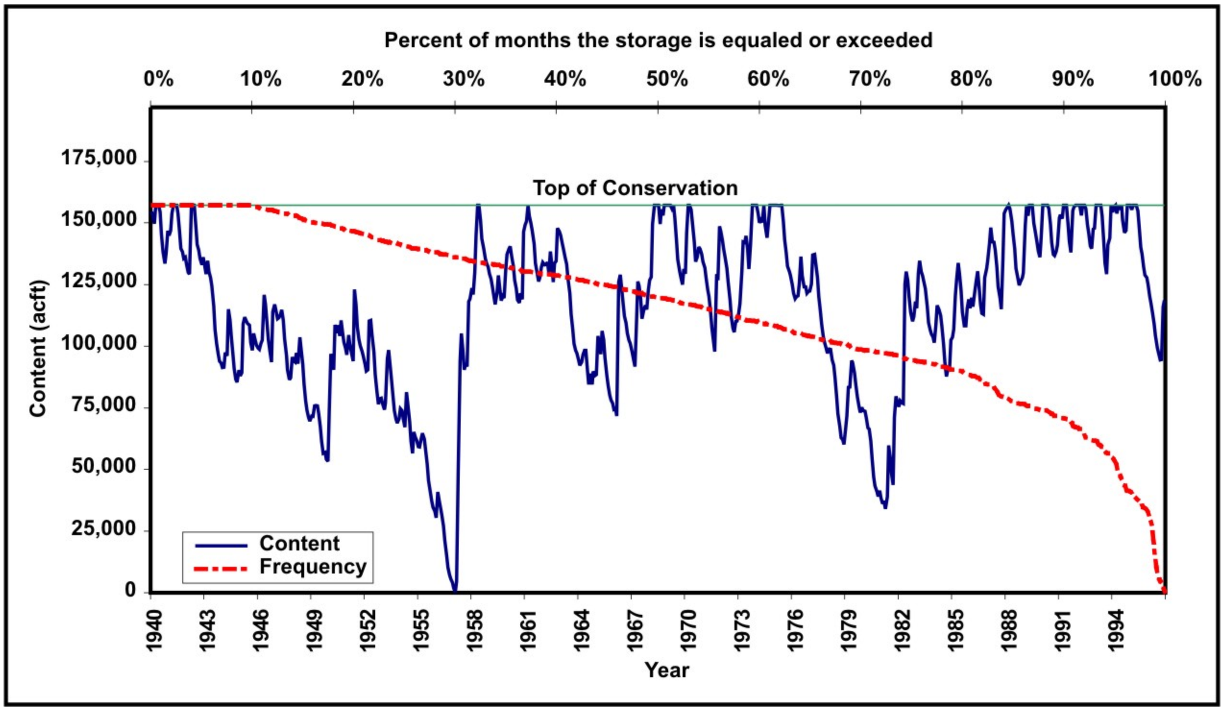

Figure 3.4.13-4. Simulated Storage in Lake Ralph Hall (Conservation Elevation = 551 ft-msl, Diversion = 32,940 acft/yr)

3.4.13.3 <u>Reservoir Costs</u>

The projected costs for the Lake Ralph Hall dam assume a zoned earthen embankment with an impervious core which will have a maximum height of 100 feet. The upstream face of the embankment will be constructed with a 3:1 slope (horizontal-to-vertical) and will be protected from wave erosion with a rock riprap blanket. The downstream face will be constructed with a 4:1 slope to improve stability and to facilitate maintenance and mowing activities. The overall top width of the embankment will be 20 feet at elevation 562 ft-msl. Internal drains will be provided to remove any seepage that may accumulate within the downstream slope of the embankment. As planned, a 5-cycle labyrinth weir will act as the principal spillway with a total spillway width of 300 feet. An emergency spillway is planned for the left abutment with a total ogee crest length of 1,550 feet. The embankment will be approximately 12,900 feet in length, including the spillways.

The conflicts identified at the site include roadways, bridges, utilities, and miscellaneous relocations. A list of the potential conflicts is provided in Table 3.4.13-3. The conflict costs represent less than 18 percent of the total construction cost of the reservoir project. Figure 3.4.13-5 shows the conflicts as mapped by TNRIS.

Table 3.4.13-3.
List of Potential Conflicts for Lake Ralph Hall

Description	*Unit*	*Quantity*
Roadways	Mile	2.1
Bridges	Mile	1.7
Utilities	Mile	10.1
Miscellaneous Relocations		

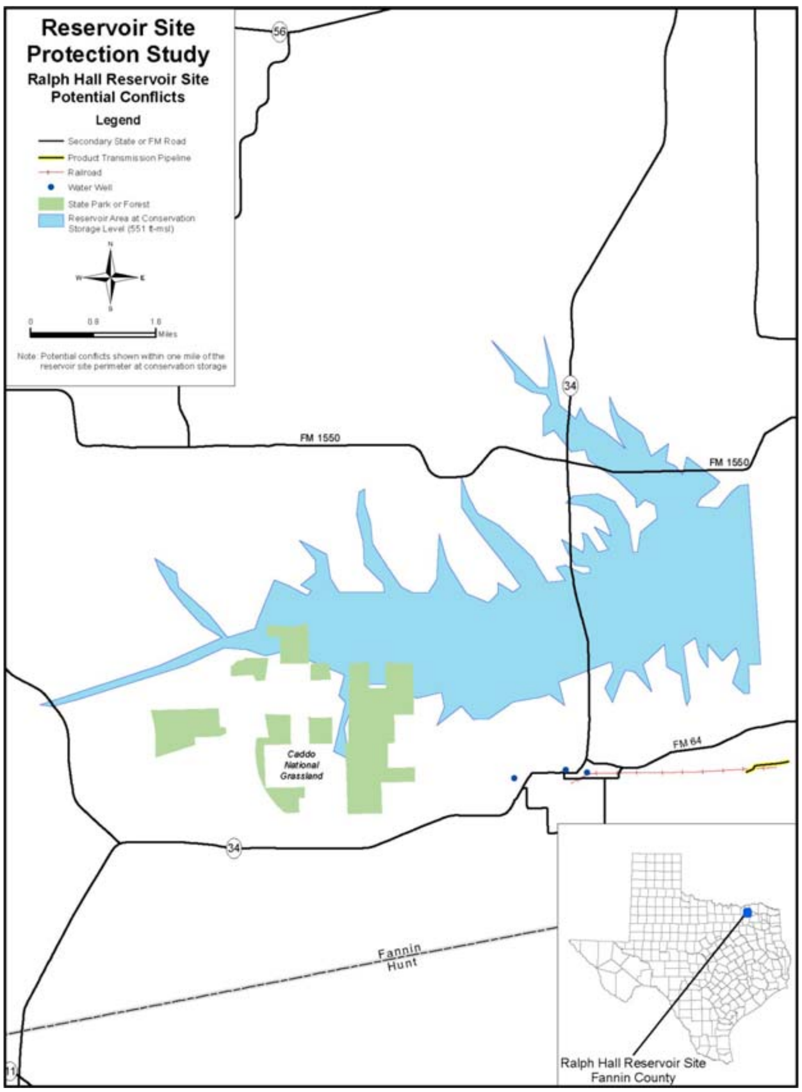

Figure 3.4.13-5. Potential Major Conflicts for Lake Ralph Hall

Table 3.4.13-4 summarizes the estimated capital costs for the Lake Ralph Hall dam and reservoir project, including construction costs, engineering, permitting and mitigation. Unit costs for the dam and reservoir are based on the cost assumptions used in this study. The total estimated cost of the project is $198.5 million (2005 prices). Assuming an annual yield of 32,940 acft/yr, raw water from the project will cost approximately $430 per acft ($1.32 per 1,000 gallons) during the debt service period.

3.4.13.4 Environmental Considerations

Environmental impacts of constructing and operating the Lake Ralph Hall project are considered to be minimal primarily because of the characteristics of the reservoir site. As noted above, the segment of the river channel that is to be inundated by the reservoir already has undergone significant change due to extensive erosion, such that the channel is a steep-walled, deep gorge approximately 40 feet deep and 300 feet wide, with the capacity to fully contain and convey the 100-year flood. Overbank areas outside of the channel consist primarily of pasture land, with some farming.

Studies conducted to date indicate that the presence of the reservoir will tend to curtail the channel erosion process and provide a more stable condition. For mitigation purposes, the UTRWD proposes to restore an abandoned segment of the original river channel within the overbank area near the dam site in order to create new aquatic and wildlife habitat.

Lake Ralph Hall will inundate approximately 7,605 acres of land at conservation storage capacity. Table 3.4.13-5 and Figure 3.4.13-6 summarize existing landcover for the Lake Ralph Hall site as determined by TPWD using methods described in Appendix C. Existing landcover within this reservoir site is dominated by grassland (48 percent) with sizeable, but fragmented, areas of upland deciduous forest (23 percent) and agricultural land (18 percent). TPWD did not classify any of the reservoir site as bottomland hardwood forest.

Table 3.4.13-4.
Cost Estimate – Lake Ralph Hall @ Elevation 551 ft-msl
(page 1 of 2)

	Size	*Quantity*	*Unit*	*Unit Price*	*Cost*
Mobilization and Demobilization (5%)		1	LS	$4,306,387	**$4,306,387**
Dam & Reservoir					
Stormwater Prevention		1	LS	$897,711	$897,711
Clearing & Grubbing		450	AC	$2,500	$1,125,000
Embankment Random Fill		3,285,720	CY	$2	$6,571,440
Embankment Core		842,830	CY	$3	$2,528,490
Principal Spillway Reinf. Conc.		38,034	CY	$320	$12,170,880
Emergency Spillway Mass/Reinf. Conc.		39,060	CY	$290	$11,327,400
Emergency Spillway Excavation.		6,630,000	CY	$2	$13,260,000
Rock Riprap		196,455	SY	$80	$15,716,400
Care of Water		1	LS	$201,000	$201,000
Subtotal for Dam and Reservoir					**$63,798,321**
Engineering and Contingencies (35% Dam & Reservoir)					**$22,329,412**
Total - Dam & Reservoir Construction					**$90,434,120**
Conflicts					
Roadways		11,140	LF	$200	$2,228,000
Bridges		9,000	LF	$2,070	$18,630,000
Utility Relocations		53,500	LF	$75	$4,012,500
Miscellaneous Relocations		1	LS	$2,000,000	$2,000,000
Subtotal Conflicts					**$26,870,500**
Engineering & Contingencies (35% Conflicts)					**$9,404,675**
Subtotal (Dam & Reservoir, Conflicts)					**$126,709,295**
Land Acquisition		**11,300**	**AC**	**$2,675**	**$30,227,500**
Mitigation		**11,300**	**AC**	**$2,675**	**$30,227,500**
CONSTRUCTION TOTAL					**$187,164,295**
Interest During Construction (24 months)					**$11,314,064**
TOTAL COST					**$198,478,359**

Table 3.4.13-4.
Cost Estimate – Lake Ralph Hall @ Elevation 551 ft-msl
(page 2 of 2)

	Size	*Quantity*	*Unit*	*Unit Price*	*Cost*
ANNUAL COSTS					
Debt Service (6% for 40 years)					$13,191,000
Operation & Maintenance					$956,975
Total Annual Costs					**$14,147,975**
FIRM YIELD (acft/yr)					**32,940**
UNIT COSTS					
Per Acre-Foot					$430
Per 1,000 Gallons					$1.32

Units: AC = Acre; CY = Cubic Yard; EA = Each; LB = Pound; LF = Linear Foot; LS = Lump Sum; SF = Square Foot; and SY = Square Yard.

Table 3.4.13-5.
Acreage and Percent Landcover for Lake Ralph Hall

Landcover Classification	***Acreage[1]***	***Percent***
Swamp	3	0.0%
Upland Deciduous Forest	1,873	23.4%
Grassland	3,874	48.5%
Shrubland	771	9.6%
Agricultural Land	1,436	18.0%
Urban / Developed Land	19	0.2%
Open Water	21	0.3%
Total	7,997	100.0%

[1] Acreage based on approximate GIS coverage rather than calculated elevation-area-capacity relationship.

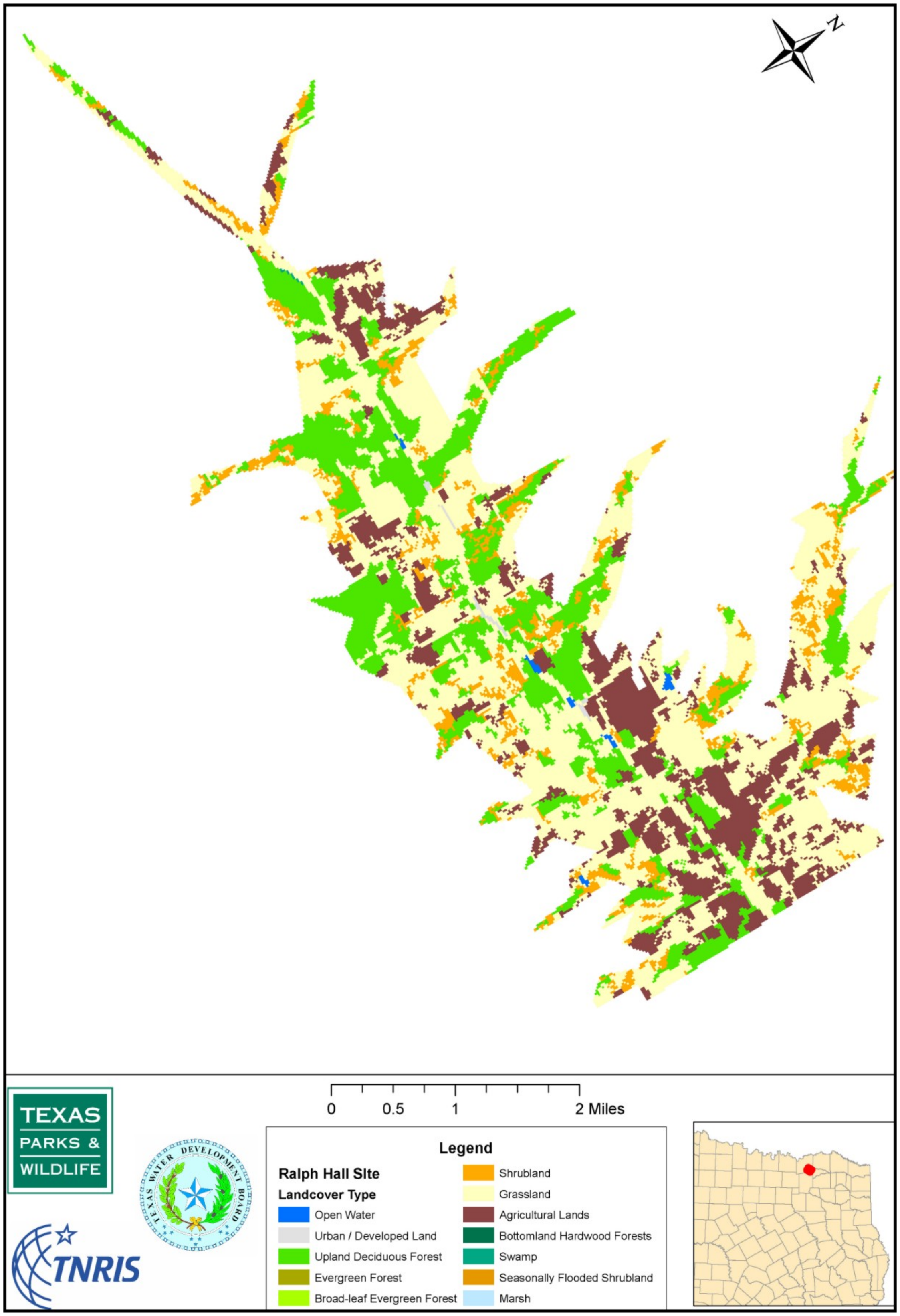

Figure 3.4.13-6. Existing Landcover for Lake Ralph Hall

(This page intentionally left blank.)

3.4.14 Ringgold Reservoir

3.4.14.1 <u>Description</u>

Ringgold Reservoir would be located on the Little Wichita River east of Henrietta, just upstream of the confluence with the Red River in Clay County. Figure 3.4.14-1 shows the location of the reservoir. The proposed conservation pool is at elevation 844 feet, with a conservation capacity of 271,600 acft. The inundated area at the top of conservation pool is 14,980 acres. The reservoir has a total contributing drainage area of 1,475 square miles, of which 822 are controlled by Lake Arrowhead.

