Volumetric Survey
of
LEON RESERVOIR

September 2015 Survey

Texas Water Development Board

January 2016

Texas Water Development Board

Bech Bruun, Chairman | Kathleen Jackson, Member | Peter Lake, Member

Kevin Patteson, Executive Administrator

Prepared for:

Eastland County Water Supply District

With Support Provided by:

U.S. Army Corps of Engineers, Fort Worth District

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Executive summary

In September 2015, the Texas Water Development Board entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, to perform a volumetric survey of Leon Reservoir. The Eastland County Water Supply District provided 50% of the funding for this survey, while the U.S. Army Corps of Engineers, Fort Worth District, provided the remaining 50% of the funding through their Planning Assistance to States Program. Surveying was performed using a multi-frequency (208 kHz, 50 kHz, and 24 kHz), sub-bottom profiling depth sounder, although only the 208 kHz frequency was analyzed for this report.

Leon Dam and Leon Reservoir are located on the Leon River in Eastland County, seven miles south of Ranger, Texas. The conservation pool elevation of Leon Reservoir is 1,375.0 feet above mean sea level (NGVD29). TWDB collected bathymetric data for Leon Reservoir between September 17, 2015, and September 24, 2015. The daily average water surface elevation during the survey ranged between 1,373.25 and 1,373.40 feet above mean sea level.

The 2015 TWDB volumetric survey indicates that Leon Reservoir has a total reservoir capacity of 28,042 acre-feet and encompasses 1,756 acres at conservation pool elevation (1,375.0 feet above mean sea level, NGVD29). Previous capacity estimates include the original design capacity of 27,290 acre-feet encompassing 1,590 acres.

TWDB recommends that a similar methodology be used to resurvey Leon Reservoir in 10 years or after a major flood event. To further improve estimates of capacity loss, TWDB recommends a volumetric and sedimentation survey. Sedimentation surveys include additional analysis of the multi-frequency data for post-impoundment sediment by correlation with sediment core samples and a map identifying the spatial distribution of sediment throughout the reservoir.

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Note: References to brand names throughout this report do not imply endorsement by the Texas Water Development Board

Introduction

The Hydrographic Survey Program of the Texas Water Development Board (TWDB) was authorized by the 72nd Texas State Legislature in 1991. Section 15.804 of the Texas Water Code authorizes TWDB to perform surveys to determine reservoir storage capacity, sedimentation levels, rates of sedimentation, and projected water supply availability.

In September 2015, the Texas Water Development Board entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, to perform a volumetric survey of Leon Reservoir. The Eastland County Water Supply District provided 50% of the funding for this survey, while the U.S. Army Corps of Engineers, Fort Worth District, provided the remaining 50% of the funding through their Planning Assistance to States Program (TWDB, 2015). This report describes the methods used to conduct the volumetric survey, including data collection and processing techniques. This report serves as the final contract deliverable from TWDB to Eastland County Water Supply District, and contains as deliverables: (1) a shaded relief plot of the reservoir bottom [Figure 4], (2) a bottom contour map [Figure 6], and (3) an elevation-area-capacity table of the reservoir acceptable to the Texas Commission on Environmental Quality [Appendix A, B].

Leon Reservoir general information

Leon Dam and Leon Reservoir are located on the Leon River in Eastland County in the Brazos River Basin, seven miles south of Ranger, and five miles southeast of Eastland, Texas (Figure 1). Construction of Leon Dam began on January 13, 1953, and deliberate impoundment of water began in April 1954 (TWDB, 1973). The dam was completed in June 1954. Leon Reservoir is owned and operated by Eastland County Water Supply District (TWDB, 1973). Leon Reservoir is primarily a water supply reservoir for the cities of Ranger, Olden, and Eastland, Texas (TWDB, 1973). Additional pertinent data about Leon Reservoir Dam and Leon Reservoir can be found in Table 1.

Water rights for Leon Reservoir have been appropriated to Eastland County Water Supply District, through Certificate of Adjudication No. 12-3470 and Amendments to Certificate of Adjudication Nos. 12-3470A and 12-3470B. The complete certificates are on file in the Information Resources Division of the Texas Commission on Environmental Quality.

