Volumetric Survey of Lake Corpus Christi

February 2016 Survey

Texas Water Development Board

March 2017

Prepared for:

City of Corpus Christi

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Executive summary

In August 2015, the Texas Water Development Board (TWDB) entered into agreement with the City of Corpus Christi, Texas to perform a volumetric survey of Lake Corpus Christi (San Patricio and Jim Wells counties, Texas). Surveying was performed using a multi-frequency (208 kHz, 50 kHz, and 24 kHz), sub-bottom profiling depth sounder; although only data collected at the 208 kHz frequency was analyzed for this report.

Wesley E. Seale Dam and Lake Corpus Christi are located on the Nueces River in San Patricio and Jim Wells counties, approximately four miles southwest of the City of Mathis, Texas. The conservation pool elevation of Lake Corpus Christi is 94.0 feet (NGVD29). The TWDB collected bathymetric data for Lake Corpus Christi between August 11, 2015, and February 12, 2016. Daily average water surface elevations during the survey ranged between 90.99 and 93.15 feet (NGVD29).

The 2016 TWDB volumetric survey indicates that Lake Corpus Christi has a total reservoir capacity of 256,339 acre-feet and encompasses 19,748 acres at conservation pool elevation (94.0 feet above mean sea level, NGVD29). Several previous capacity estimates for Lake Corpus Christi have been developed, most notably a 1957 survey estimate of 302,100 acre-feet, a 1972 survey estimate by McCaughan & Etheridge of 272,352 acre-feet, a 1987 U.S. Geological Survey survey estimate of 266,832 acre-feet, a 1991 re-calculation of the 1987 U.S. Geological Survey survey by HDR, Inc. estimating 241,241 acre-feet, and a 2002 TWDB survey that was re-evaluated resulting in an updated capacity estimate of 262,564 acre-feet.

The TWDB recommends a volumetric and sedimentation survey of Lake Corpus Christi within a 10 year time-frame or after a major flood event to assess changes in lake capacity and to further improve estimates of sediment accumulation rates.

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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. The Texas Water Code section 15.804 authorizes the TWDB to perform surveys to determine reservoir storage capacity, sedimentation levels, rates of sedimentation, and projected water supply availability.

In August 2015, the TWDB entered into an agreement with the City of Corpus Christi to perform a volumetric survey of Lake Corpus Christi (Texas Water Development Board, 2015). The results of this agreement, described herein, include an overview of the data collection and processing techniques used to conduct the volumetric survey and the following final contract 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 (Appendices A and B).

Lake Corpus Christi general information

Wesley E. Seale Dam and Lake Corpus Christi are located on the Nueces River in San Patricio and Jim Wells counties, approximately 4 miles southwest of Mathis, Texas (Figure 1). The reservoir also inundates part of Live Oak County. Wesley E. Seale Dam and Lake Corpus Christi are owned and operated by the City of Corpus Christi (City of Corpus Christi, 2013). Construction of Wesley E. Seale Dam began on November 19, 1955. Dam completion and impoundment of water began on April 26, 1958 (Texas Water Development Board, 1967). Additional information about the reservoir can be found in the 2012 TWDB survey report (Texas Water Development Board, 2013).

Water rights for Lake Corpus Christi have been appropriated to the City of Corpus Christi through Certificate of Adjudication No. 21-2464. The complete certificate is on file in the Information Resources Division of the Texas Commission on Environmental Quality.