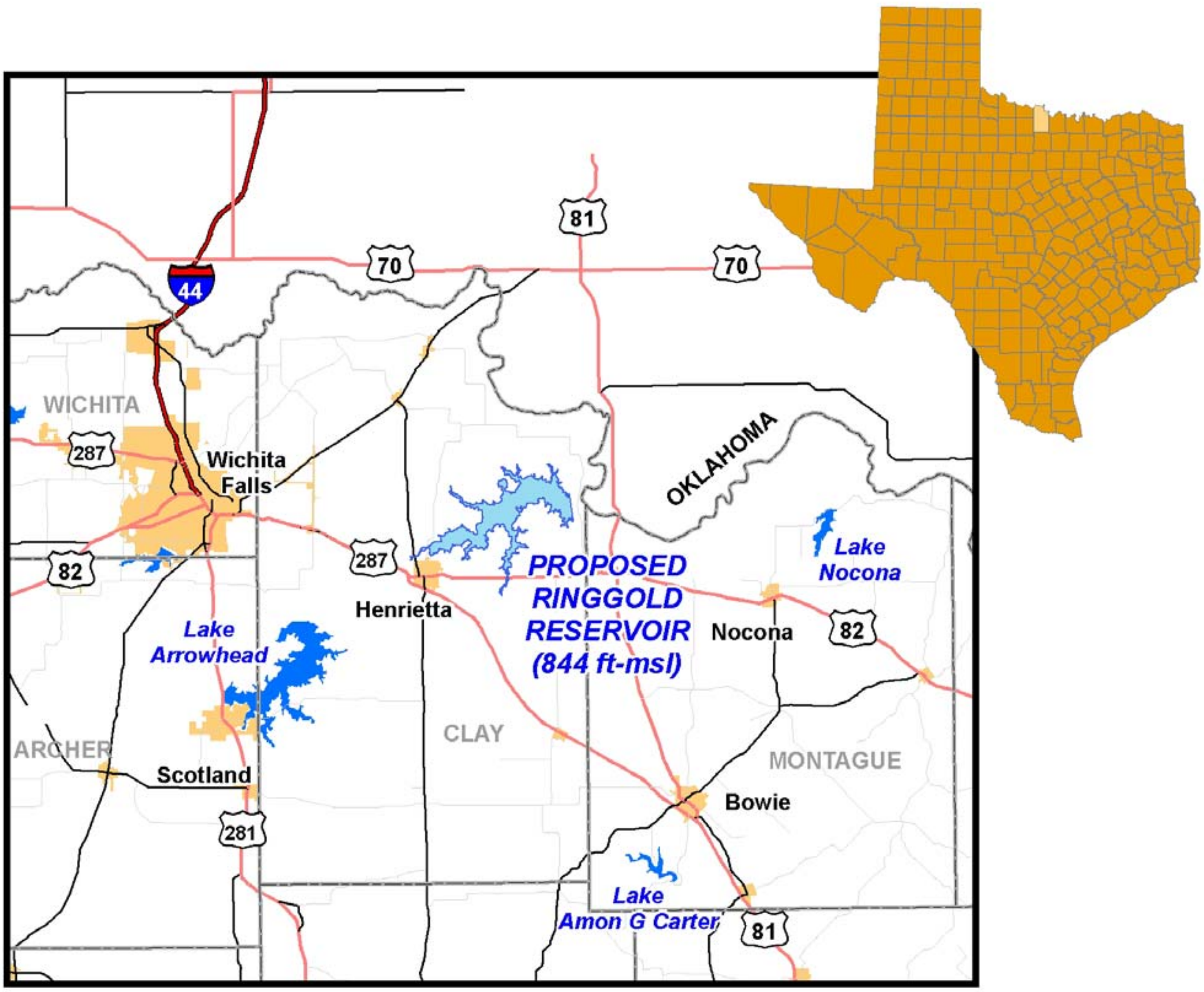

Figure 3.4.14-1 Location Map of Ringgold Reservoir

This reservoir has been previously studied by Freese and Nichols (1958 and 1981). Ringgold Reservoir was a recommended water management strategy for the City of Wichita Falls in the 2001 Region B Water Plan, and it is an alternate water management strategy in the 2006 Region B Water Plan (Biggs & Mathews *et al.*, 2001 and 2006).

The Region B Water Planning Group recognizes that the Ringgold Reservoir site may be one of the last viable reservoir sites in the area, but the region chose not to recommend designation as a Unique Reservoir Site until additional information is made available to the planning group. The reservoir has historically been included as part of the long-term water supply plans for the City of Wichita Falls, which provides most of the municipal and manufacturing supplies in Region B. The projected needs for additional water supply within 50 miles of the proposed reservoir site are 313,933 acft/yr. Much of this need is associated with Region C, located east and south of the proposed reservoir site. The nearest major demand center is the Dallas-Fort Worth metroplex, which is located approximately 96 miles southeast of the reservoir site.

3.4.14.2 Reservoir Yield Analysis

The elevation-area-capacity relationship is included in Table 3.4.14-1 and Figure 3.4.14-2. The data in Table 3.4.14-1 were developed by Freese and Nichols (1981) by measurement from U.S. Geological Survey topographic quadrangle maps. Figure 3.4.14-3 shows the inundation map at different elevations in a 10-foot interval. Figure 3.4.14-3 also shows the inundation of the reservoir at elevation 847 ft-msl, which is the estimated maximum elevation before the emergency spillway starts operating in a flood event. The elevation of the emergency spillway was also determined in the 1981 Study.

Table 3.4.14-1.
Elevation-Area-Capacity Relationship for Ringgold Reservoir

Elevation (feet)	***Area (acres)***	***Capacity (acft)***
783.0	5	4
785.0	14	22
790.0	64	198
795.0	170	754
800.0	330	1,954
805.0	820	4,499
810.0	1,920	11,259
815.0	3,270	24,194
820.0	4,850	44,344
825.0	6,610	72,904
830.0	8,480	110,629
835.0	10,510	158,014
840.0	12,800	216,189
844.0	14,980	271,600
845.0	15,620	286,900
847.0	16,990	319,500

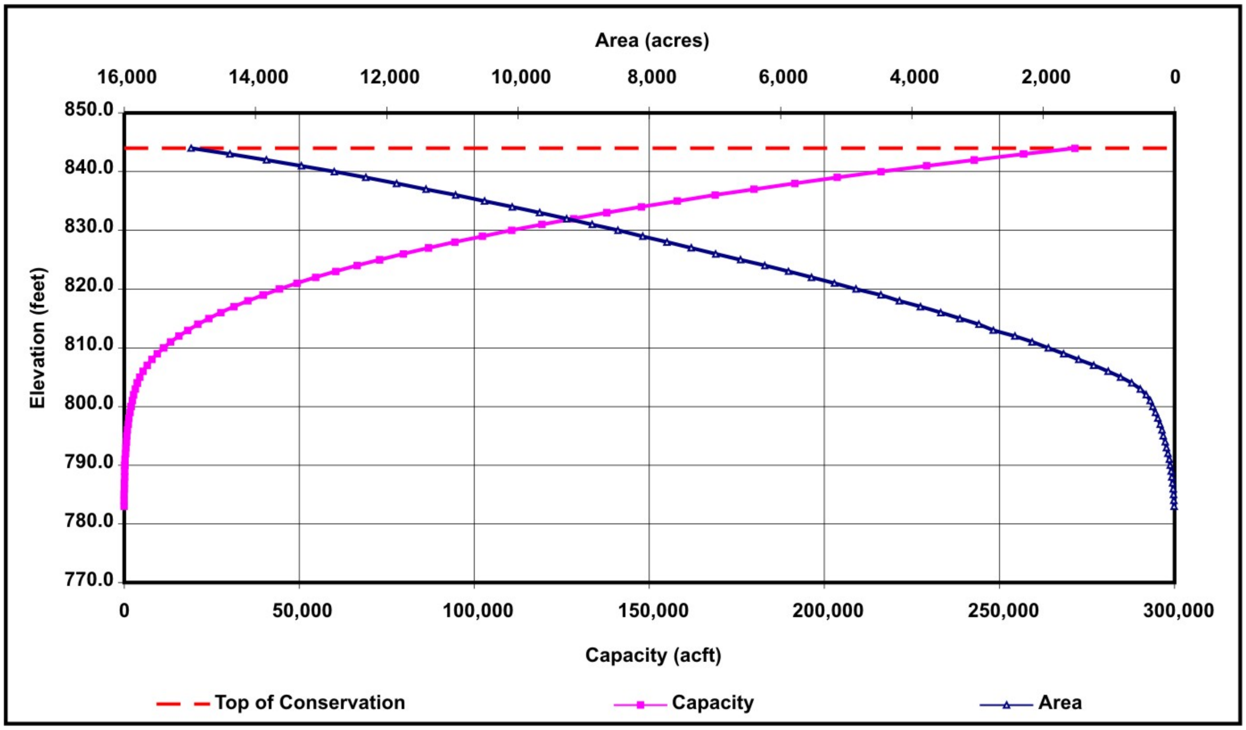

Figure 3.4.14-2. Elevation-Area-Capacity Relationship for Ringgold Reservoir

The reservoir will be subject to regulatory bypass to meet environmental needs. For this study, the Consensus Criteria for Environmental Flow Needs (TWDB, 1997) were adopted and are shown in Table 3.4.14-2. The reservoir will have to pass the lesser of the inflow and the values of Table 3.4.14-2.

The firm yield of Ringgold Reservoir was calculated with the full authorization scenario (Run 3) of the Water Availability Model of Red River Basin (dated April 1, 2006) obtained from TCEQ (Espey Consultants *et al.*, 2002 and TCEQ, 2006). A control point (U10021) was added on the Little Wichita River below the existing control point U10020. Natural flows at the dam site were calculated using the drainage area ratio method with the naturalized flows at the Little Wichita above Henrietta (S10000) and the East Fork Little Wichita River near Henrietta (T10000). These gages are located in the same watershed of the reservoir and are appropriate for estimating flows at the reservoir site. The control point of Ringgold was entered as primary control point with calculated inflow.

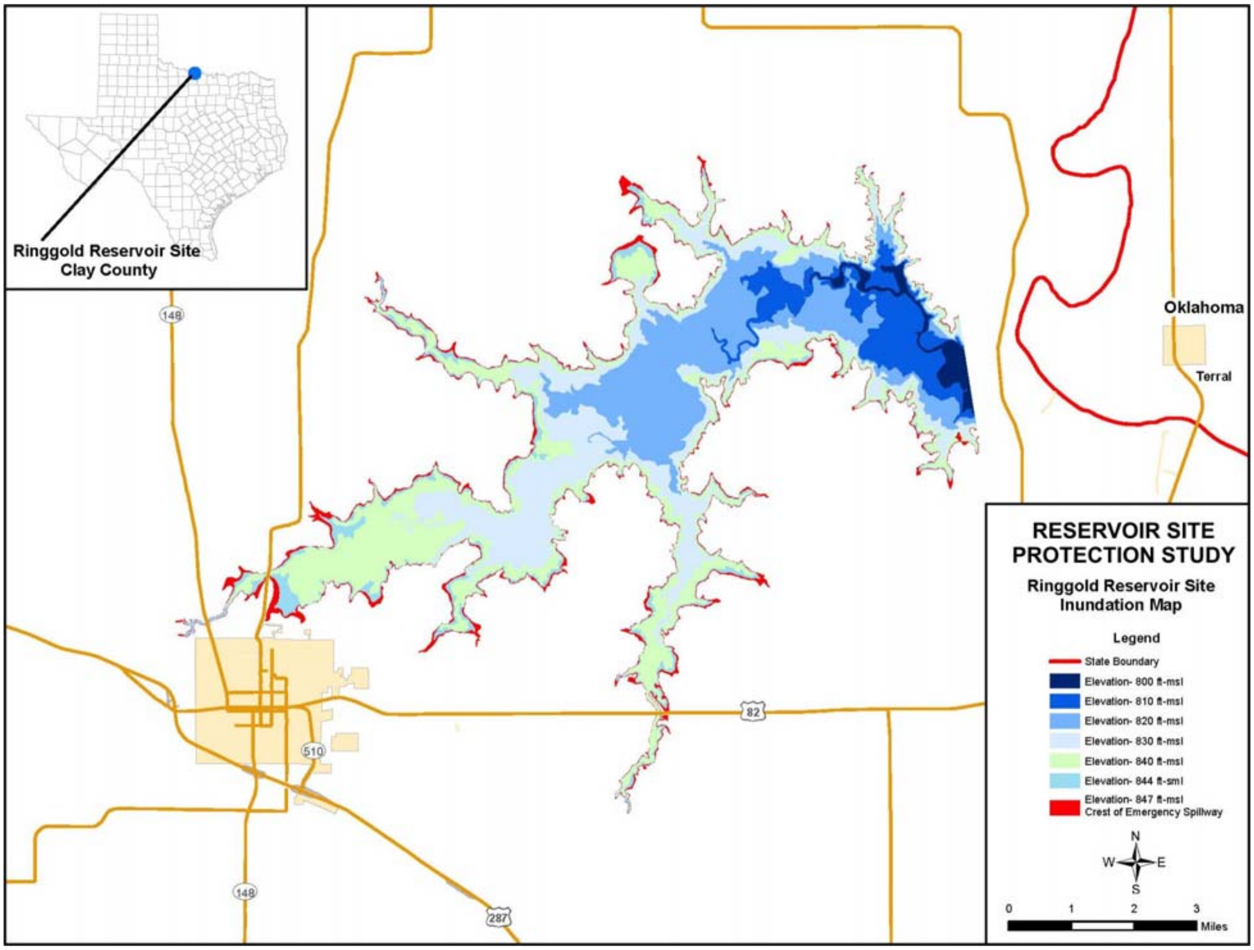

Figure 3.4.14-3. Inundation Map for Ringgold Reservoir

Table 3.4.14-2.
Consensus Criteria for Environmental Flow Needs for Ringgold Reservoir

	Median		***25th Percentile***		***7Q2***	
	acft/mo	***cfs***	***acft/mo***	***cfs***	***acft/mo***	***cfs***
Jan	640	10.4	0	0.0	0	0.0
Feb	930	16.6	22	0.4	0	0.0
Mar	1,341	21.8	92	1.5	0	0.0
Apr	1,393	23.4	208	3.5	0	0.0
May	2,534	41.2	332	5.4	0	0.0
Jun	2,643	44.4	388	6.5	0	0.0
Jul	437	7.1	0	0.0	0	0.0
Aug	394	6.4	0	0.0	0	0.0
Sep	202	3.4	0	0.0	0	0.0
Oct	49	0.8	0	0.0	0	0.0
Nov	30	0.5	0	0.0	0	0.0
Dec	92	1.5	0	0.0	0	0.0
Total	10,684		1,043		0	
Average	890	14.8	87	1.4	0	0.0

The Red River WAM calculates natural flows at other control points in the Little Wichita watershed using not only the gages in the Little Wichita River, but also the gages at Wichita River at Charlie, the Red River near Burkburnett, and the Red River near Terral, Oklahoma. However, use of the WAM hydrology of the main stem tends to overestimate flows in this part of the basin. Therefore, yield analyses for this study considered local gages in the Little Wichita subbasin. The reservoir location was entered as a primary control point (with known naturalized flows) in the WAM model. The flow distribution parameters of other secondary control points in the Little Wichita basin below the Henrietta gage were changed to use known flows in the same watershed (including the calculated flow at Ringgold as the downstream source) to avoid discontinuity in flow between consecutive control points.

Net evaporation rates were calculated from TWDB quadrangle data of precipitation and gross lake evaporation. Evaporation at the reservoir site was based on data from Quadrangles 409 and 410. Net evaporation rates entered in the WAM model were adjusted to remove the portion of the precipitation in the reservoir surface area that has been accounted for in the natural inflow.

Yields were calculated for elevations 844, 840, 835, and 830 ft-msl, subject to environmental flow needs and assuming stand-alone reservoir operations with no minimum reserve content. Results of firm yield analyses at these elevations are included in Table 3.4.14-3 and Figure 3.4.14-4. At the conservation pool level of 844 feet, the firm yield is 32,800 acft/yr. Assuming no environmental flow releases, the yield of the reservoir increases by 400 acft/yr at the recommended conservation pool elevation.