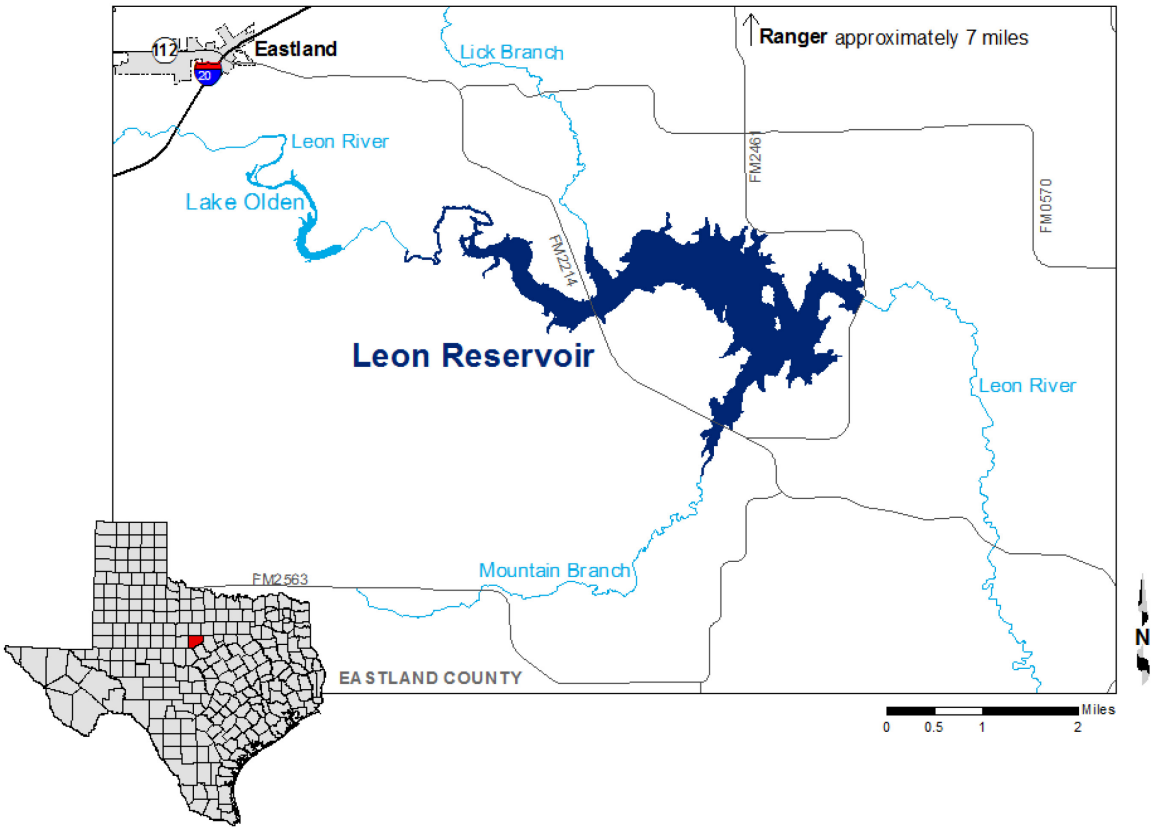

Figure 1. Location of Leon Reservoir

Table 1. Pertinent data for Leon Dam and Leon Reservoir

Owner	
Eastland County Water Supply District	
Engineer (Design)	
Freese, Nichols and Endress	
Location of dam	
On the Leon River in Eastland County, 7 miles south of Ranger	
Drainage area	
252 square miles	
Dam	
Type	Earthfill
Length	3,700 feet
Maximum height	90 feet
Top width	20 feet
Top elevation	1,398.0 feet above mean sea level
Spillway (emergency)	
Location	Left of dam
Type	Natural ground
Crest elevation	1,382.0 feet above mean sea level
Crest length	1,200 feet
Spillway (service)	
Location	Near center of dam
Type	Drop inlet, 34.5 feet diameter
Discharge conduit	11 feet diameter
Crest elevation	1,375.0 feet above mean sea level
Outlet works	
Type	Gated control tower
Discharge	24-inch diameter concrete pipe
Pump station location	Below dam
Treating plant location	4 miles north of dam

Reservoir data (Based on 2015 TWDB survey)

Feature	**Elevation (feet** NGVD29[a]**)**	**Capacity (acre-feet)**	**Area (acres)**
Top of dam	1,398.0	N/A	N/A
Crest of emergency spillway	1,382.0	N/A	N/A
Crest of service spillway/ Conservation pool elevation	1,375.0	28,042	1,756
Invert low flow outlet	1,335.0	280	67
Usable conservation storage space[b]	-	27,762	-

Source: (TWDB, 1973)

[a] NGVD29 = National Geodetic Vertical Datum 1929

[b] Usable conservation storage space equals total capacity at conservation pool elevation minus dead pool capacity. Dead pool refers to water that cannot be drained by gravity through a dam's outlet works.

Volumetric survey of Leon Reservoir

Datum

The vertical datum used during this survey is the National Geodetic Vertical Datum 1929 (NGVD29). This datum is also utilized by the United States Geological Survey (USGS) for the reservoir elevation gage *USGS 08099000 Leon Res nr Ranger, TX* (USGS, 2015). Elevations herein are reported in feet relative to the NGVD29 datum. Volume and area calculations in this report are referenced to water levels provided by the USGS gage.

The horizontal datum used for this report is North American Datum 1983 (NAD83), and the horizontal coordinate system is State Plane Texas North Central Zone (feet).

TWDB bathymetric data collection

TWDB collected bathymetric data for Leon Reservoir between September 17, 2015, and September 24, 2015. The daily average water surface elevations during the survey ranged between 1,373.25 and 1,373.40 feet above mean sea level (NGVD29). For data collection, TWDB used a Specialty Devices, Inc. (SDI), single-beam, multi-frequency (208 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder integrated with differential global positioning system (DGPS) equipment. Data was collected along pre-planned survey lines oriented perpendicular to the assumed location of the original river channels and spaced between approximately 250 and 500 feet apart. The depth sounder was calibrated daily using a velocity profiler to measure the speed of sound in the water column and a weighted tape or stadia rod for depth reading verification. Figure 2 shows where data collection occurred during the 2015 TWDB survey.