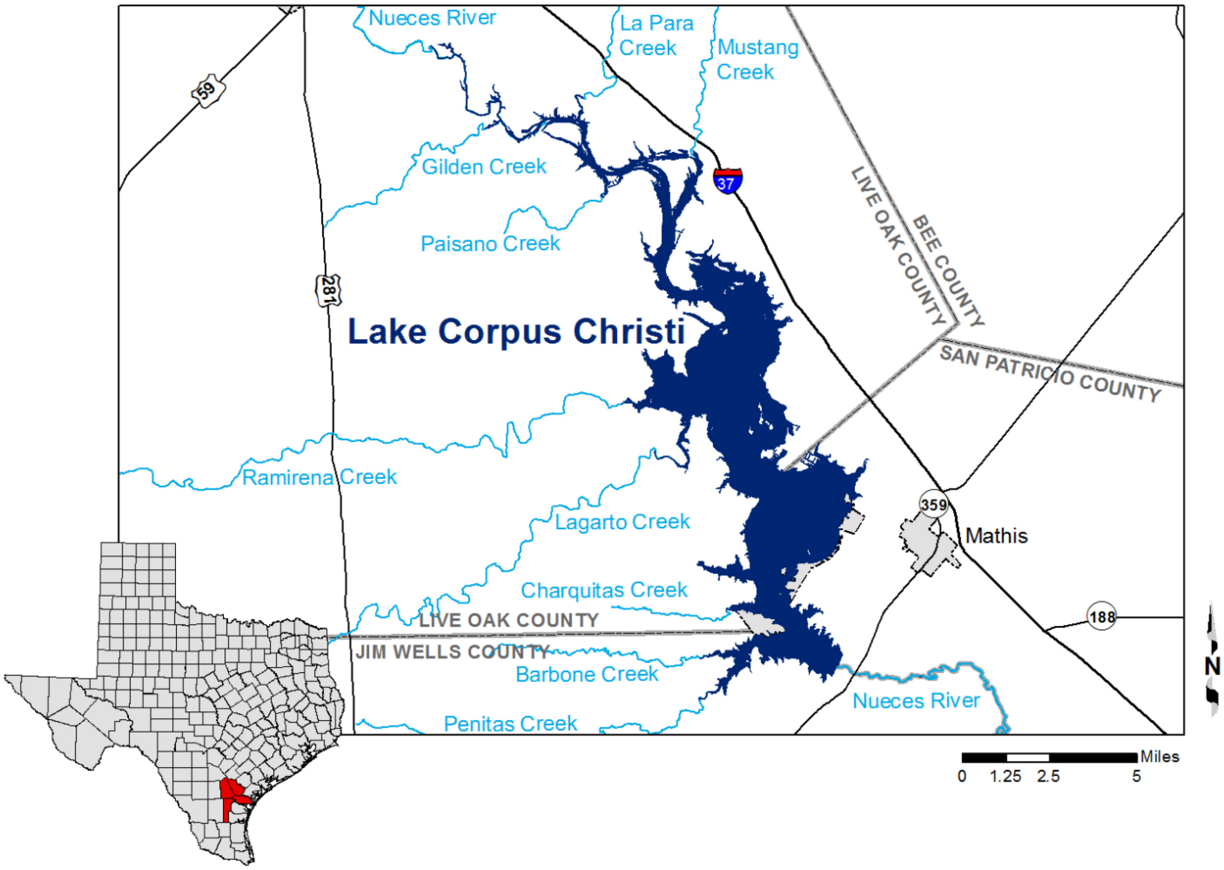


Figure 1. Location map of Lake Corpus Christi.

Table 1. Pertinent data for Wesley E. Seale Dam and Lake Corpus Christi.

Owner
City of Corpus Christi, Texas

Design Engineer
Ambursen Engineering Company (dam and original gates)
Forrest and Cotton, Inc. (modification of gates, completed September 4, 1966)

General contractor for the dam
H.B. Zachry Co.