Table 3.4.14-3.
Firm Yield vs. Conservation Storage for Ringgold Reservoir

Conservation Pool Elevation (ft-msl)	*Conservation Storage (acft)*	*Environmental Bypass Criteria*	*Yield (acft/yr)*	*Critical Period*
830.0	110,629	CCEFN	23,700	8/75-2/81
835.0	158,014	CCEFN	29,300	7/75-2/81
840.0	216,189	CCEFN	31,900	5/58-2/81
844.0 *	271,600	CCEFN	32,800	11/57-2/81
		None	33,200	11/57-2/81
*Proposed Conservation Storage				

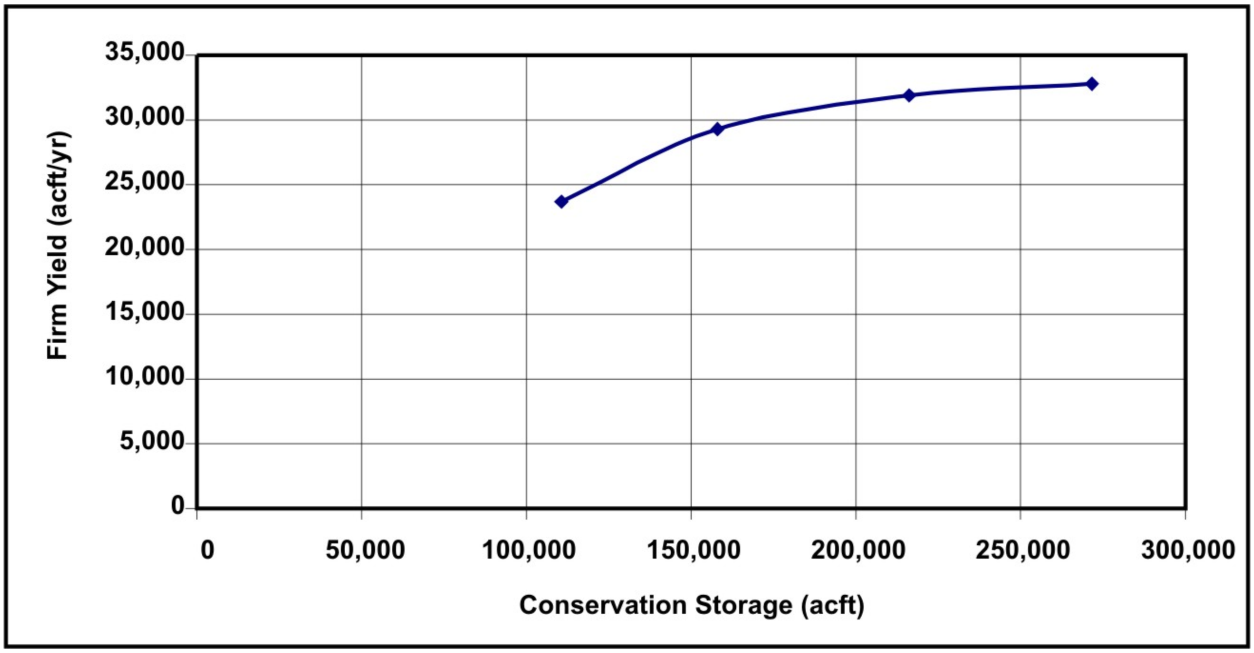

Figure 3.4.14-4. Firm Yield vs. Conservation Storage for Ringgold Reservoir

As part of a previous study, Freese and Nichols (1981) evaluated the gain of yield when operating Ringgold as a system with Lakes Kickapoo and Arrowhead. The 1981 study determined a net gain of 27,640 acft/yr, which is lower than the firm yield determined in this study. The yield from the 1981 study is lower because it assumes that Ringgold Reservoir has a minimum reservoir reserve at elevation 805 ft-msl, leaving about 4,500 acft in storage. The study also assumes a runoff depletion due to soil and water conservation practices on farm lands and the construction of numerous small ponds on small tributaries that will tend to diminish the amount of runoff available to large reservoirs. The 1981 study determined that runoff depletions would reduce the firm yield of Ringgold Reservoir by 1,800 acft/yr. The WAM hydrology does not account for changes in land use or future small impoundments.

Figure 3.4.14-5 presents a simulated storage trace and a frequency curve for storage content derived using the Red River WAM as modified for this study. At the conservation pool of 844 ft-msl and assuming full diversion, the reservoir would be full about 5 percent of the time and would be below 50 percent of the conservation storage about 33 percent of the months.

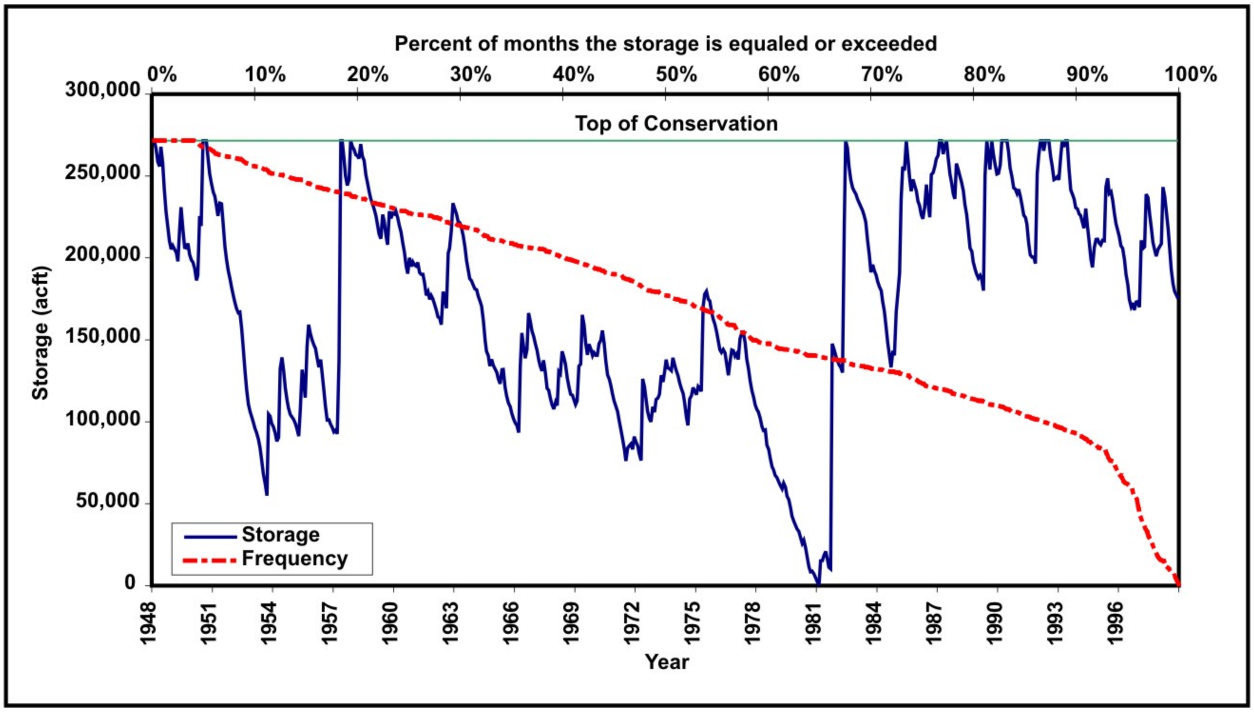

Figure 3.4.14-5. Simulated Storage in Ringgold Reservoir (Conservation Elevation = 844 ft-msl, Diversion = 32,800 acft/yr)

3.4.14.3 Reservoir Cost

The costs for the Ringgold Reservoir Dam assume a zoned earthen embankment and a gated spillway. The length of the dam is estimated at 9,350 feet with the top of the embankment at elevation 871 ft-msl. The service spillway is designed as a control structure with five tainter gates, each 40 feet wide by 25 feet high. The reservoir also includes an emergency spillway, approximately 900 wide, at elevation 847 ft-msl.

The conflicts identified at the site include electrical lines, minor roads, oil and gas lines and one oil and gas well. A list of the potential conflicts is provided in Table 3.4.14-4. Costs for these conflict resolutions were developed from data provided by TNRIS. The conflict costs represent 6 percent of the total construction cost of the reservoir project. Figure 3.4.14-6 shows the conflicts as mapped by TNRIS.

Table 3.4.14-4. List of Potential Conflicts for Ringgold Reservoir

Oil and Gas Pipelines	Power Transmission Lines
Roads	Oil and Gas Well

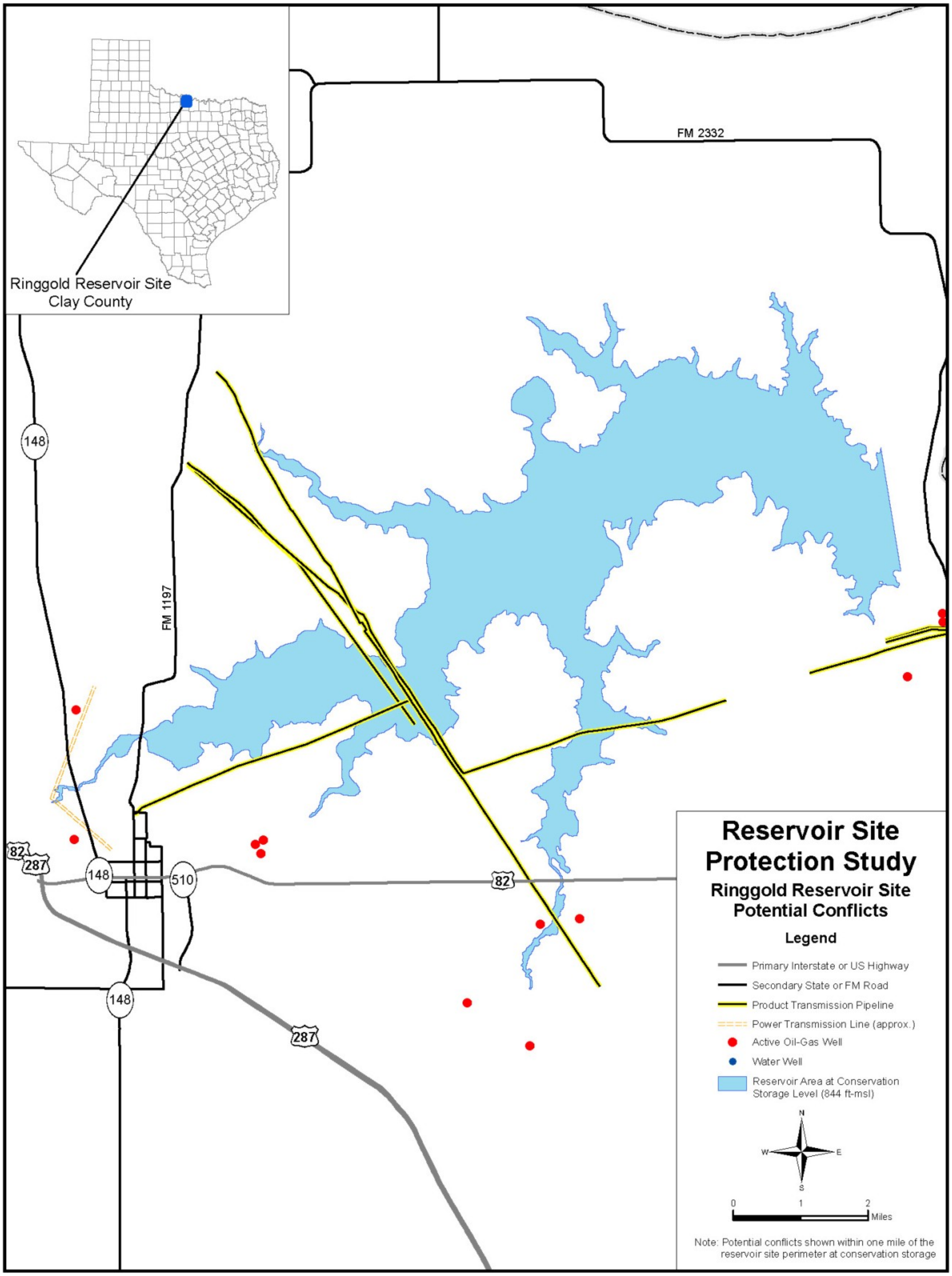

Figure 3.4.14-6. Potential Major Conflicts for Ringgold Reservoir

Table 3.4.14-5 shows the estimated capital costs for the Ringgold Reservoir Project, including construction costs, engineering, permitting and mitigation. Costs for the dam and reservoir are based on the unit cost assumptions used in this study. Quantities are taken from the 1981 Freese and Nichols study. The total estimated cost of the project is $119 million (2005 prices). Assuming a yield of 32,800 acft/yr, raw water from the project will cost approximately $273 per acft ($0.84 per 1,000 gallons) during the debt service period.

3.4.14.4 Environmental Considerations

Ringgold Reservoir is not located on or immediately upstream of an identified ecologically significant stream segment. There are no known significant environmental concerns with this reservoir site. Ringgold Reservoir will inundate approximately 15,000 acres of land at conservation storage capacity. Table 3.4.14-6 and Figure 3.4.14-7 summarize existing landcover for the Ringgold Reservoir site as determined by TPWD using methods described in Appendix C. Existing landcover within this reservoir site is dominated by grassland (52 percent) with sizeable, contiguous areas of upland deciduous forest (28 percent) along the Little Wichita River and its tributaries. Agricultural lands are concentrated near the dam site and the upper end of the reservoir and comprise about 13 percent of the inundated area.

Table 3.4.14-5.
Acreage and Percent Landcover for Ringgold Reservoir

Landcover Classification	Acreage[1]	Percent
Upland Deciduous Forest	4,316	28.1%
Grassland	8,020	52.2%
Shrubland	1,942	12.6%
Agricultural Land	756	4.9%
Open Water	335	2.2%
Total	15,369	100.0%

[1] Acreage based on approximate GIS coverage rather than calculated elevation-area-capacity relationship.

Table 3.4.13-5.
Cost Estimate – Ringgold Reservoir @ Elevation 844 ft-msl

	Quantity	*Unit*	*Unit Price*	*Cost*
Dam & Reservoir				
Unclassified Excavation	2,591,000	CY	$2.50	$6,478,000
Structural Excavation	700,000	CY	$2.50	$1,750,000
Fill				
Random Compacted Fill	2,229,000	CY	$2.50	$5,573,000
Impervious Fill	743,000	CY	$3.00	$2,229,000
Filter	337,000	CY	$35	$11,795,000
Bridge	240	LF	$1,300	$312,000
Roadway	23,333	SY	$20	$467,000
Slurry Trench	118,000	SF	$15	$1,770,000
Soil Cement	121,000	CY	$65	$7,865,000
Gates				
Gate & Anchor	5,000	SF	$275	$1,375,000
Stop Gate & Lift	200	LF	$2,000	$400,000
Hoist	5	Ea	$250,000	$1,250,000
Electrical	1	LS	$550,000	$550,000
Power Drop	1	LS	$250,000	$250,000
Spillway Low-Flow System	1	LS	$400,000	$400,000
Embankment Internal Drainage	15,400	LF	$60	$924,000
Guardrail	480	LF	$30	$14,000
Grassing	50	AC	$4,500	$225,000
Concrete (mass)	54,747	CY	$150	$8,212,000
Reinforced Concrete (formed)	14,160	CY	$475	$6,726,000
Mobilization (5% of subtotal)				$2,928,000
Care of water (1% of subtotal)				$586,000
Clearing and Grubbing	150	AC	$4,000	$600,000
Land Clearing	425	AC	$1,000	$425,000
Engineering and Contingencies (35%)				$22,086,000
Subtotal for Dam & Reservoir				**$85,190,000**
Conflicts				
Highways	6650	LF	$150	$998,000
Pipelines				
4.5-in crude oil	58,900	LF	$17	$1,001,000
16-inch gas	55,800	LF	$42	$2,344,000
8.63-inch crude oil	23,800	LF	$25	$595,000
Oil & gas well (plug & abandon)	1	EA	$25,000	$25,000
Power Lines	240	LF	$450	$108,000
Engineering and Contingencies (35%)				$1,388,000
Subtotal of Conflicts				**$6,459,000**
Land Acquisition	17,000	AC	$850	$14,450,000
Environmental Studies and Mitigation Lands	17,000	AC	$850	$14,450,000
Total Reservoir Construction Cost				**$106,099,000**
Interest During Construction (36 months)				**$12,909,000**
TOTAL COST				**$119,008,000**
ANNUAL COSTS				
Debt Service (6% for 40 years)				$7,909,000
Operation & Maintenance				$1,054,000
Total Annual Costs				**$8,963,000**
UNIT COSTS				
Per Acre-Foot				$273
Per 1,000 Gallons				$0.84

Units: AC = Acre; CY = Cubic Yard; EA = Each; LB = Pound; LF = Linear Foot; LS = Lump Sum; SF = Square Foot; and SY = Square Yard.