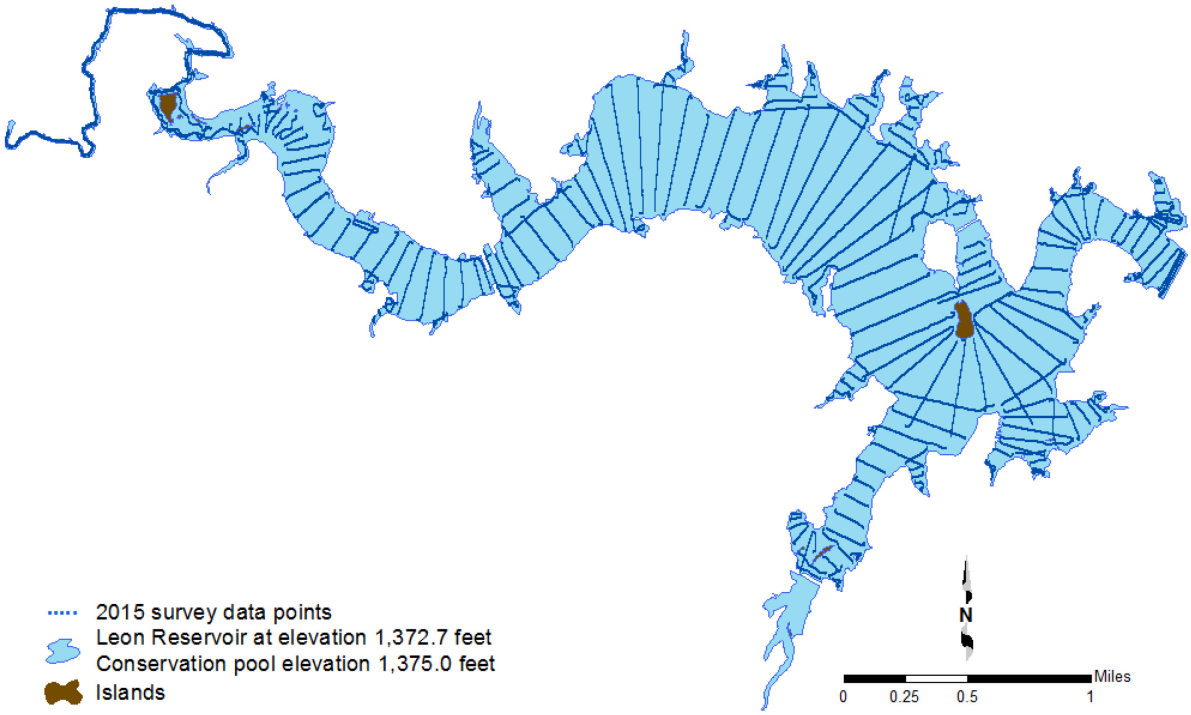

Figure 2. Data collected during 2015 TWDB Leon Reservoir survey

Data processing

Model boundaries

The reservoir boundary was digitized using Environmental Systems Research Institute's ArcGIS software (ArcGIS) from aerial photographs, also known as digital orthophoto quarter-quadrangle images (DOQQs), obtained from the Texas Natural Resources Information System (TNRIS, 2015). The quarter-quadrangles that cover Leon Reservoir are Kokomo (NW, NE), Carbon (NE), Eastland (SE), and Ranger (SW). The DOQQs were photographed on August 31, 2008, and September 27, 2008, while the daily average water surface elevation measured 1,373.34 feet and 1,372.74 feet, respectively (NGVD29). According to metadata associated with the 2008 DOQQs, the photographs have a resolution or ground sample distance of 0.5-meters and a horizontal accuracy within 3-5 meters to true ground. For this analysis, the boundary was digitized at the land-water interface in the 2008 photographs and assigned an elevation of 1,372.7 feet as the majority of the reservoir was photographed on September 27, 2008. The section titled "Area, volume, and contour calculation" describes how areas and capacities were generated up to the conservation pool elevation.

Triangulated Irregular Network model

Following completion of data collection, the raw data files were edited to remove data anomalies. DepthPic©, software developed by SDI, Inc., was used to display, interpret, and edit the multi-frequency data by manually removing data anomalies in the current bottom surface. For processing outside of DepthPic©, an in-house software package, HydroTools, was used to identify the current reservoir-bottom surface, and to output the data into a single file. The water surface elevation at the time of each sounding was used to convert each sounding depth to a corresponding reservoir-bottom elevation. This survey point dataset was then preconditioned by inserting a uniform grid of artificial survey points between the actual survey lines. Bathymetric elevations at these artificial points are determined using an anisotropic spatial interpolation algorithm described in the next section. This technique creates a high resolution, uniform grid of interpolated bathymetric elevation points throughout a majority of the reservoir (McEwen et al., 2011a). Finally, the point file resulting from spatial interpolation was used in conjunction with sounding and boundary data to create volumetric Triangulated Irregular Network (TIN) models utilizing the 3D Analyst Extension of ArcGIS. The 3D Analyst algorithm uses Delaunay's criteria

for triangulation to create a grid composed of triangles from non-uniformly spaced points, including the boundary vertices (ESRI, 1995).

Spatial interpolation of reservoir bathymetry

Isotropic spatial interpolation techniques such as the Delaunay triangulation used by the 3D Analyst extension of ArcGIS are, in many instances, unable to suitably interpolate bathymetries between survey lines common to reservoir surveys. Reservoirs and stream channels are anisotropic morphological features where bathymetry at any particular location is more similar to upstream and downstream locations than to transverse locations. Interpolation schemes that do not consider this anisotropy lead to the creation of several types of artifacts in the final representation of the reservoir bottom surface and hence to errors in volume. These include: artificially-curved contour lines extending into the reservoir where the reservoir walls are steep or the reservoir is relatively narrow; intermittent representation of submerged stream channel connectivity; and oscillations of contour lines in between survey lines. These artifacts reduce the accuracy of the resulting volumetric TIN models in areas between actual survey data.