Location of dam
On the Neuces River in San Patricio and Jim Wells counties, approximately 4 miles southwest of Mathis, Texas

Drainage area
16,656 square miles

Dam

Type	Earthfill and concrete
Length (including gates)	5,980 feet
Height	75 feet
Top width	varies 15 to 51 feet

Spillway (north or emergency)

Type	Concrete section
Control (screw type hoists, and portable engines)	33 gates, each 37.5 by 8.75 feet
Spillway crest elevation	88.0 feet above mean sea level
Top of gates elevation	94.3 feet above mean sea level

Spillway (south or service)

Type	Concrete section
Control (screw type hoists, and electric motors)	27 gates, each 37.5 by 8.75 feet
Spillway crest elevation	88.0 feet above mean sea level
Top of gates elevation	94.0 feet above mean sea level

Outlet works

Type	3 openings, each 2.5 by 4 feet
Control	48-inch cylinder valve
Invert elevation	55.5 feet above mean sea level

Water flows in river channel to treating plant.

Reservoir data (Based on 2015 TWDB survey)

Feature	**Elevation (feet** NGVD29[a]**)**	**Capacity (acre-feet)**	**Area (acres)**
Top of dam	109.3	N/A	N/A
Top of north spillway gates	94.3	N/A	N/A
Top of south spillway gates/ conservation pool elevation	94.0	256,339	19,748
Spillway crest	88.0	149,794	15,432
Invert low flow outlet	55.5	278	42
Usable conservation storage space[b]	-	256,061	-

Source: (Texas Water Development Board, 1967, Texas Water Development Board, 1971, City of Corpus Christi, 2001)

[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 Lake Corpus Christi

Datum

The vertical datum used during this survey is the National Geodetic Vertical Datum 1929 (NGVD29). This datum also is utilized by the United States Geological Survey (USGS) for the reservoir elevation gage *USGS 08210500 Lk Corpus Christi nr Mathis, TX* (U.S. Geological Survey, 2016). 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 South Central Zone (feet).

TWDB bathymetric data collection

The TWDB collected bathymetric data for Lake Corpus Christi between August 11, 2015, and February 16, 2016. Daily average water surface elevations during the survey ranged between 90.99 and 93.15 feet above mean sea level (NGVD29). For data collection, the 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 and an SDI motion reference unit to account for heave. Data was collected along pre-planned survey lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 500 feet apart. Many of the same survey lines also were used by the TWDB during the 2002 and 2012 surveys. 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 the data collection locations for the 2016 TWDB survey of Lake Corpus Christi.