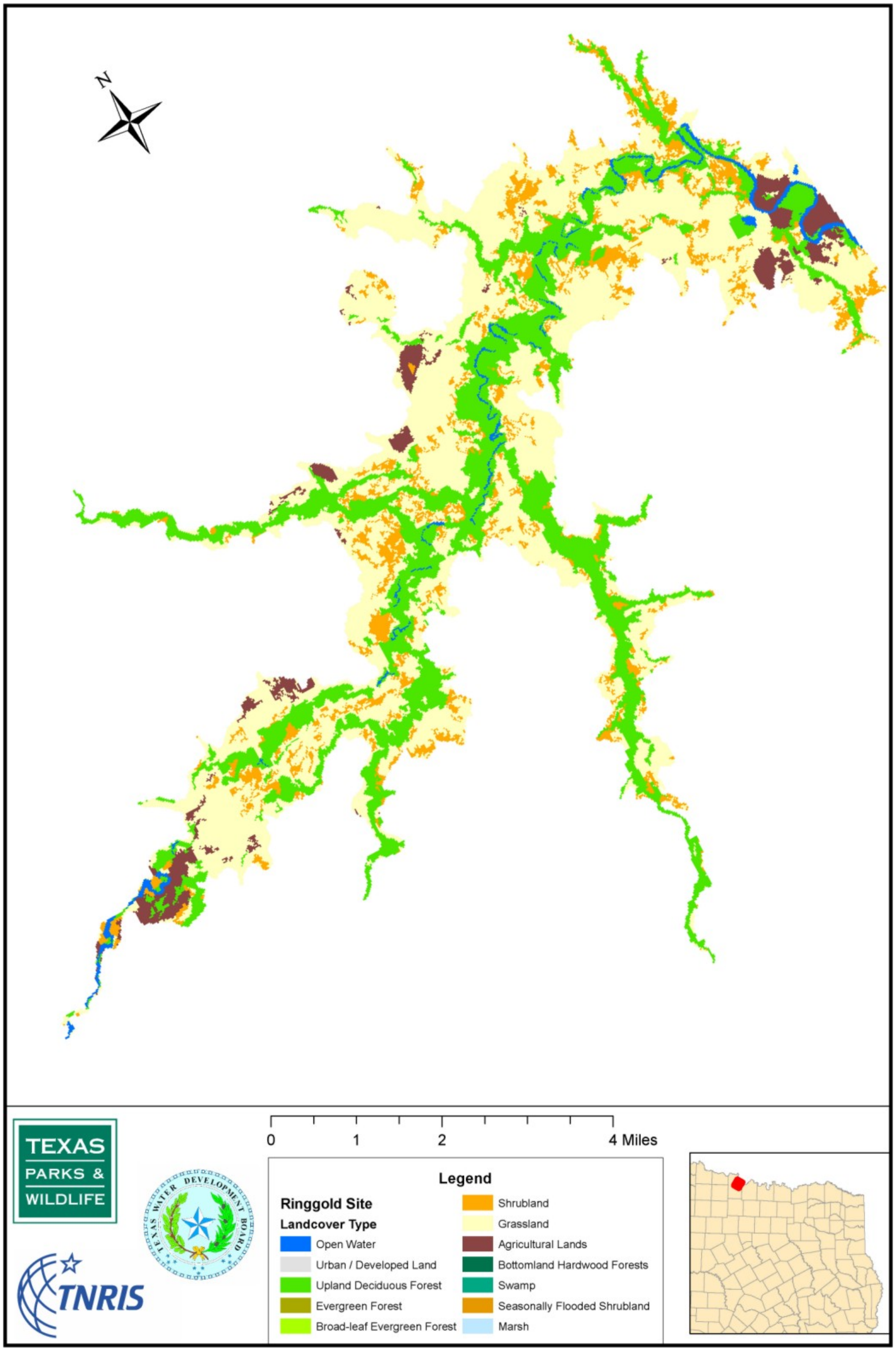

Figure 3.4.14-7. Existing Landcover for Ringgold Reservoir

3.4.15 Tehuacana Reservoir

3.4.15.1 Description

Tehuacana Reservoir is a proposed water supply project on Tehuacana Creek within the Trinity River Basin. Tehuacana Creek is a tributary of the Trinity River and lies immediately south and adjacent to Richland Creek on which the existing Richland-Chambers Reservoir is located. Tehuacana Reservoir, which would likely be sponsored by the Tarrant Regional Water District (TRWD), would connect to the TRWD's Richland-Chambers Reservoir by a 9,000-foot channel and be operated as an integrated extension of Richland-Chambers Reservoir. Figure 3.4.15-1 presents a map showing the location of Tehuacana and Richland-Chambers Reservoirs in Freestone and Navarro Counties. The project would inundate approximately 15,000 acres adjacent to Richland-Chambers Reservoir.

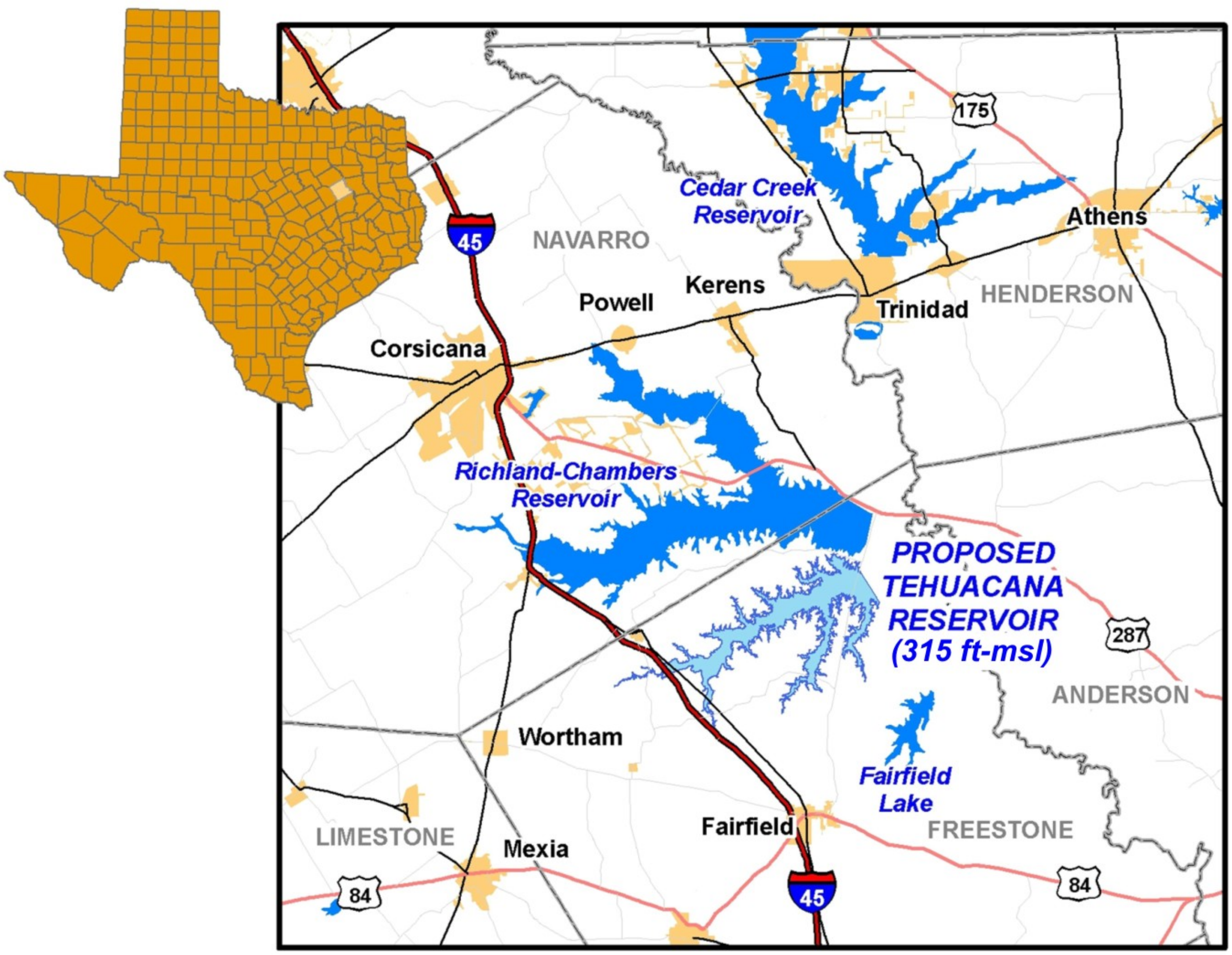

Figure 3.4.15-1. Location Map of Tehuacana Reservoir

Tehuacana Reservoir has been a part of the TRWD's long-term planning since the project was first proposed in the late 1950s. It is included as an alternative strategy for the TRWD in the 2001 and 2006 Region C Water Plans (Freese and Nichols *et al.*, 2001 and 2006a) and is not a recommended water management strategy for any Region C water supplier. The projected needs within 50 miles of the proposed reservoir site by 2060 are 890,895 acft/yr. The nearest major demand center is the greater Dallas-Fort Worth area, which is located approximately 80 miles northwest of the reservoir site.

The existing spillway for Richland-Chambers Reservoir was designed to provide enough discharge capacity to accommodate the increased flood flows from Tehuacana Reservoir for the probable maximum flood event. Therefore, the dam for Tehuacana Reservoir can be constructed without a spillway and actually can function as merely an extension of Richland-Chambers Reservoir. Development of this site will require a new water right, construction of the dam and reservoir, and up-sizing of the TRWD's pipelines to deliver water to Tarrant County.

3.4.15.2 Reservoir Yield Analysis

Tehuacana Reservoir was studied by Freese and Nichols in 2005 as part of the Region C water supply planning process (Freese and Nichols *et al.*, 2006a). These analyses treated Tehuacana Reservoir as an extension of the existing Richland-Chambers Reservoir.

The firm yield of Tehuacana Reservoir was calculated in this present study using a version of the water availability model (WAM) of the Trinity River Basin (dated July 23, 2005), with Run 3 assumptions, as provided by Freese and Nichols. The monthly WAM simulations were performed using the Water Rights Analysis Package (WRAP, executable dated 5/24/2004). This version of the WAM, as modified by Freese and Nichols, includes the proposed Tehuacana Reservoir combined with Richland-Chambers Reservoir. Since the two reservoirs are to be connected by a channel, they are represented as a single reservoir in the WAM. The additional storage capacity of Tehuacana Reservoir is added to the existing storage capacity of Richland-Chambers, with a junior priority date for refilling. The conservation pool elevation of the combined reservoirs is assumed to be the same as that of Richland-Chambers (i.e., 315 ft-msl).

The elevation-area-capacity relationship for Tehuacana Reservoir, as developed by Freese & Nichols, is presented in Table 3.4.15-1 and Figure 3.4.15-2. The combined elevation-area-capacity relationship for the Richland-Chambers and Tehuacana Reservoir system is presented in Table 3.4.15-2 and Figure 3.4.15-3. Figure 3.4.15-4 shows the reservoir inundation at 10-foot contours.

Table 3.4.15-1.
Elevation-Area-Capacity Relationship for Tehuacana Reservoir

Elevation (feet)	Area (acres)	Capacity (acft)
250.0	20	10
255.0	286	775
260.0	552	2,870
265.0	1,168	7,170
270.0	1,784	14,550
275.0	2,586	25,474
280.0	3,387	40,406
285.0	4,701	60,625
290.0	6,014	87,411
295.0	7,551	121,323
300.0	9,087	162,917
305.0	10,694	212,368
310.0	12,300	269,852
315.0	14,938	337,947

Table 3.4.15-2.
Elevation-Area-Capacity Relationship for Tehuacana and Richland Chambers Reservoirs Combined

Elevation (feet)	Area (acres)	Capacity (acft)
250.0	20	10
255.0	674	1,294
260.0	2,522	9,290
265.0	5,677	29,674
270.0	9,035	65,213
275.0	12,861	121,065
280.0	16,825	194,794
285.0	21,947	290,422
290.0	27,162	413,626
295.0	32,253	561,859
300.0	37,445	736,215
305.0	43,885	938,794
310.0	50,517	1,176,219
315.0	58,559	1,447,257

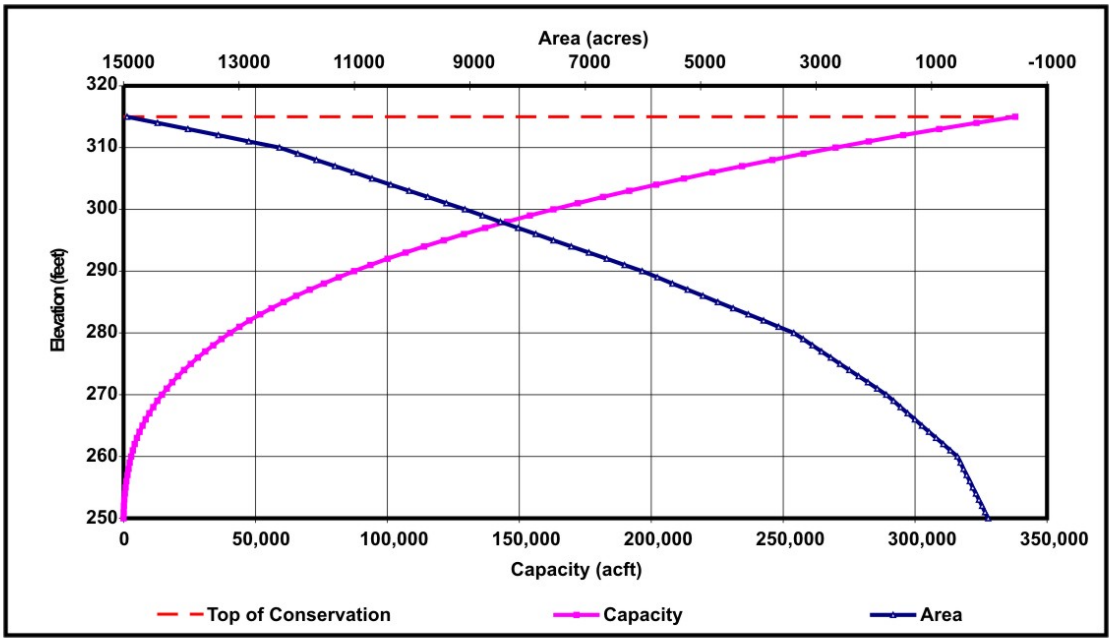

Figure 3.4.15-2. Elevation-Area-Capacity Relationship for Tehuacana Reservoir

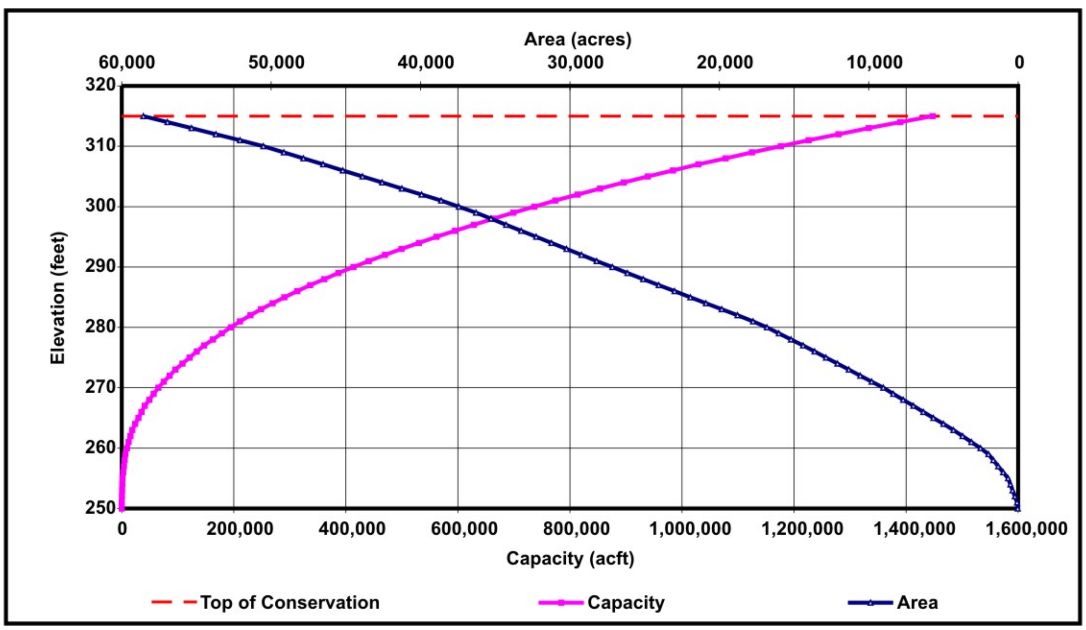

Figure 3.4.15-3. Elevation-Area-Capacity Relationship for Tehuacana and Richland Chambers Reservoirs Combined

For purposes of this yield study, it is assumed that inflows to Tehuacana Reservoir would have to be passed downstream to provide environmental flows for Tehuacana Creek. These minimum environmental flow requirements are based on Consensus Criteria for Environmental Flow Needs (CCEFN) (TWDB, 1997), and they are summarized in Table 3.4.15-3. The reservoir has to pass the lesser of the inflow and the values in Table 3.4.15-3 depending on storage in the reservoir, i.e., the median or the 25-percentile flow when the storage is greater than 80 or 50 percent full, respectively, and the 7Q2 flow when the storage is less than 50 percent full.