To improve the accuracy of bathymetric representation between survey lines, TWDB developed various anisotropic spatial interpolation techniques. Generally, the directionality of interpolation at different locations of a reservoir can be determined from external data sources. A basic assumption is that the reservoir profile in the vicinity of a particular location has upstream and downstream similarity. In addition, the sinuosity and directionality of submerged stream channels can be determined by directly examining survey data or more robustly by examining scanned USGS 7.5 minute quadrangle maps (known as digital raster graphics or DRGs) and hypsography files (the vector format of USGS 7.5 minute quadrangle map contours), when available. Using the survey data, polygons are created to partition the reservoir into segments with centerlines defining directionality of interpolation within each segment. For surveys with similar spatial coverage, these interpolation definition files are in principle independent of the survey data and could be applied to past and future survey data of the same reservoir. In practice, however, minor revisions of the interpolation definition files may be needed to account for differences in spatial coverage and boundary conditions between surveys. Using the interpolation definition files and survey data, the current reservoir-bottom elevation, when applicable, is calculated for each point in the high resolution uniform grid of artificial

survey points. The reservoir boundary, artificial survey points grid, and survey data points are used to create the volumetric TIN model representing the reservoir bathymetry. Specific details of this interpolation technique can be found in the HydroTools manual (McEwen et al., 2011a) and in McEwen et al., 2011b.

In areas inaccessible to survey data collection such as small coves and shallow upstream areas of the reservoir, linear interpolation is used for volumetric estimations. The linear interpolation follows a linear definition file linking the survey points file to the lake boundary file (McEwen et al., 2011a). Without interpolated data, the TIN model builds flat triangles. A flat triangle is defined as a triangle where all three vertices are equal in elevation, generally the elevation of the reservoir boundary. Reducing flat triangles by applying linear interpolation improves the elevation-capacity and elevation-area calculations. It is not always possible to remove all flat triangles, and linear interpolation is only applied where adding bathymetry is deemed reasonable. For example, linear interpolation was applied throughout Leon Reservoir following features indicated by aerial photographs taken on July 8 and July 27, 2014, while the water surface elevation measured 1,369.88 and 1,369.41 feet, respectively. Photographs taken on December 21, 1947, December 29, 1947, and January 14, 1948, before the dam was constructed, were also referenced for modeling the reservoir.

Figure 3 illustrates typical results from application of the anisotropic interpolation and linear interpolation techniques to Leon Reservoir. In Figure 3A, deeper channels indicated by surveyed cross sections are not continuously represented in areas between survey cross sections. This is an artifact of the TIN generation routine rather than an accurate representation of the physical bathymetric surface. Inclusion of interpolation points, represented in Figure 3B, in creation of the volumetric TIN model directs Delaunay triangulation to better represent the lake bathymetry between survey cross-sections. The bathymetry shown in Figure 3C was used in computing reservoir capacity and area tables (Appendix A, B).

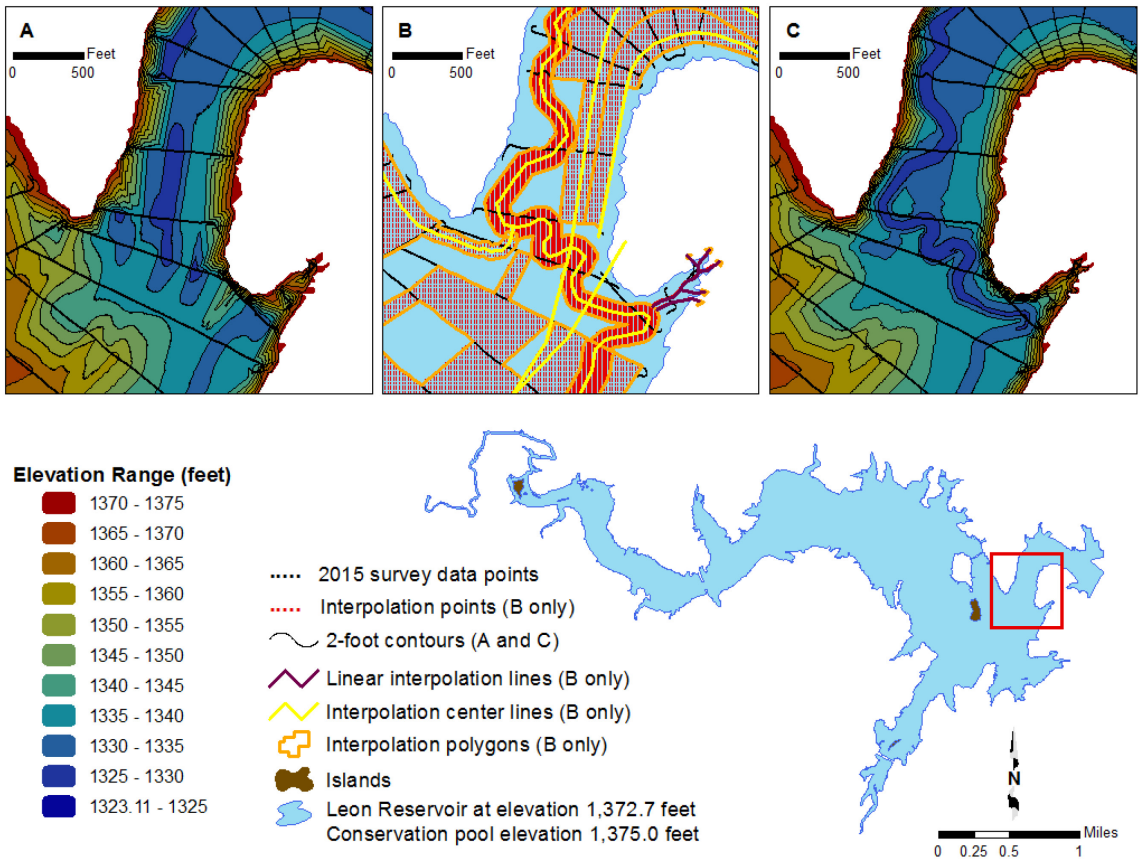

Figure 3. **Anisotropic spatial interpolation and linear interpolation of Leon Reservoir sounding data - A) bathymetric contours without interpolated points, B) sounding points (black) and interpolated points (red), C) bathymetric contours with the interpolated points**