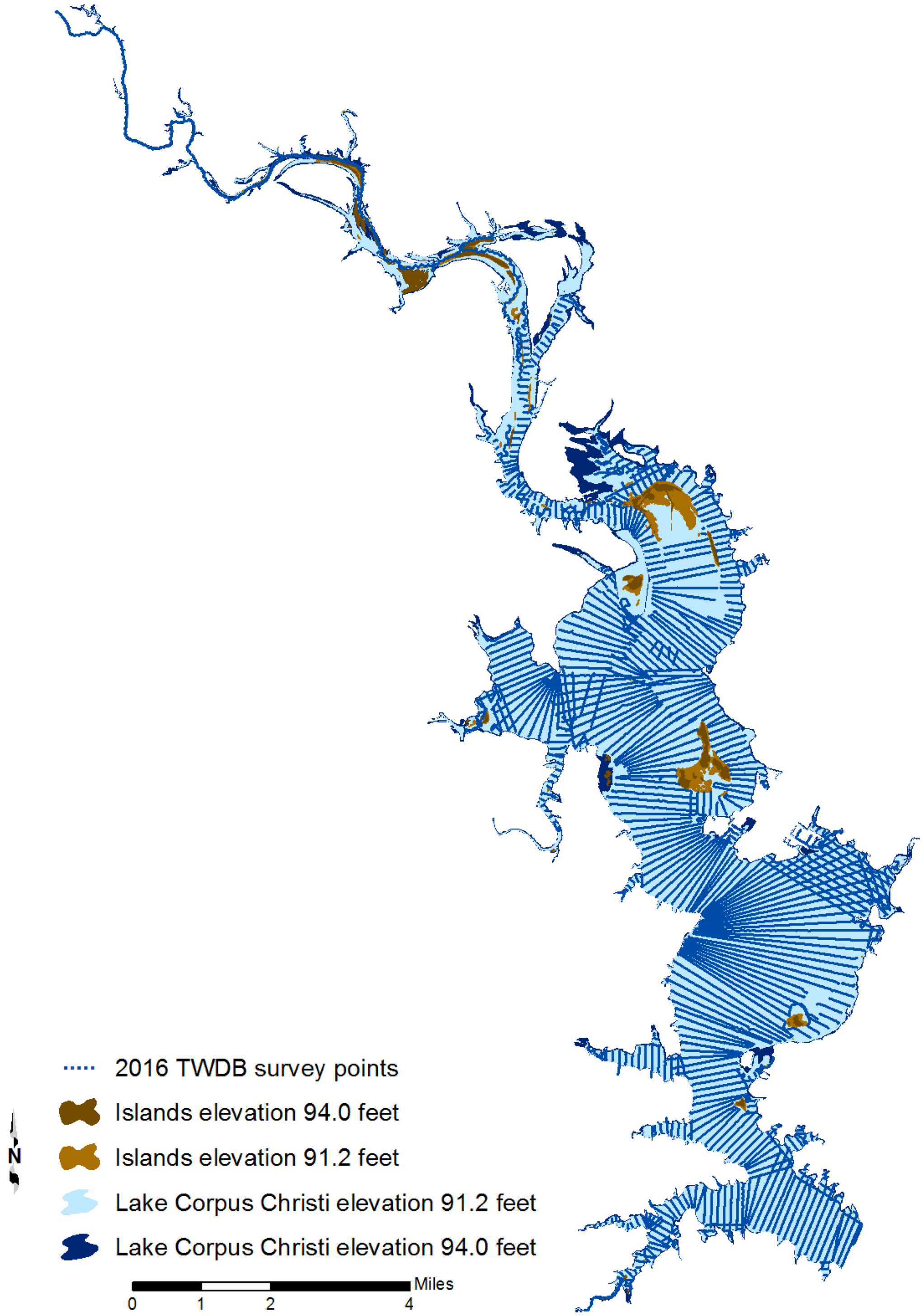


Figure 2. 2016 TWDB Lake Corpus Christi survey data (*blue dots*).

Data processing

Model boundary

The reservoir boundary was digitized from aerial photographs, also known as digital orthophoto quarter-quadrangle images (DOQQs), obtained from the Texas Natural Resources Information System (Texas Natural Resources Information System, 2016a) using Environmental Systems Research Institute's ArcGIS software. The quarter-quadrangles that cover Lake Corpus Christi are Sandia (NE, SE), Mathis (NW, SW), Tynan (SW), Dinero (NE, NW, SE, SW), Mulos Hills (SW, SE), and George West (SE). The DOQQs Dinero (NW, SW), Mulos Hills (SW), and Goerge West (SE) were photographed on January 18, 2016, while the remaining DOQQs were photographed on January 29, 2016. Daily average water surface elevations measured 91.39 and 91.17 feet, respectively. The DOQQs have a resolution or ground sample distance of 0.5 meters and a horizontal accuracy within ± 2.45 meters at 95 percent confidence level, according to the associated metadata (Texas Natural Resources Information System, 2016b). For modeling and analysis purposes, the boundary was digitized at the land-water interface in the 2016 photographs and assigned an elevation of 91.2 feet, the average elevation of the water surface in all the photographs.