Table 3.4.15-3.
Consensus Criteria for Environmental Flow Needs for Tehuacana and Richland Chambers Reservoirs Combined

		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Median	acft/mo	694	1,054	1,215	934	1,218	505	68	6	6	12	138	465
	cfs	11.3	18.8	19.8	15.7	19.8	8.5	1.1	0.1	0.1	0.2	2.3	7.6
25th	acft/mo	74	267	329	243	251	69	6	6	6	6	6	22
	cfs	1.2	4.8	5.3	4.1	4.1	1.2	0.1	0.1	0.1	0.1	0.1	0.4
7Q2	acft/mo	6	6	6	6	6	6	6	6	6	6	6	6
	cfs	0.1											
Note: The 7Q2 value is used when it exceeds the value of the median and/or quartile.													

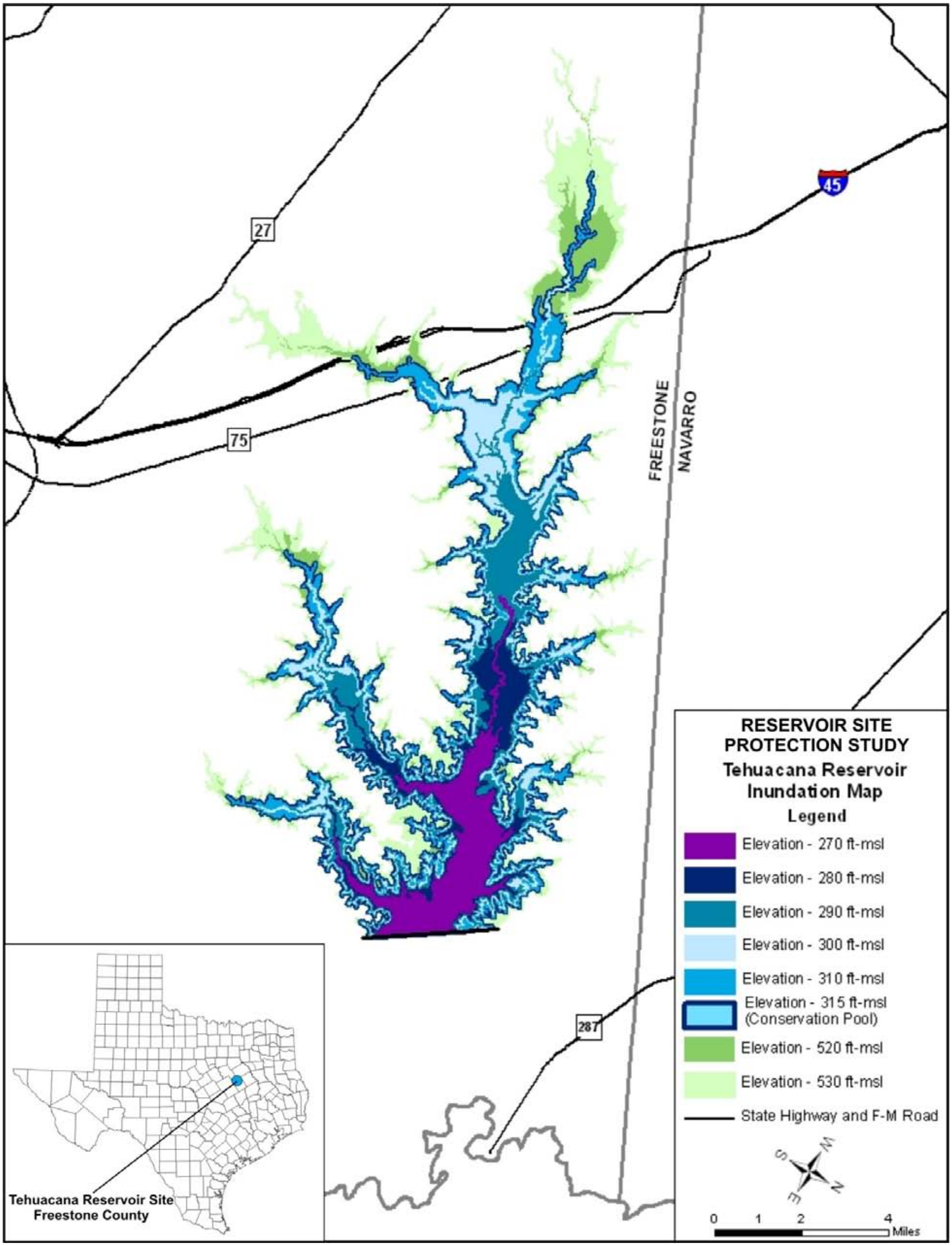

Figure 3.4.15-4. Inundation Map for Tehuacana Reservoir

As stated in Certificate of Adjudication No. 4248, Lake Livingston, even though it is senior in priority, will be subordinated to Tehuacana Reservoir when and if Tehuacana Reservoir is issued a water right by the TCEQ. The Lake Livingston subordination to Tehuacana Reservoir is recognized and modeled in this yield study.

WAM simulations were made for firm annual yield determinations with the top of the conservation pool of the combined Richland-Chambers and Tehuacana reservoir assumed to be at elevations 312, 313, 314, and 315 ft-msl. For these simulations, the minimum reservoir content was set at 116,975 acft to be consistent with the simulated minimum storage in Richland-Chambers Reservoir (stand-alone) with its demand equal to its own authorized diversion amount (i.e., 210,000 acft/yr). (This is consistent with the TRWD's operation of its reservoirs on a safe yield basis.) The incremental increase in firm yield above the authorized diversion amount for Richland-Chambers Reservoir was considered to be the firm yield attributable to the addition of Tehuacana Reservoir. Results from these simulations are summarized in Table 3.4.15-4 and Figure 3.4.15-5. As shown, at the conservation pool level of 315 feet, or 1,447,257 acft of total combined storage capacity, the incremental firm yield of Tehuacana Reservoir is 41,900 acft/yr. CCEFN requirements reduce the yield of the reservoir by about 2,200 acft/yr.

Table 3.4.15-4
Firm Yield vs. Conservation Storage for Tehuacana and Richland Chambers Reservoirs Combined

Pool Elevation (ft-msl)	Storage (acft)	Environmental Bypass Criteria	Firm Yield[1] (acft/yr)	Critical Period
312.0	1,279,413	CCEFN	26,300	5/48-6/57
313.0	1,333,378	CCEFN	32,100	5/48-6/57
314.0	1,389,508	CCEFN	34,400	5/48-6/57
315.0*	1,447,257	CCEFN	41,900	5/48-6/57
		None	44,100	5/48-6/57

[1]Incremental firm yield attributable to Tehuacana Reservoir.
*Proposed conservation storage.

Figure 3.4.15-6 presents a simulated storage trace for the combined Tehuacana-Richland-Chambers Reservoir with a conservation storage capacity of 1,447,257 acft (elevation 315 ft-msl) and an incremental firm yield diversion of 41,900 acft/yr attributable to Tehuacana Reservoir. The corresponding storage frequency curve is also shown in Figure 3.4.15-5. Based on the 1940-1996 monthly WAM simulations, at the conservation pool level of 315 ft-msl, the combined reservoir would be full about 26 percent of the time and would be below 50 percent full about 6 percent of the time.

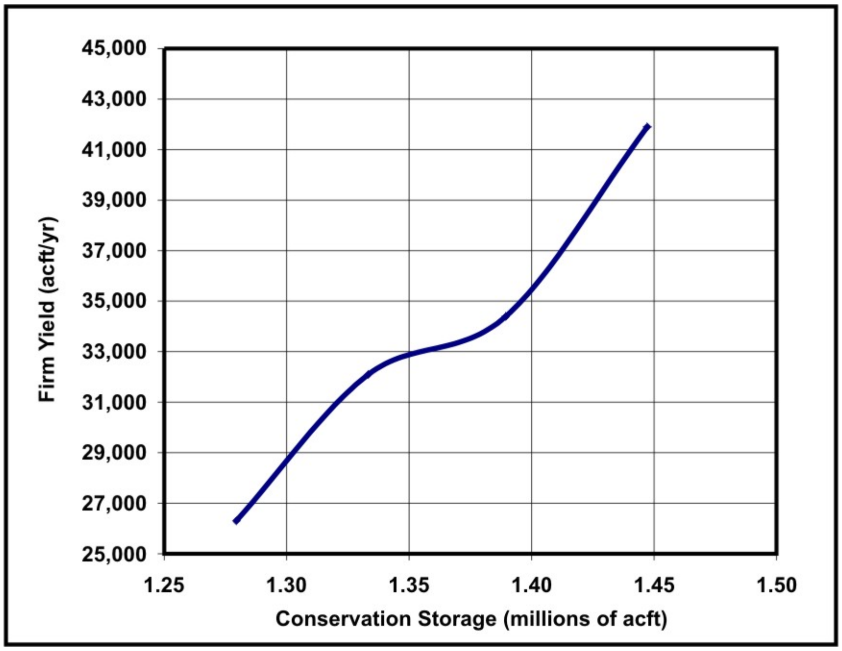

Figure 3.4.15-5. System Yield vs. Conservation Storage for Tehuacana and Richland Chambers Reservoirs Combined

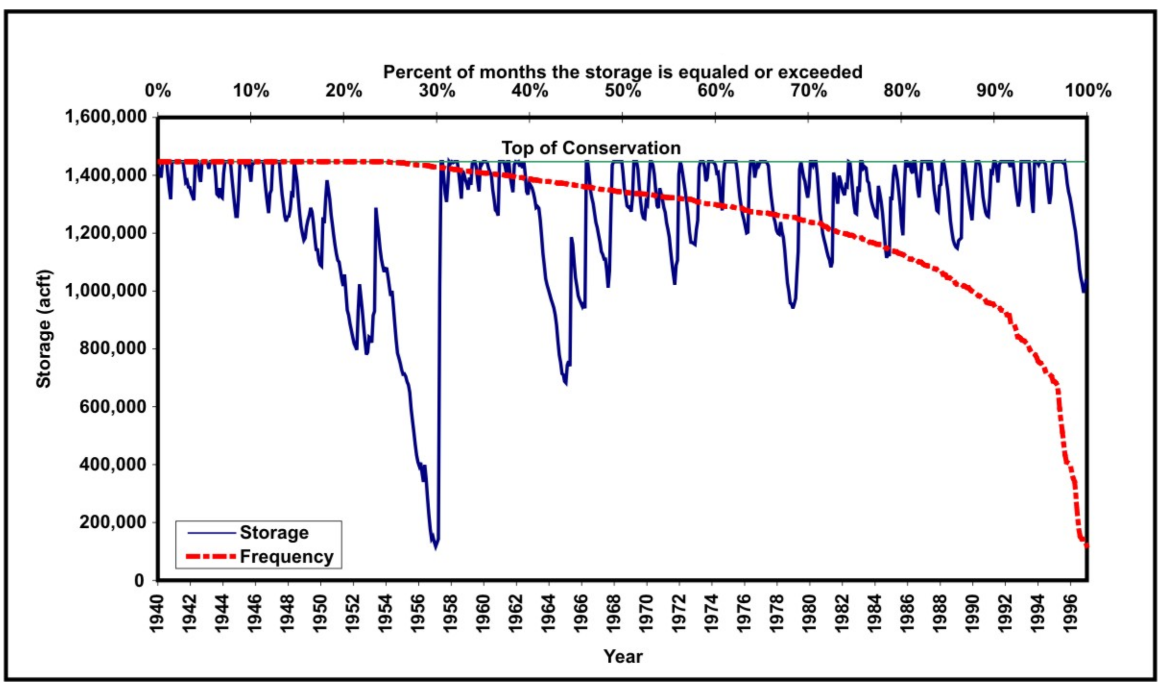

Figure 3.4.15-6. Simulated Storage in Tehuacana and Richland-Chambers Reservoirs (Conservation Elevation = 315 ft-msl, Incremental Yield = 41,900 acft/yr)

3.4.15.3 Reservoir Costs

The estimated costs for the Tehuacana Reservoir dam assume a zoned earthen embankment with a maximum height of 81 feet. As planned, the lake will be hydraulically connected to nearby Richland-Chambers Reservoir with a 9,000-foot channel. The length of the additional embankment is estimated to be 13,700 feet. It is assumed that no modifications to Richland-Chambers dam are required.

The potential conflicts identified at the site include pipelines, power lines, roads, railroads and oil fields. A list of the potential conflicts is provided in Table 3.4.15-5. The conflict costs represent less than 10 percent of the total construction cost of the reservoir project. Figure 3.4.1-7 shows the conflicts as mapped by TNRIS.

Table 3.4.15-5.
List of Potential Conflicts for Tehuacana Reservoir

Roads	Powerlines
Railroads	Oil Wells
Transmission Pipelines	

Table 3.4.15-6 presents the estimated capital costs for the Tehuacana Reservoir dam, including construction costs, engineering, permitting and mitigation. Unit costs for the dam and reservoir are based on the cost assumptions used in this study. The total estimated cost of the project is approximately $192 million (2005 prices). Assuming an annual yield of 41,900 acft/yr, raw water from the project will cost approximately $320 per acft ($0.98 per 1,000 gallons) during the debt service period.