Area, volume, and contour calculation

Using ArcInfo software and the volumetric TIN model, volumes and areas were calculated for the entire reservoir at 0.1 feet intervals, from 1,323.1 to 1,372.7 feet. While linear interpolation was used to estimate the topography in areas that were inaccessible by boat or too shallow for the instruments to work properly, development of anomalous "flat triangles", that is triangles whose three vertices all have the same elevation, in the TIN model are unavoidable. The flat triangles in turn lead to anomalous calculations of surface area and volume at the boundary elevation 1,372.7 feet. To eliminate the effects of the flat triangles on area and volume calculations, areas between elevations 1,371.0 feet and 1,372.7 feet were linearly interpolated between the computed values, and volumes above elevation 1,371.0 feet were calculated based on the corrected areas. Areas above elevation 1,372.7 feet were linearly extrapolated and capacities were calculated from the extrapolated areas. The elevation-capacity table and elevation-area table, updated for 2015, are presented in Appendices A and B, respectively. The capacity curve is presented in Appendix C, and the area curve is presented in Appendix D.

The volumetric TIN model was converted to a raster representation using a cell size of 1 foot by 1 foot. The raster data was then used to produce: an elevation relief map (Figure 4), representing the topography of the reservoir bottom; a depth range map (Figure 5), showing shaded depth ranges for Leon Reservoir; and a 5-foot contour map (Figure 6 - attached).

Figure 4

Leon Reservoir

Elevation relief map

1,890,000 1,900,000 1,910,000

6,820,000 6,810,000

Elevation (feet)

1,372 - 1,372.7	1,346 - 1,348
1,370 - 1,372	1,344 - 1,346
1,368 - 1,370	1,342 - 1,344
1,366 - 1,368	1,340 - 1,342
1,364 - 1,366	1,338 - 1,340
1,362 - 1,364	1,336 - 1,338
1,360 - 1,362	1,334 - 1,336
1,358 - 1,360	1,332 - 1,334
1,356 - 1,358	1,330 - 1,332
1,354 - 1,356	1,328 - 1,330
1,352 - 1,354	1,326 - 1,328
1,350 - 1,352	1,324 - 1,326
1,348 - 1,350	1,323.1 - 1,324

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N

0 0.5 1 Miles

10-ft contours

Leon Reservoir at elevation 1,372.7 feet

Conservation pool elevation: 1,375 feet above mean sea level

Projection: NAD83
State Plane
Texas North Central Zone (feet)

Figure 5

Leon Reservoir

Depth ranges map

1,890,000 1,900,000 1,910,000

6,820,000 6,810,000

Depth ranges
(feet below conservation pool)

- 2.3 - 5'
- 5 - 10'
- 10 - 15'
- 15 - 20'
- 20 - 25'
- 25 - 30'
- 30 - 35'
- 35 - 40'
- 40 - 45'
- 45 - 50'
- > 50'

Texas Water Development Board

September 2015 Survey

N

0 0.5 1 Miles

Islands

Leon Reservoir at elevation 1,372.7 feet

Conservation pool elevation: 1,375 feet above mean sea level

Projection: NAD83
State Plane
Texas North Central Zone (feet)

Survey results

Volumetric survey

The results of the 2015 TWDB volumetric survey indicate Leon Reservoir has a total reservoir capacity of 28,042 acre-feet and encompasses 1,756 acres at conservation pool elevation (1,375.0 feet above mean sea level, NGVD29). The original design estimate for Leon Reservoir indicates a total reservoir capacity of 27,290 acre-feet encompassing 1,590 acres (TWDB, 1973). Because of differences in past and present survey methodologies, direct comparison of volumetric surveys to estimate loss of capacity is difficult and can be unreliable.

Recommendations

To improve estimates of sediment accumulation rates, TWDB recommends resurveying Leon Reservoir in approximately 10 years or after a major flood event. To further improve estimates of capacity loss, TWDB recommends a volumetric and sedimentation survey. Sedimentation surveys include additional analysis of the multi-frequency data for post-impoundment sediment by correlation with sediment core samples and a map identifying the spatial distribution of sediment throughout the reservoir.

TWDB contact information

More information about the Hydrographic Survey Program can be found at:
http://www.twdb.texas.gov/surfacewater/surveys/index.asp
Any questions regarding the TWDB Hydrographic Survey Program may be addressed to:

Jason J. Kemp
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Phone: (512) 463-2456
Email: Jason.Kemp@twdb.texas.gov