Due to a lack of recent aerial imagery taken when reservoir levels were at or near conservation pool elevation, the City of Corpus Christi requested TWDB use aerial imagery from 2004 to digitize a model boundary for calculating area and capacity at conservation pool elevation in place of an approach using linear extrapolation of the area curve computed by modeling the reservoir with the 2016 boundary at 91.2 feet (Larijai Francis, written commun., 2017). The model boundary of the reservoir was digitized from aerial photographs taken on June 2, October 11, and November 3, 2004, while daily average water surface elevations measured 94.04, 94.15, and 93.95 feet, respectively. According to metadata associated with the 2004 DOQQs, the photographs have a resolution or ground sample distance of 1.0-meters and a horizontal accuracy of within ±5 meters of reference DOQQs from the National Digital Ortho Program (U.S. Department of Agriculture, 2016). Some areas of vegetation and island seen in the 2004 photographs were no longer visible or had changed significantly when compared to the 2016 photographs. In these locations, islands at elevation 94.0 feet were digitized at the tree line in the 2016 DOQQs. The 91.2-foot boundary contour digitized from the 2016 DOQQs was input into the model as a hard line.

Triangulated Irregular Network model

Following completion of data collection, 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 reservoir-bottom surface. For processing outside of DepthPic©, HydroTools, a software package developed by TWDB staff, 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 were 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 and others, 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 (Environmental Systems Research Institute, 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 bathymetry 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 TIN model in areas between actual survey data.

To improve the accuracy of bathymetric representation between survey lines, the 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. DOQQs photographed on May 22, 2012, while the daily average water surface elevation of the lake measured 83.13 feet, were especially useful for determining sinuosity and directionality of the stream channels for the 2016 TIN model of this reservoir. Polygons are created to partition the reservoir into segments with centerlines defining directionality of interpolation within each segment using the survey data. 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 TIN model representing reservoir bathymetry. Specific details of this interpolation technique can be found in the HydroTools manual (McEwen and others, 2011a) and in McEwen and others (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. Linear interpolation follows a line linking the survey points file to the lake boundary file (McEwen and others 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, although it is not always possible to remove all flat triangles.

Figure 3 illustrates typical results from application of the anisotropic interpolation and linear interpolation techniques to Lake Corpus Christi. 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 in creation of the TIN model, represented in Figure 3B, directs Delaunay triangulation to better represent the reservoir bathymetry between survey cross-sections. The bathymetry shown in Figure 3C was used in computing reservoir elevation-capacity (Appendix A) and elevation-area (Appendix B) tables.