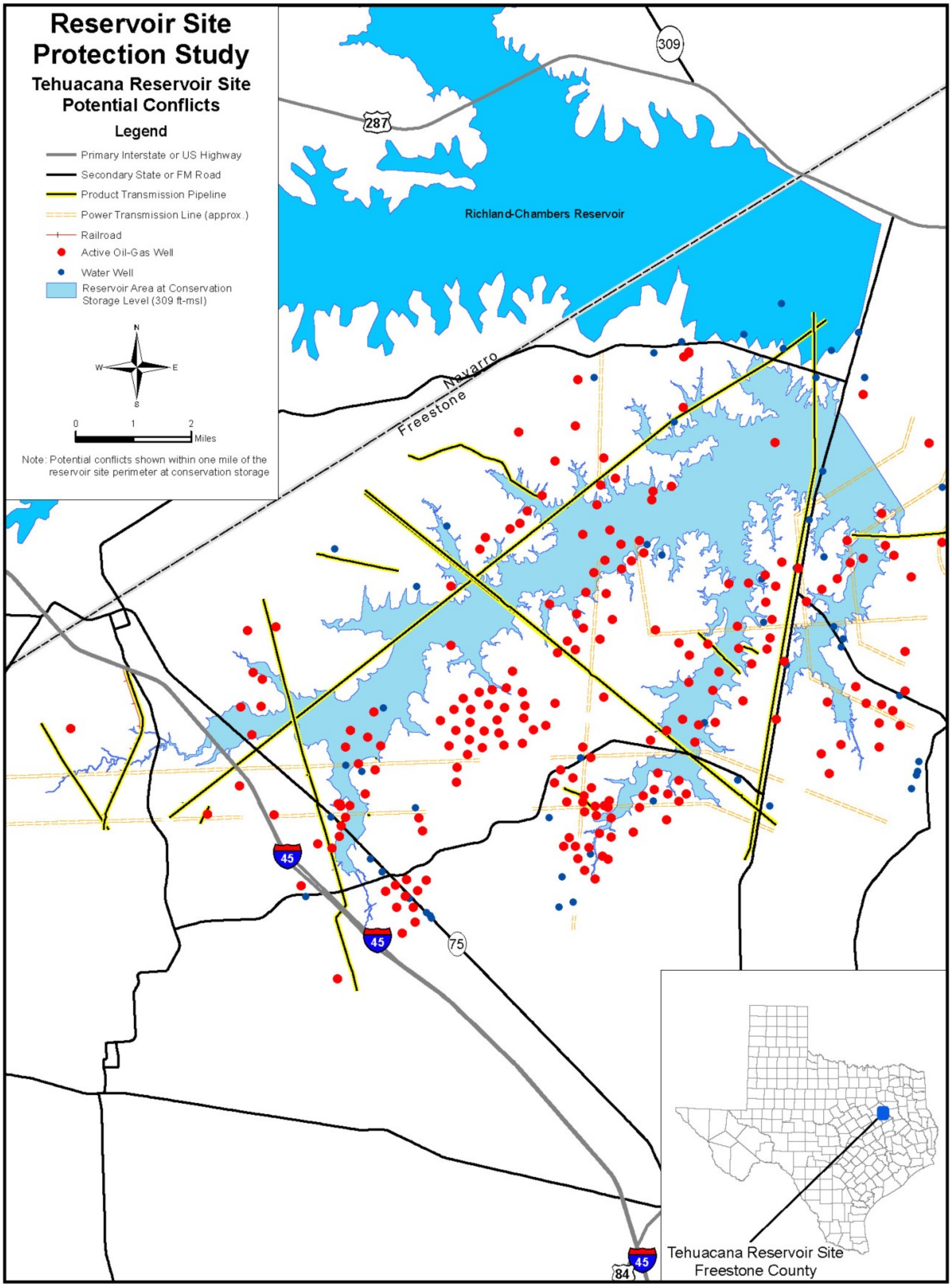

Figure 3.4.15-7. Potential Major Conflicts for Tehuacana Reservoir

Table 3.4.15-6.
Cost Estimate - Tehuacana Reservoir @ Elevation 315 ft-msl

	SIZE	UNIT	QUANTITY	UNIT COST	COST
MOBILIZATION (5%)		LS	1	$5,525,524	**$5,525,524**
DAM & RESERVOIR CONSTRUCTION					
EMBANKMENT					
CHANNEL		CY	2,250,000	$2.00	$4,500,000
CORE TRENCH & BORROW		CY	1,764,000	$2.00	$3,528,000
FILL MATERIAL					
EMBANKMENT		CY	3,488,000	$2.50	$8,720,000
WASTE MATERIAL		CY	80,000	$2.00	$160,000
FILTER, 1 & 2 (FOUNDATION DRAINAGE)		CY	181,800	$35.00	$6,363,000
STABILIZED ROADWAY BASE		SY	59,555	$20.00	$1,191,100
CUTOFF SLURRY TRENCH		SF	514,800	$15.00	$7,722,000
SOIL CEMENT		CY	137,800	$65.00	$8,957,000
GUARD RAILS		EA	1,680	$25.27	$42,454
GRASSING		AC	34	$4,500.00	$153,000
SUBTOTAL - DAM & RESERVOIR CONSTRUCTION					**$41,336,554**
ENGINEERING & CONTINGENCIES (35% DAM & RESERVOIR)					**$14,467,794**
TOTAL - DAM & RESERVOIR CONSTRUCTION					**$55,804,347**
CONFLICTS (RELOCATIONS):					**$40,523,054**
ENGINEERING & CONTINGENCIES (35% CONFLICTS)					**$14,183,069**
TOTAL CONFLICTS (RELOCATIONS)					**$54,706,123**
CONSTRUCTION TOTAL					**$110,510,471**
LAND PURCHASE COSTS		AC	14,938	$2009	**$30,010,442**
ENVIRONMENTAL STUDIES & MITIGATION COSTS		AC	14,938	$2009	**$30,010,442**
RESERVOIR TOTAL COST					**$176,056,878**
INTEREST DURING CONSTRUCTION (36-MONTHS)					**$16,135,005**
TOTAL COST -DAM &RESERVOIR, LAND ACQUISITION, PERMITTING &MITIGATION, INTEREST DURING CONSTRUCTION					**$192,191,883**
ANNUAL COSTS					
DEBT SERVICE (6% FOR 40 YEARS)					**$12,773,368**
OPERATION & MAINTENANCE (1.5% OF DAM & RESERVOIR COSTS)					**$620,048**
TOTAL ANNUAL COSTS					**$13,393,416**
FIRM YIELD (acft/yr)					**41,900**
UNIT COST OF WATER (DURING AMORTIZATION)					
PER ACFT					**$320**
PER 1,000 GALLONS					**$0.98**

Units: AC = Acre; CY = Cubic Yard; EA = Each; LB = Pound; LF = Linear Foot; LS = Lump Sum; SF = Square Foot; and SY = Square Yard.

3.4.15.4 Environmental Considerations

The Tehuacana Reservoir site is not located on an ecologically significant stream segment as identified by the Texas Parks and Wildlife Department (TWDB, 1999) nor is it identified as ecologically unique in the 2007 State Water Plan. It is, however, located just upstream of a segment of the Trinity River identified by TPWD as ecologically significant due to a population of rare endemic Texas heelspliter freshwater mussels. The Tehuacana Reservoir site is also located immediately upstream of two Priority 5 bottomland hardwood preservation sites identified as Tehuacana Creek and Boone Fields (USFWS, 1985).

Previous water quality studies conducted for the Tarrant Regional Water District (Freese and Nichols and Alan Plummer and Associates, 1990) concluded that the flow-weighted quality data in the combined Richland-Chambers-Tehuacana Reservoir would be very comparable to existing water supply sources indicating that no significant changes to the existing treatment processes would be necessary for this reservoir. The project would inundate approximately 14,938 surface acres and 25.2 river miles of Tehuacana Creek. Part of the Tehuacana Reservoir site is underlain by lignite, and the project has been deferred in the past for that reason (Freese and Nichols and Alan Plummer and Associates, 1990).

Table 3.4.15-7 and Figure 3.4.15-8 summarize existing landcover for the Tehuacana Reservoir site as determined by TPWD using methods described in Appendix C. Existing landcover within this reservoir site is dominated by upland deciduous forest (58 percent) and grassland (20 percent). Bottomland hardwood forest, concentrated near the dam site and the upper end of the reservoir comprises about 8 percent of the inundated area. Approximately 2.7 percent of the site is presently classified as marsh or open water.

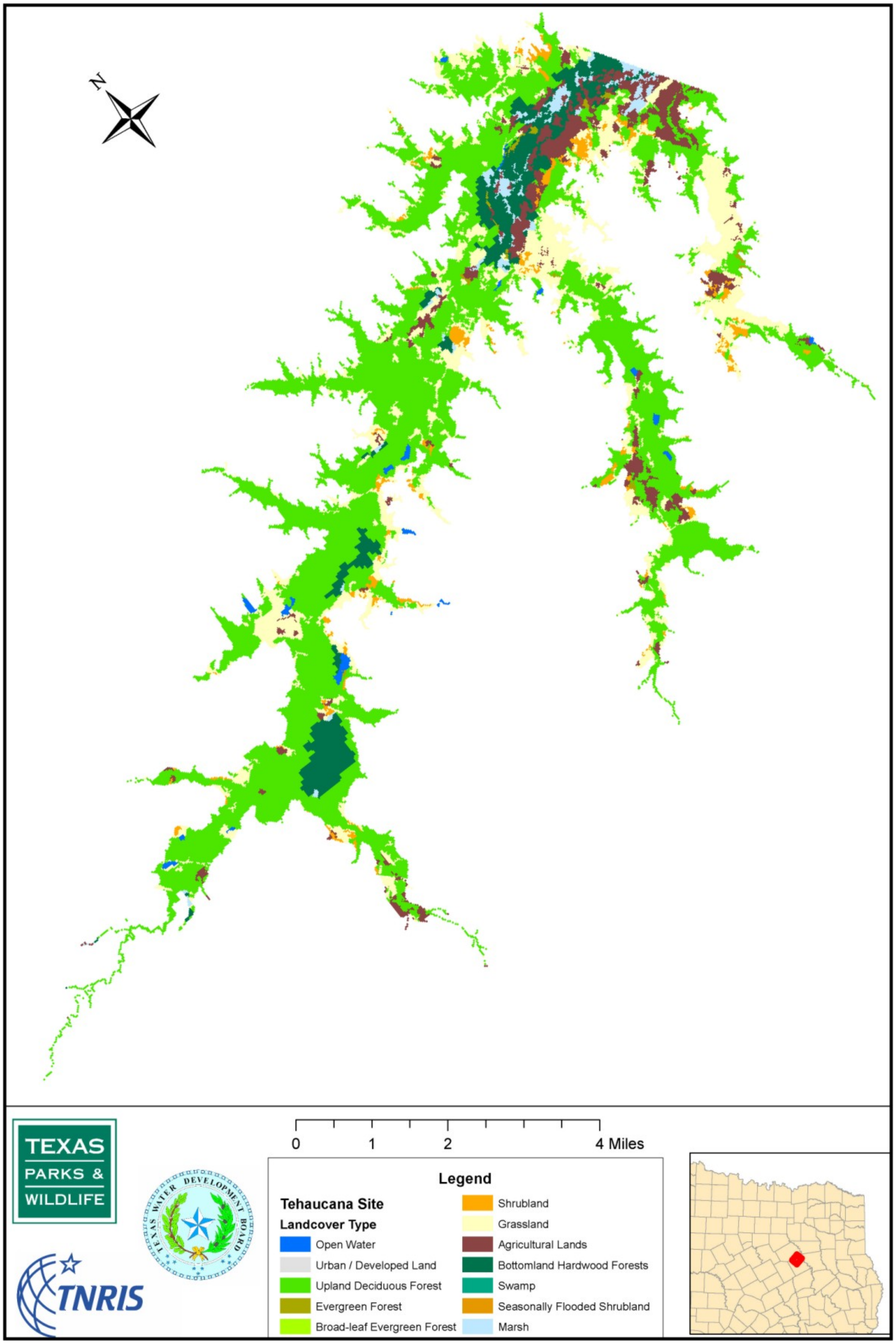

Figure 3.4.15-8. Existing Landcover for Tehuacana Reservoir

Table 3.4.15-7.
Acreage and Percent Landcover for Tehuacana Reservoir

Landcover Classification	***Acreage[1]***	***Percent***
Bottomland Hardwood Forest	1,213	8.2%
Marsh	285	1.9%
Evergreen Forest	65	0.4%
Upland Deciduous Forest	8,605	58.0%
Grassland	2,992	20.1%
Shrubland	427	2.9%
Agricultural Land	1,136	7.7%
Open Water	122	0.8%
Total	**14,845**	**100.0%**

[1] Acreage based on approximate GIS coverage rather than calculated elevation-area-capacity relationship.

3.4.16 Wilson Hollow Reservoir

3.4.16.1 Project Description

In 1986, a volumetric survey was performed by HDR Engineering, Inc. to determine the capacity of Lake Palo Pinto. The survey indicated the capacity of the lake to be 27,650 acft or about 16,450 acft less than the authorized capacity of 44,100 acft. This lesser capacity for Lake Palo Pinto was subsequently verified by the Texas Water Development Board using more sophisticated technology. In order to help restore the capacity and firm yield of Lake Palo Pinto, an off-channel reservoir site has been investigated (HDR, April 2005). The proposed off-channel reservoir is located approximately 1.6 miles north of Lake Palo Pinto at Wilson Hollow as shown in Figure 3.4.16-1. The proposed dam would be an earthfill embankment that would provide a conservation storage capacity of 22,000 acft at elevation 1,077 ft-msl and inundate 333 surface acres.

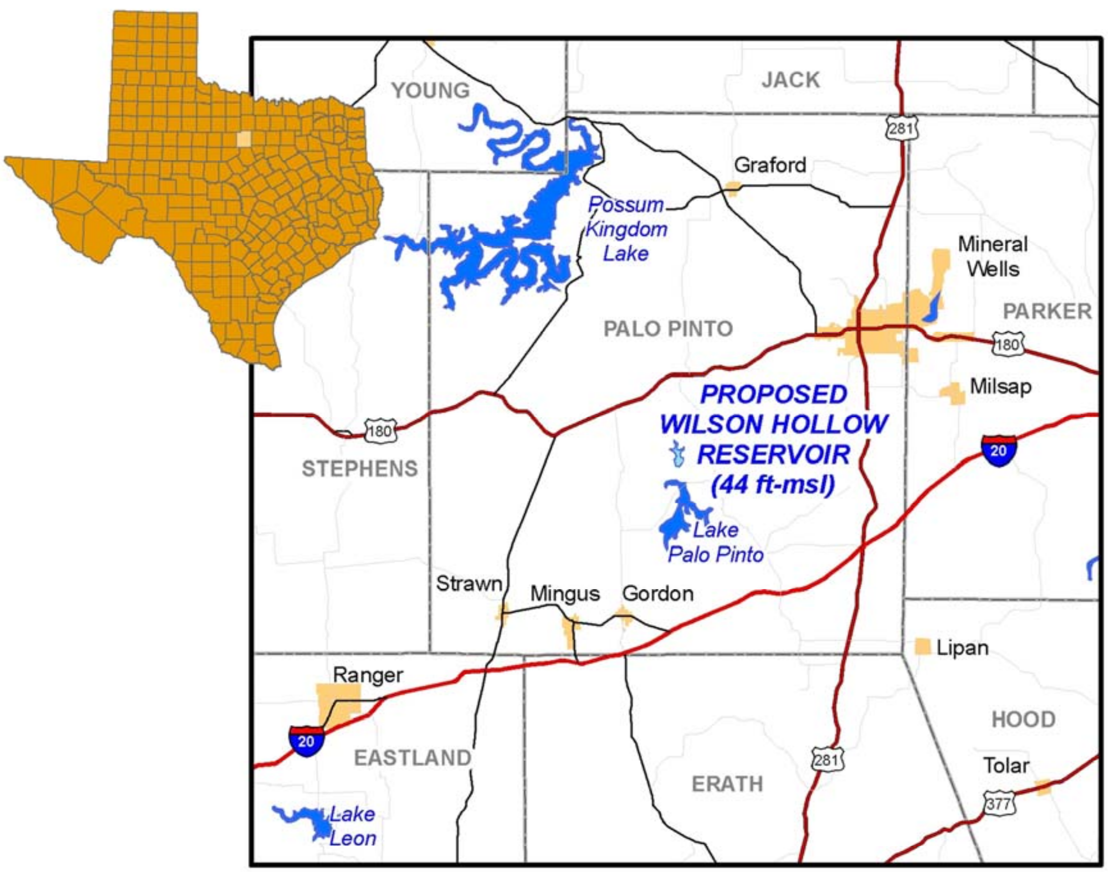

Figure 3.4.16-1. Location Map of Wilson Hollow Reservoir

The proposed off-channel reservoir would be filled by natural drainage and by pumping water from Lake Palo Pinto when it is spilling or nearly full. When the level of Lake Palo Pinto is lowered due to drought conditions, water would be released by gravity from the off-channel reservoir to Lake Palo Pinto to increase its supply capability. When both the off-channel reservoir and Lake Palo Pinto are at their conservation elevations, 1,077 ft-msl and 867 ft-msl respectively, the combined storage capacity in 2060 would be approximately 44,100 acft, the currently authorized storage capacity of Lake Palo Pinto. Wilson Hollow Reservoir will likely be constructed in two phases so that the site storage capacity is increased as the capacity of Lake Palo Pinto is decreased by sediment accumulation. The 2006 Brazos G Regional Water Plan (HDR and FNI, 2006) also identified Turkey Peak Reservoir as an alternative water management strategy to Wilson Hollow Reservoir for recovery of authorized Lake Palo Pinto storage capacity.

Projected municipal, industrial (including manufacturing), and steam-electric needs for additional water supply prior to year 2060 total 511,124 acft/yr for counties within a 50-mile radius of the Wilson Hollow Reservoir site. The nearest major population and water demand center to the Wilson Hollow Reservoir site is Dallas-Ft Worth (79 miles).

3.4.16.2 Reservoir Yield Analyses

The elevation-area-capacity relationship for Wilson Hollow Reservoir is presented in Figure 3.4.16-2 and Table 3.4.16-1 and was developed from 10-ft contour, digital hypsography data from the Texas Natural Resources Information System (TNRIS). These data are derived from the 1:24,000-Scale (7.5-minute) quadrangle maps developed by the USGS. The total area inundated at each 10-ft elevation contour is shown in Figure 3.4.16-3. Surface areas and capacities associated with 1077 ft-msl are computed by linear interpolation between values for 1070 ft-msl and 1080 ft-msl and are subject to future refinement based on more detailed topographic information. At the conservation storage pool elevation of 1077 ft-msl, Wilson Hollow Reservoir would inundate 333 acres and have a capacity of 22,000 acft.