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Appendix A

Leon Reservoir

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — September 2015 Survey

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 1,375.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1,323	0	0	0	0	0	0	0	0	0	0
1,324	0	0	0	0	1	1	1	1	2	2
1,325	2	3	3	3	4	4	5	5	6	7
1,326	7	8	8	9	10	11	11	12	13	14
1,327	15	16	17	18	19	20	21	22	23	25
1,328	26	27	29	30	32	34	35	37	39	41
1,329	43	44	46	48	50	53	55	57	59	61
1,330	64	66	69	71	74	76	79	82	85	88
1,331	91	94	97	100	104	107	111	114	118	122
1,332	125	129	133	137	141	145	149	154	158	162
1,333	167	171	176	181	186	191	196	201	207	212
1,334	218	223	229	235	241	248	254	260	267	273
1,335	280	287	294	301	308	315	322	329	337	344
1,336	352	359	367	375	382	390	398	406	415	423
1,337	431	440	448	457	466	475	483	492	501	511
1,338	520	529	539	548	558	567	577	587	597	607
1,339	618	628	639	649	660	671	682	694	705	717
1,340	728	740	752	764	776	789	801	814	827	840
1,341	853	866	879	893	906	920	934	948	962	976
1,342	991	1,005	1,020	1,035	1,050	1,065	1,081	1,096	1,112	1,128
1,343	1,144	1,161	1,177	1,194	1,211	1,228	1,245	1,263	1,281	1,299
1,344	1,317	1,335	1,354	1,374	1,393	1,413	1,434	1,456	1,478	1,501
1,345	1,524	1,548	1,572	1,597	1,621	1,646	1,672	1,697	1,723	1,750
1,346	1,776	1,803	1,830	1,857	1,885	1,913	1,941	1,970	1,998	2,028
1,347	2,057	2,087	2,117	2,148	2,179	2,211	2,243	2,275	2,307	2,340
1,348	2,373	2,406	2,440	2,474	2,508	2,543	2,578	2,614	2,649	2,685
1,349	2,722	2,758	2,795	2,833	2,870	2,908	2,946	2,985	3,024	3,063
1,350	3,103	3,143	3,184	3,225	3,267	3,308	3,350	3,393	3,436	3,479
1,351	3,522	3,565	3,609	3,654	3,699	3,744	3,789	3,835	3,882	3,928
1,352	3,976	4,023	4,072	4,120	4,169	4,219	4,268	4,319	4,369	4,420
1,353	4,472	4,524	4,576	4,629	4,683	4,736	4,791	4,845	4,900	4,956
1,354	5,012	5,068	5,125	5,183	5,240	5,299	5,357	5,417	5,477	5,537
1,355	5,598	5,659	5,721	5,783	5,846	5,909	5,973	6,038	6,103	6,168
1,356	6,234	6,300	6,367	6,434	6,502	6,570	6,638	6,707	6,777	6,846
1,357	6,917	6,987	7,058	7,130	7,202	7,275	7,348	7,421	7,495	7,569
1,358	7,644	7,718	7,794	7,869	7,945	8,021	8,098	8,175	8,253	8,331
1,359	8,409	8,487	8,566	8,646	8,726	8,806	8,887	8,969	9,051	9,133
1,360	9,216	9,300	9,384	9,468	9,553	9,639	9,725	9,811	9,898	9,985
1,361	10,073	10,161	10,249	10,338	10,428	10,517	10,608	10,698	10,790	10,881
1,362	10,973	11,066	11,160	11,254	11,348	11,444	11,539	11,636	11,733	11,830
1,363	11,929	12,028	12,127	12,227	12,328	12,430	12,532	12,635	12,739	12,843
1,364	12,948	13,053	13,159	13,265	13,372	13,480	13,588	13,697	13,806	13,916
1,365	14,026	14,137	14,249	14,361	14,473	14,587	14,700	14,815	14,930	15,045
1,366	15,161	15,278	15,395	15,513	15,631	15,750	15,869	15,989	16,109	16,230
1,367	16,352	16,473	16,596	16,719	16,842	16,966	17,091	17,216	17,342	17,468
1,368	17,595	17,722	17,850	17,979	18,108	18,238	18,368	18,499	18,630	18,762
1,369	18,894	19,027	19,160	19,294	19,429	19,563	19,699	19,835	19,972	20,109
1,370	20,247	20,386	20,525	20,664	20,805	20,946	21,087	21,229	21,372	21,516
1,371	21,659	21,799	21,944	22,090	22,236	22,383	22,531	22,679	22,828	22,978
1,372	23,128	23,281	23,434	23,588	23,743	23,898	24,054	24,212	24,370	24,528
1,373	24,688	24,848	25,009	25,171	25,334	25,497	25,661	25,826	25,992	26,158
1,374	26,326	26,494	26,663	26,832	27,003	27,174	27,346	27,519	27,693	27,867
1,375	28,042									

Note: Capacities above elevation 1,371.0 feet calculated from interpoalted and extrapolated areas