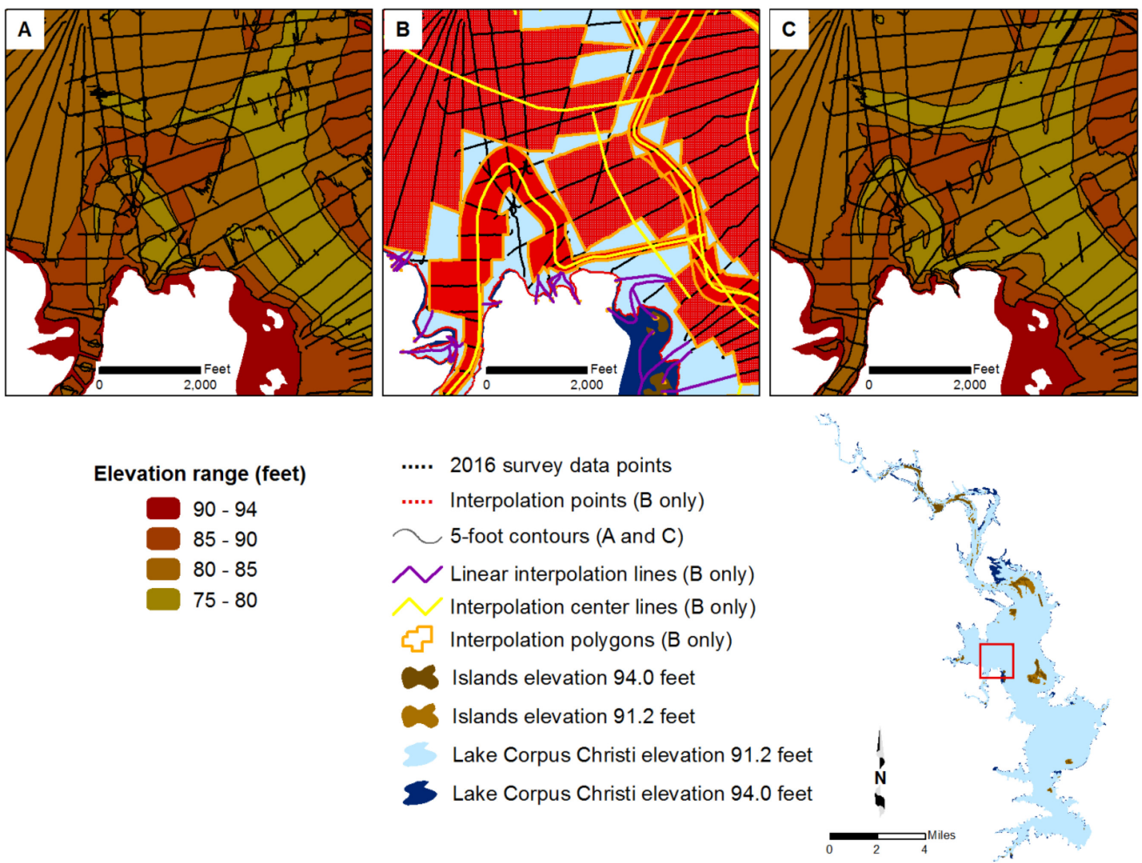


Figure 3. **Anisotropic spatial interpolation and linear interpolation of Lake Corpus Christi sounding data; A) bathymetric contours without interpolated points, B) sounding points (*black*) and interpolated points (*red*), C) bathymetric contours with interpolated points.**

Area, volume, and contour calculation

Using ArcInfo software and the TIN model, volumes and areas were calculated for the entire reservoir at 0.1-foot intervals from 38.0 to 94.0 feet. While linear interpolation was used to estimate topography in areas that were inaccessible by boat or too shallow for the instruments to work properly, development of anomalous flat triangles (triangles whose 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 near the model boundaries at elevation 91.2 and 94.0 feet. To eliminate the effects of the flat triangles on area and volume calculations, areas between elevations 88.5 feet and 91.2 feet and 91.2 and 94.0 feet were linearly interpolated between the computed values at 88.5 and 94.0 feet and the digitized area at 91.2 feet. Volumes above elevation 88.5 feet were calculated based on the corrected areas. The elevation-capacity table and elevation-area table, based on the 2016 survey and analysis, 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 TIN model was converted to a raster representation using a cell size of 2 feet by 2 feet. The raster data was then used to produce three figures: (1) an elevation relief map representing the topography of the reservoir bottom (Figure 4); (2) a depth range map showing shaded depth ranges for Lake Corpus Christi (Figure 5); and, (3) a 5-foot contour map (Figure 6).