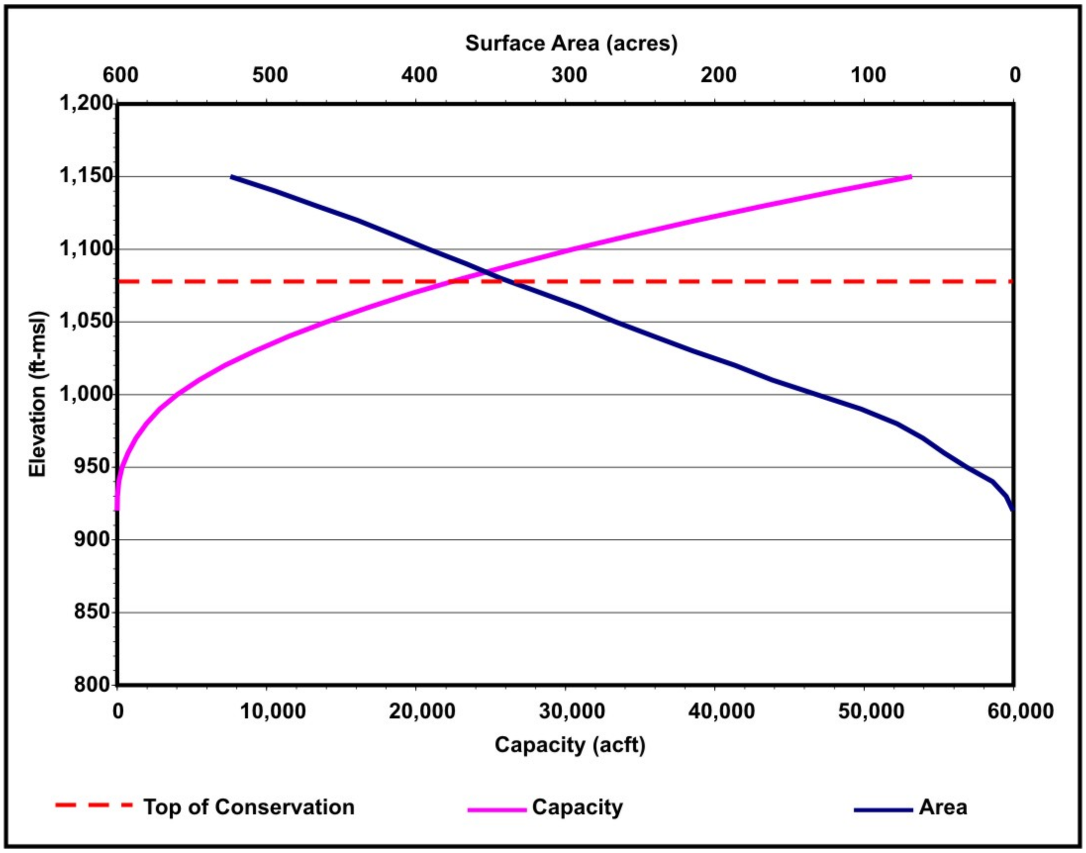

Figure 3.4.16-2. Elevation-Area-Capacity Relationship for Wilson Hollow Reservoir

Table 3.4.16-1.
Elevation-Area-Capacity Relationship for Wilson Hollow Reservoir

Elevation (feet)	*Area (acres)*	*Capacity (acft)*
920	0	0
930	5	24
940	14	115
950	31	336
960	47	724
970	61	1,259
980	78	1,951
990	102	2,849
1,000	132	4,014
1,010	162	5,477
1,020	187	7,216
1,030	215	9,221
1,040	241	11,498
1,050	266	14,034
1,060	290	16,815
1,070	317	19,845
1,077	333	22,000
1,080	343	23,143

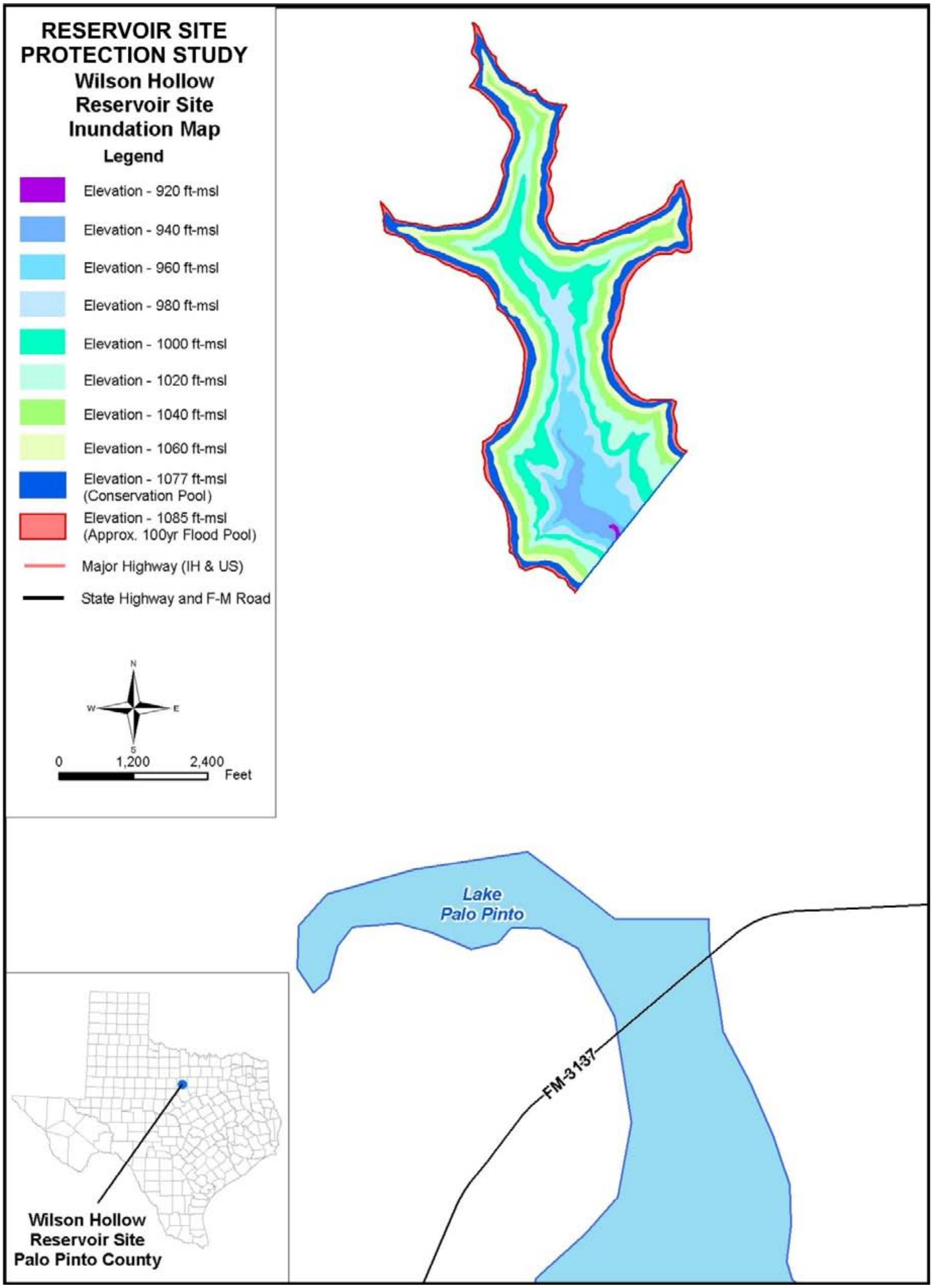

Figure 3.4.16-3. Inundation Map for Wilson Hollow Reservoir

The firm yield of Wilson Hollow Reservoir is estimated using the TCEQ Brazos River Basin Water Availability Model (Brazos WAM) (HDR, 2001) data sets and the Water Rights Analysis Package (WRAP). The Brazos WAM simulates a repeat of the natural streamflows over the 57-year period of 1940 through 1996 accounting for the appropriated water rights of the Brazos River Basin with respect to location, priority date, diversion amount, diversion pattern, storage, and special conditions including instream flow requirements.

For the purposes of this study, Lake Granbury and other senior water rights are assumed to be subordinated to Lake Palo Pinto authorized storage capacity. Specific terms of such subordination are, or will be, the subject of negotiations between the reservoir sponsor, the Brazos River Authority, and others.

Four potential conservation storage capacities are modeled for Wilson Hollow Reservoir. These conservation storage capacities are 10,000 acft, 15,000 acft, 20,000 acft, and 22,000 acft. Wilson Hollow Reservoir is simulated with the priority date of Lake Palo Pinto since it is envisioned as a project to recover "lost" storage in Lake Palo Pinto. Firm yield estimates for Wilson Hollow Reservoir for all four conservation capacities are shown in Table 3.4.16-2. Current planning initiatives envision a conservation elevation of 1077 ft-msl for Wilson Hollow Reservoir, thereby yielding an additional water supply of 5,873 acft/yr above the Year 2060 Lake Palo Pinto firm yield of 11,340 acft/yr. Figure 3.4.16-4 shows the relationship between firm yield and conservation capacity for the Wilson Hollow Reservoir / Lake Palo Pinto System. For the purposes of this study, a 54 MGD diversion intake, pump station, and pipeline were assumed to pump water up from Lake Palo Pinto to Wilson Hollow.

Wilson Hollow Reservoir was most recently studied by Region G and identified as a recommended water management strategy in the 2006 Regional Water Plan. In the Region G plan, Wilson Hollow Reservoir was evaluated at a location slightly upstream and at a smaller size (10,000 acft). Additionally, the Lake Palo Pinto / Wilson Hollow System was evaluated on a safe yield basis.

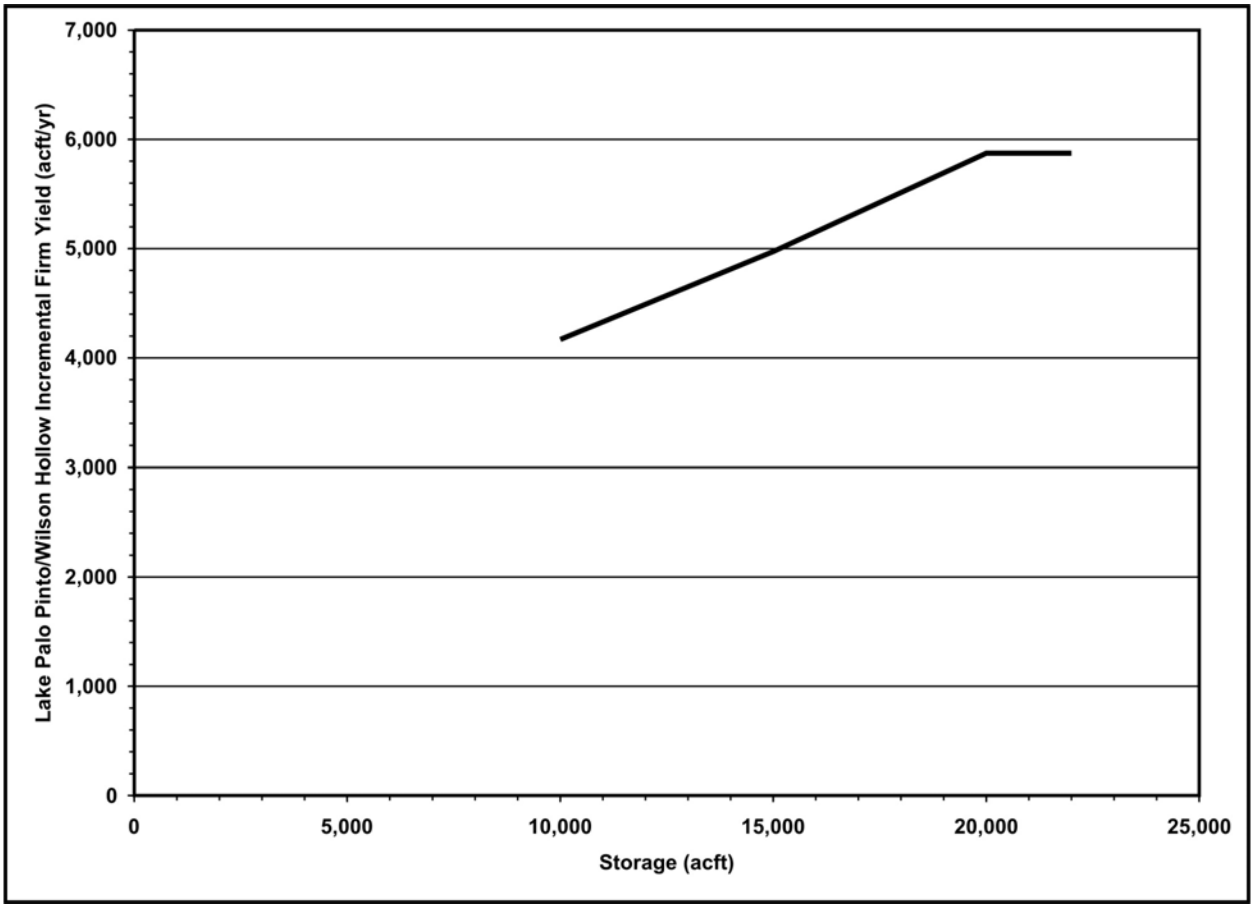

Figure 3.4.16-4. Firm Yield vs. Conservation Storage for Wilson Hollow Reservoir

Table 3.4.16-2.
Firm Yield vs. Conservation Storage for Wilson Hollow Reservoir

Wilson Hollow Conservation Capacity (acft)	*Lake Palo Pinto / Wilson Hollow System Yield (acft/yr)*	*Wilson Hollow Incremental Firm Yield (acft/yr)*
10,000	15,508	4,168
15,000	16,314	4,974
20,000	17,213	5,873
22,000*	17,213	5,873
*Ultimate proposed conservation storage.		

Figure 3.4.16-5 illustrates storage fluctuations through time for Wilson Hollow Reservoir and Figure 3.4.16-6 shows combined system storage in Lake Palo Pinto and Wilson Hollow Reservoir. The storage frequency curve in Figure 3.4.16-5 indicates that the reservoir would be full about 30 percent of the time, more than half full about 80 percent of the time, and empty about 7 percent of the time. As shown in Figure 3.4.16-6, however, the system of reservoirs would be above 50 percent of capacity about 90 percent of the time.

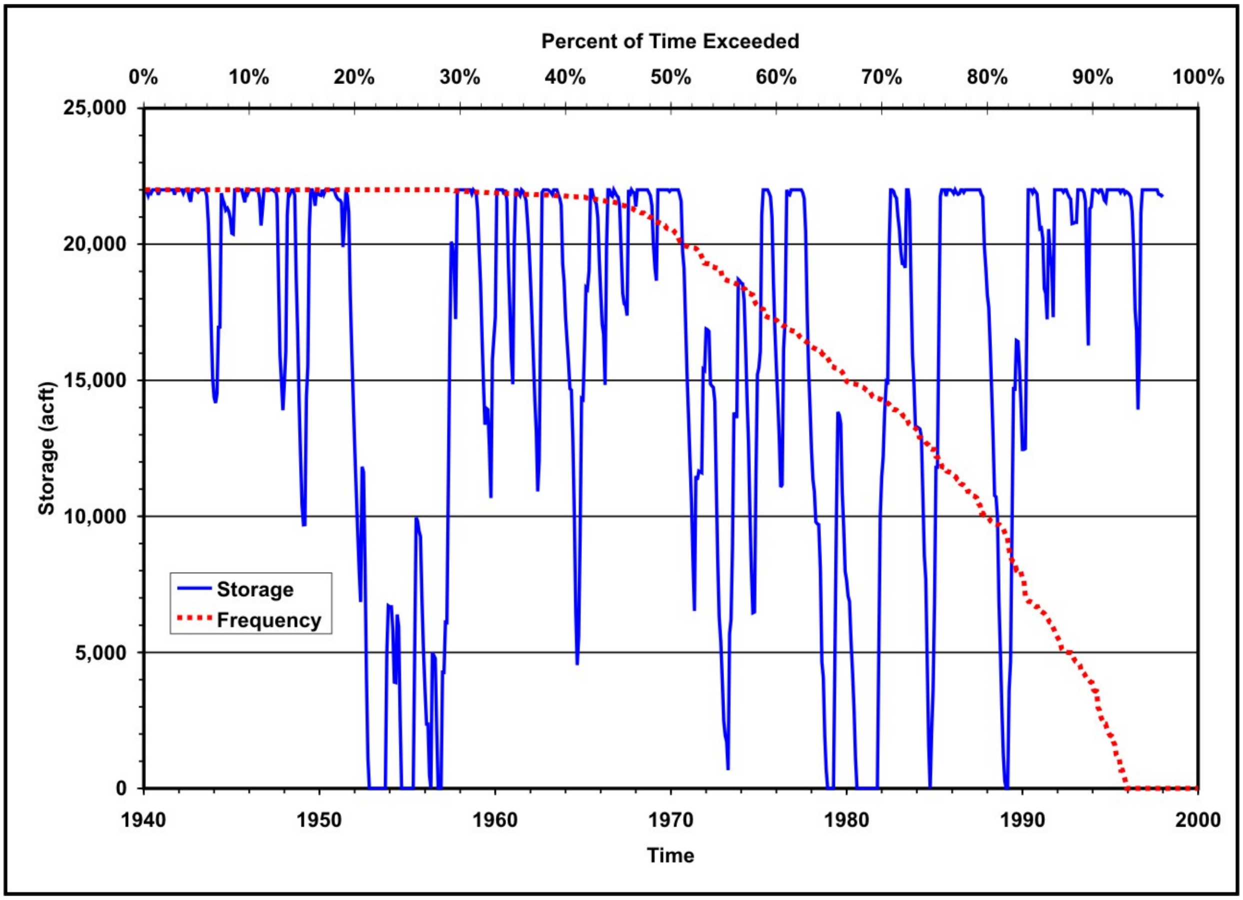

Figure 3.4.16-5. Simulated Storage in Wilson Hollow Reservoir (Conservation Elevation = 1077 ft-msl, Incremental Diversion = 5,873 acft/yr)