Appendix B

Leon Reservoir

RESERVOIR AREA TABLE

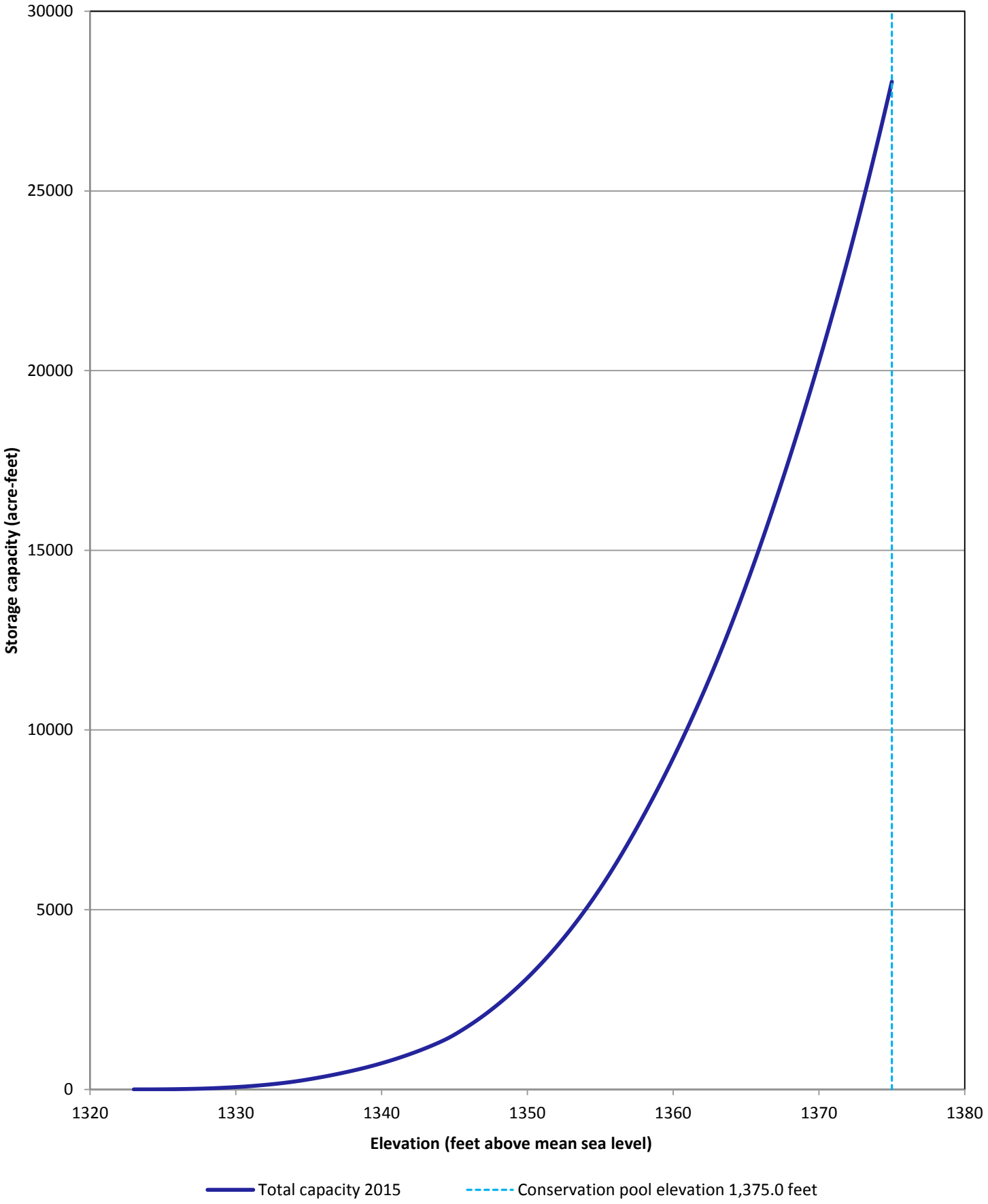
TEXAS WATER DEVELOPMENT BOARD — September 2015 Survey

AREA IN ACRES — Conservation Pool Elevation 1,375.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