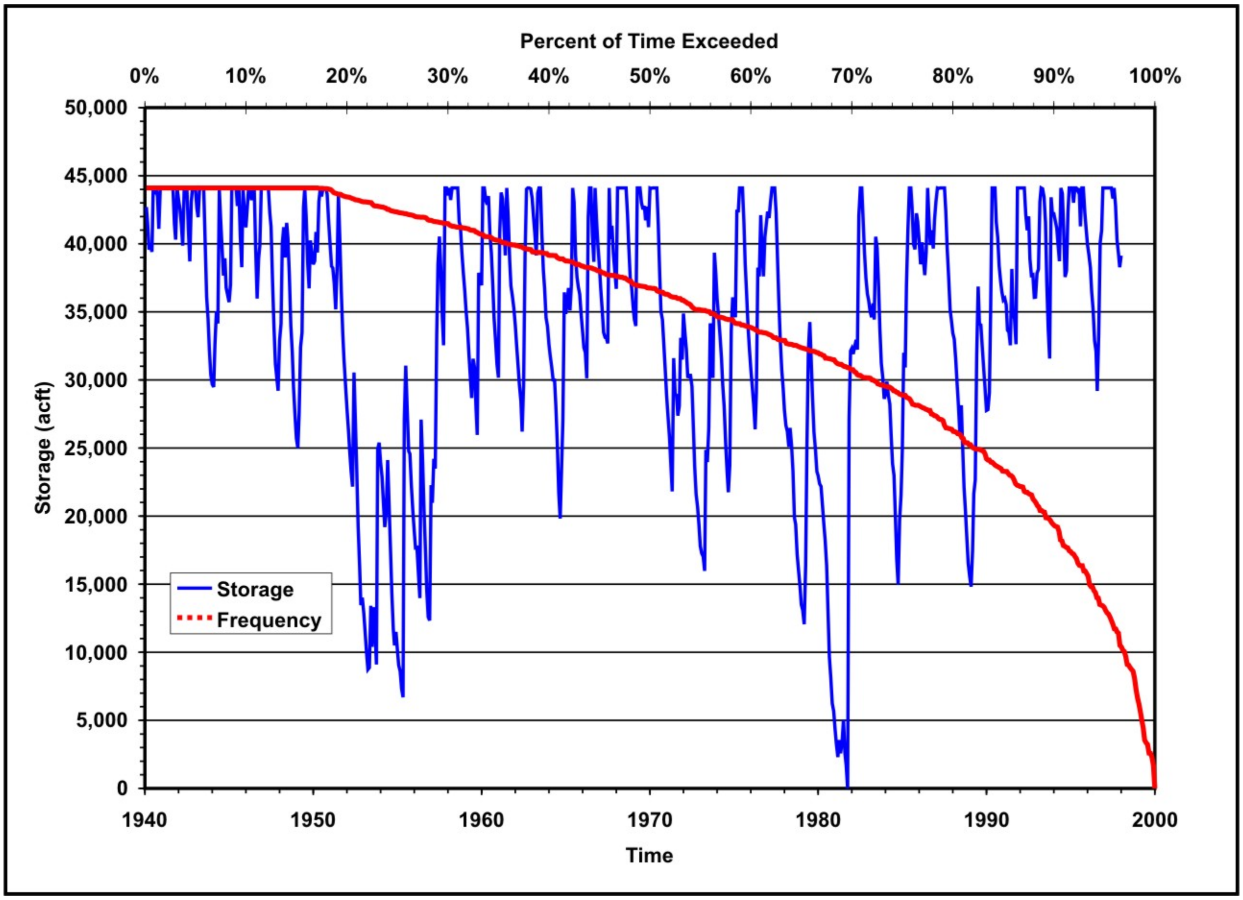

Figure 3.4.16-6. Simulated System Storage for Lake Palo Pinto and Wilson Hollow Reservoirs (System Diversion = 17,213 acft/yr)

3.4.16.3 Reservoir Project Cost Estimates

Costs for Wilson Hollow Reservoir assume a zoned earthen embankment. The dam is estimated to be approximately 2,500 feet in length and have a maximum height of approximately 168 feet. Diversion works from Lake Palo Pinto to Wilson Hollow Reservoir include a 54 MGD intake and pump station, a 1.5 mile, 54-inch pipeline, and a stilling basin.

Figure 3.4.16-7 shows the major conflicts within the conservation pool of Wilson Hollow Reservoir. Potential conflicts for Wilson Hollow Reservoir are limited to existing gas infrastructure. Resolution of facility conflicts represents less than 1 percent of the total construction cost.

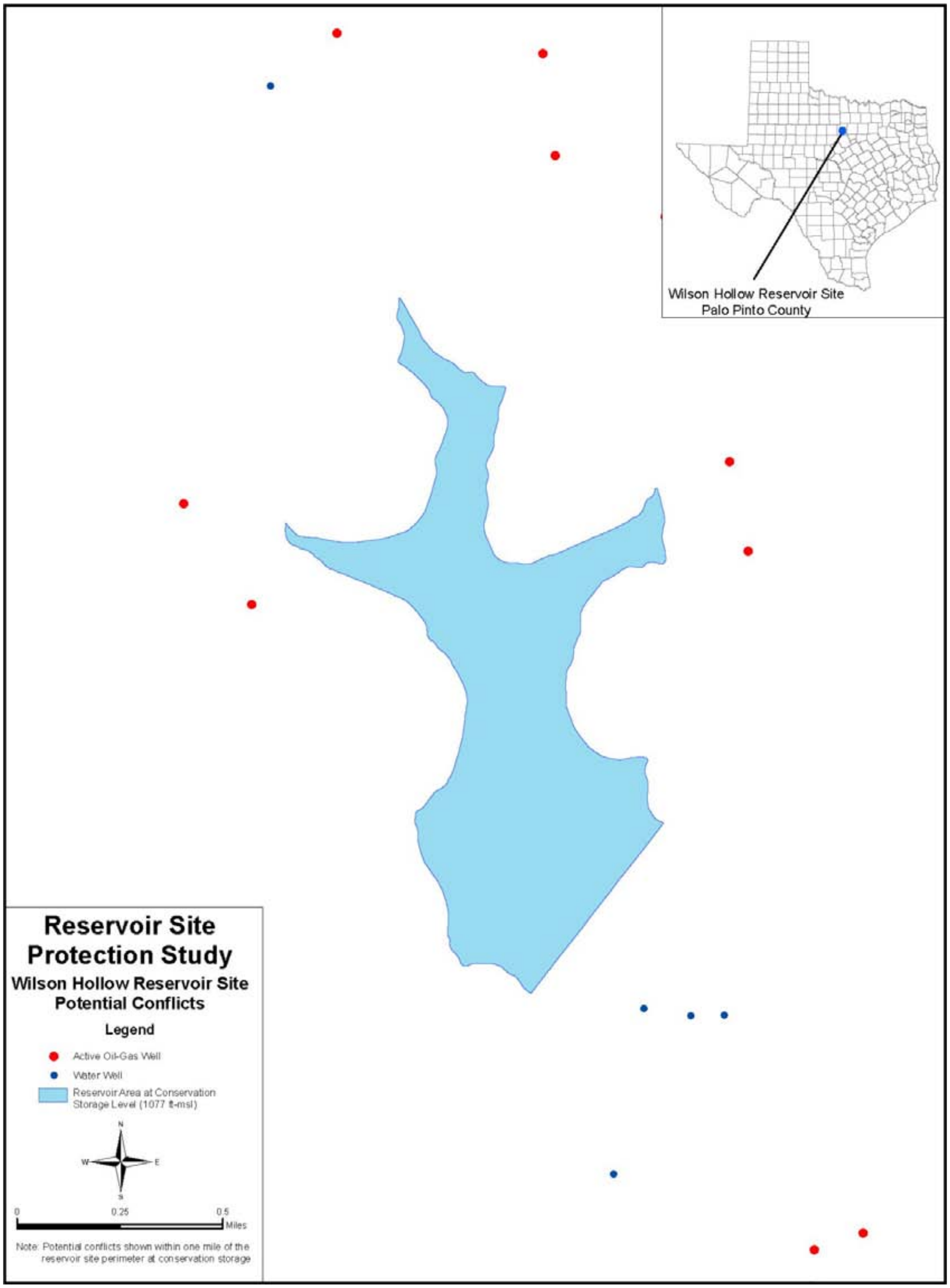

Figure 3.4.16-7. Potential Major Conflicts for Wilson Hollow Reservoir

A summary cost estimate for Wilson Hollow Reservoir at elevation 1077 ft-msl is shown in Table 3.4.16-3. Dam and reservoir costs total about $47 million, while relocations total another $540,000. Land, which includes mitigation lands, totals about $3.4 million. The diversion intake, pump station, and pipeline from Lake Palo Pinto to Wilson Hollow Reservoir adds another $10.5 million. Annual costs for Wilson Hollow Reservoir are approximately $5.4 million during the 40-year debt service period, giving the project a unit cost of raw water at the reservoir of $920/acft ($2.82 per 1000 gallons).

Table 3.4.16-3.
Cost Estimate – Wilson Hollow Reservoir @ Elevation 1077 ft-msl

	Quantity	Unit	Unit Price	Cost
Dam & Reservoir				
Mobilization (5%)	1	LS		$1,595,016
Care of Water During Construction (3%)	1	LS		$957,009
Cutoff Trench	1	LS	$1,242,866	$1,242,866
Embankment	1	LS	$21,019,975	$21,019,975
Drains & Filters	1	LS	$4,179,930	$4,179,930
Grouting and Foundation Preparation	1	LS	$494,517	$494,517
Geocomposite Liner/ Riprap	1	LS	$4,313,025	$4,313,025
Outlet Works Tower and Conduit	1	LS	$650,000	$650,000
Engineering Contingencies (35%)				$12,058,318
Subtotal Dam & Reservoir				**$46,510,657**
Pump & Pipeline				
Pump Station & Intake (54 MGD)	1	LS	$5,708,000	$5,708,000
Pipeline (54-inch)	7794	LF	$240	$1,870,560
Stilling Basin (83.5 cfs)	1	LS	$252,588	$252,588
Engineering Contingencies (35%)				$2,740,902
Subtotal Pump & Pipeline				**$10,572,049**
Conflicts				
Gas Infrastructure	1	LS	$400,000	$400,000
Engineering Contingencies (35%)				$140,000
Subtotal Conflicts				**$540,000**
Land				
Land Acquisition	400	AC	$4,250	$1,700,000
Environmental Studies and Mitigation Lands	400	AC	$4,250	$1,700,000
Subtotal Land				**$3,400,000**
CONSTRUCTION TOTAL				**$61,022,706**
Interest During Construction (36 months)				**$7,322,725**
TOTAL COSTS				**$68,345,430**
ANNUAL COSTS				
Debt Service (6% for 40 Years)				$4,542,237
Operations & Maintenance				$861,591
Pumping Energy				$550,276
Total Annual Costs				**$5,403,829**
Firm Yield (acft/yr)				**5,873**
Unit Costs of Water ($/acft/yr)				**$920**

Units: AC = Acre; CY = Cubic Yard; EA = Each; LB = Pound; LF = Linear Foot; LS = Lump Sum; SF = Square Foot; and SY = Square Yard.

3.4.16.4 Environmental Considerations

Wilson Hollow Reservoir is not located on or immediately upstream of any ecologically significant stream segments as recommended by Texas Parks and Wildlife Department (TPWD, 1999). The reservoir will inundate 333 acres of land. Table 3.4.16-4 and Figure 3.4.16-8 summarize existing landcover for the Wilson Hollow Reservoir site as determined by TPWD using methods described in Appendix C. Existing landcover within this reservoir site is 96 percent upland deciduous forest with one small homestead near the dam site.

Table 3.4.16-4.
Acreage and Percent Landcover for Wilson Hollow Reservoir

Landcover Classification	*Acreage*[1]	*Percent*
Upland Deciduous Forest	330	96.0%
Urban / Developed Land	14	4.0%
Total	**344**	**100.0%**

[1] Acreage based on approximate GIS coverage rather than calculated elevation-area-capacity relationship.

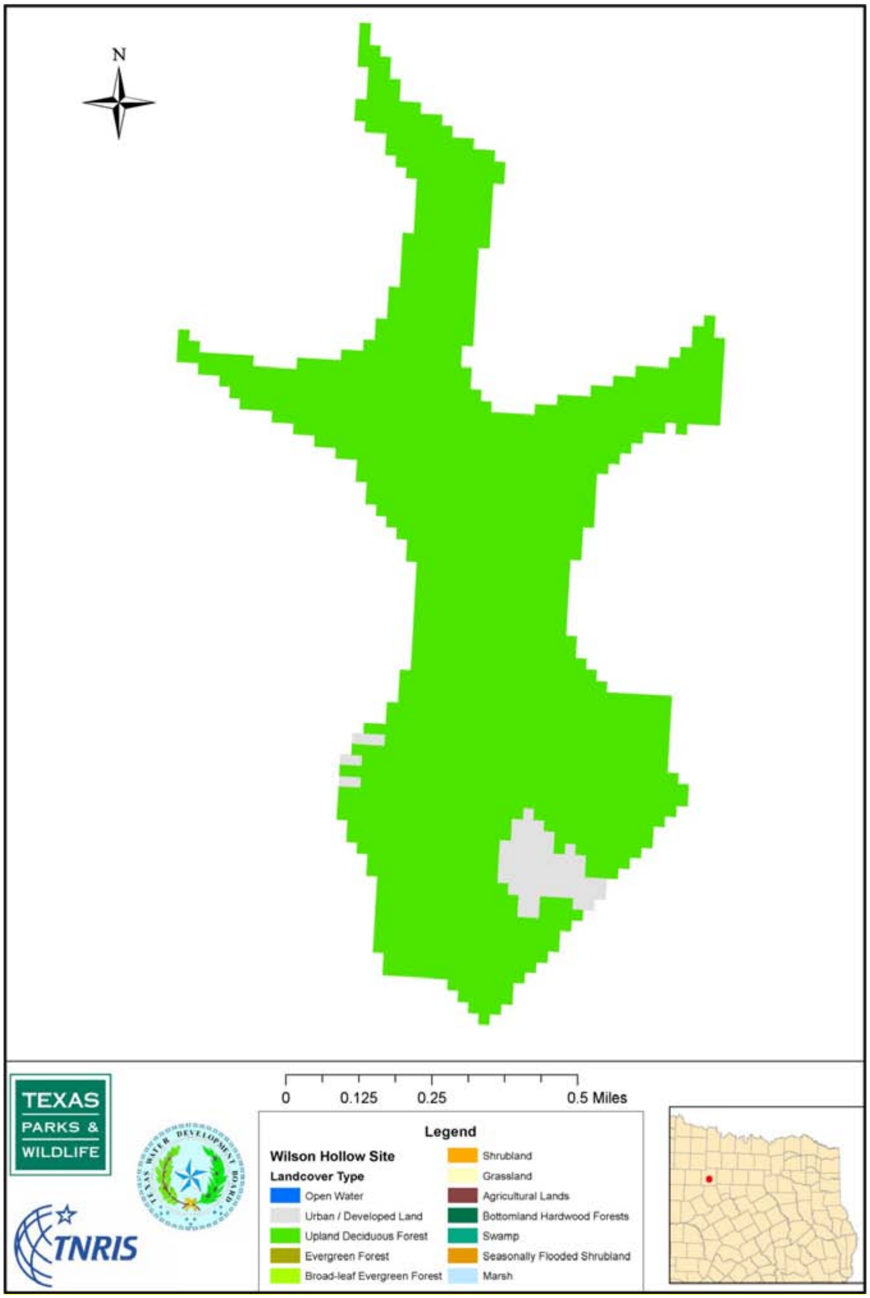

Figure 3.4.16-8. Existing Landcover for Wilson Hollow Reservoir