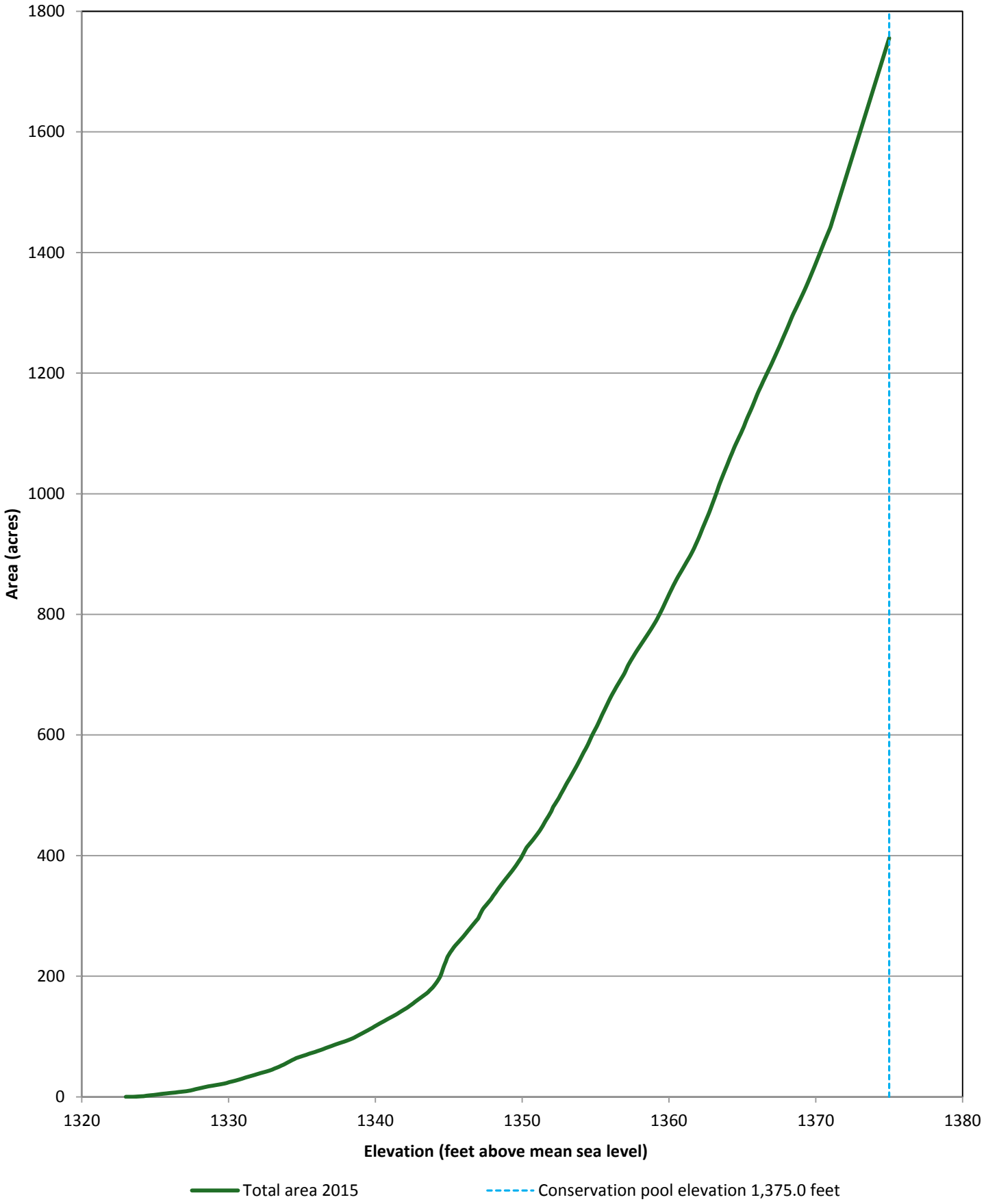
ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1,323	0	0	0	0	0	0	0	0	0	1
1,324	1	1	1	1	2	2	2	3	3	3
1,325	3	4	4	4	5	5	5	5	6	6
1,326	6	7	7	7	7	8	8	8	8	9
1,327	9	9	10	10	10	11	12	12	13	13
1,328	14	15	15	16	16	17	17	18	18	18
1,329	19	19	20	20	21	21	21	22	22	23
1,330	24	25	25	26	26	27	28	28	29	30
1,331	31	32	32	33	34	34	35	36	37	37
1,332	38	39	39	40	41	41	42	43	44	45
1,333	45	47	48	49	49	51	52	53	54	55
1,334	57	58	59	61	62	63	64	65	66	67
1,335	67	68	69	70	71	72	72	73	74	74
1,336	75	76	77	78	79	80	81	82	82	83
1,337	84	85	86	87	88	89	89	90	91	92
1,338	93	94	94	95	96	98	99	100	101	103
1,339	104	105	107	108	109	110	112	113	114	116
1,340	118	119	120	122	123	124	126	127	128	130
1,341	131	132	134	135	136	138	139	141	142	144
1,342	145	147	148	150	152	154	155	157	159	161
1,343	163	165	166	168	170	172	174	176	179	181
1,344	184	187	191	195	199	205	212	219	225	231
1,345	236	240	243	246	250	252	255	258	261	263
1,346	266	269	272	275	278	281	284	287	290	293
1,347	296	301	306	310	314	317	320	323	325	328
1,348	332	336	339	343	346	349	353	356	359	362
1,349	365	368	371	374	378	381	384	388	392	395
1,350	400	404	409	413	416	419	422	425	428	432
1,351	435	438	441	445	449	454	458	462	466	470
1,352	474	480	484	488	492	496	500	505	509	514
1,353	518	522	527	531	535	540	544	548	553	557
1,354	562	567	572	576	581	585	591	596	601	606
1,355	610	615	620	626	631	636	641	646	651	656
1,356	661	666	670	675	679	683	687	691	695	699
1,357	704	709	715	719	723	727	731	735	739	743
1,358	747	750	754	758	761	765	769	772	776	780
1,359	784	788	793	798	802	807	812	817	823	828
1,360	833	838	843	848	853	857	862	866	870	874
1,361	878	883	887	891	895	900	904	909	915	920
1,362	925	931	937	943	949	955	961	967	973	979
1,363	986	993	999	1,006	1,013	1,020	1,026	1,032	1,038	1,044
1,364	1,050	1,056	1,062	1,068	1,074	1,080	1,085	1,090	1,095	1,100
1,365	1,106	1,111	1,118	1,124	1,129	1,135	1,140	1,146	1,152	1,158
1,366	1,164	1,170	1,175	1,180	1,186	1,191	1,196	1,201	1,206	1,211
1,367	1,216	1,222	1,227	1,232	1,238	1,243	1,249	1,254	1,260	1,266
1,368	1,271	1,277	1,283	1,289	1,295	1,300	1,305	1,310	1,315	1,320
1,369	1,325	1,331	1,336	1,341	1,347	1,352	1,358	1,364	1,370	1,376
1,370	1,382	1,388	1,394	1,400	1,406	1,413	1,419	1,425	1,430	1,436
1,371	1,442	1,450	1,458	1,466	1,473	1,481	1,489	1,497	1,505	1,513
1,372	1,520	1,528	1,536	1,544	1,552	1,560	1,567	1,575	1,583	1,591
1,373	1,599	1,607	1,615	1,622	1,630	1,638	1,646	1,654	1,662	1,669
1,374	1,677	1,685	1,693	1,701	1,709	1,716	1,724	1,732	1,740	1,748
1,375	1,756									

Note: Areas between elevations 1,371.0 and 1,372.7 feet linearly interpolated, areas above elevation 1,372.7 feet linearly extrapolated



Leon Reservoir
September 2015 Survey
Prepared by: TWDB

Appendix C: Capacity curve



Leon Reservoir
September 2015 Survey
Prepared by: TWDB

Appendix D: Area curve

Figure 6

Leon Reservoir

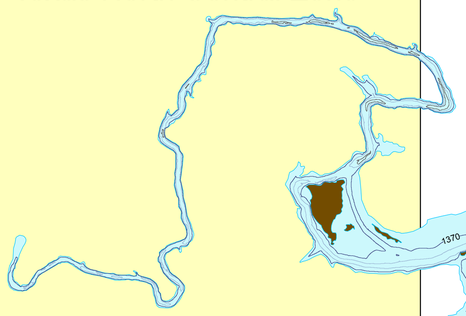
5' - contour map

Islands

Leon Reservoir at elevation 1,372.7 feet

Conservation pool elevation 1,375.0 feet NGVD29

Projection: NAD83
State Plane
Texas North Central Zone



CONTOURS

(feet)

1370
1365
1360
1355
1350
1345
1340
1335
1330
1325

This map is the product of a survey conducted by the Texas Water Development Board's Hydrographic Survey Program to determine the capacity of Leon Reservoir. The Texas Water Development Board makes no representations nor assumes any liability.

Texas Water Development Board

September 2015 survey