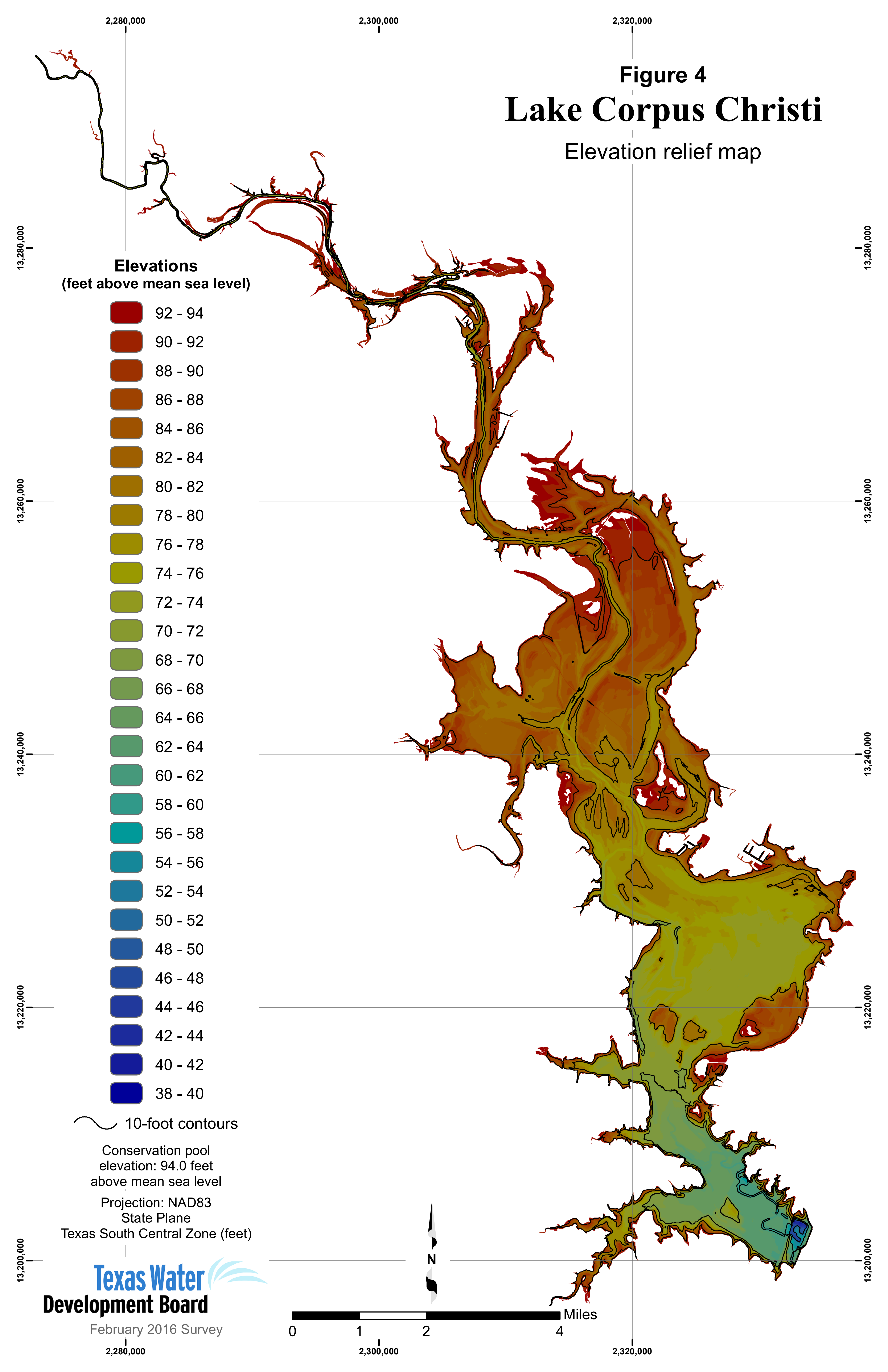
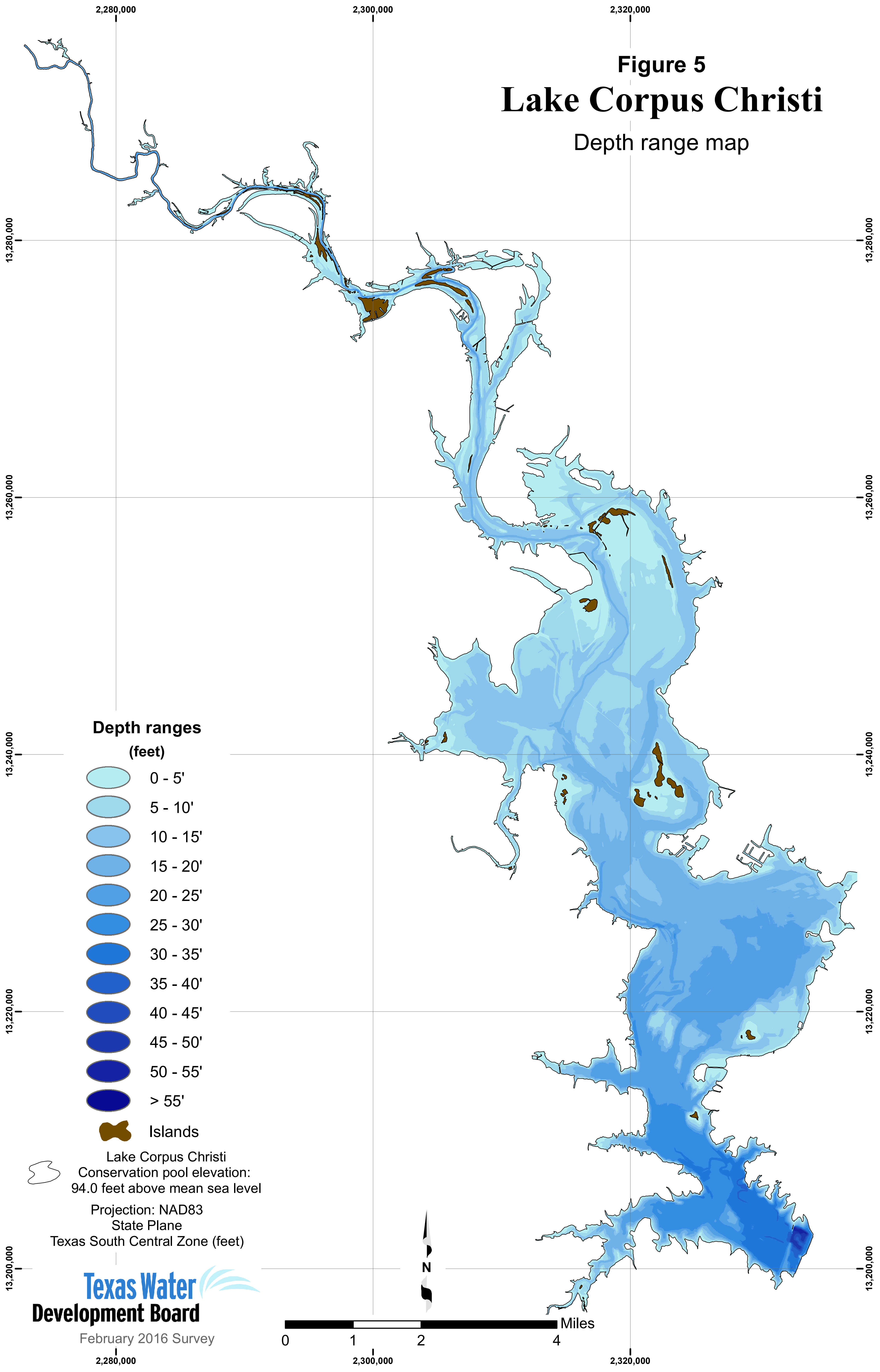


Figure 4
Lake Corpus Christi
Elevation relief map
Elevations
(feet above mean sea level)
92 - 94
90 - 92
88 - 90
86 - 88
84 - 86
82 - 84
80 - 82
78 - 80
76 - 78
74 - 76
72 - 74
70 - 72
68 - 70
66 - 68
64 - 66
62 - 64
60 - 62
58 - 60
56 - 58
54 - 56
52 - 54
50 - 52
48 - 50
46 - 48
44 - 46
42 - 44
40 - 42
38 - 40
10-foot contours
Conservation pool elevation: 94.0 feet above mean sea level
Projection: NAD83 State Plane Texas South Central Zone (feet)
Texas Water Development Board
February 2016 Survey
N
Miles
0
1
2
4
2,280,000
2,300,000
2,320,000
13,280,000
13,260,000
13,240,000
13,220,000
13,200,000

Figure 5

Lake Corpus Christi

Depth range map



Survey results

Volumetric survey

The results of the 2016 TWDB volumetric survey indicate Lake Corpus Christi has a total reservoir capacity of 256,339 acre-feet and encompasses 19,748 acres at conservation pool elevation (94.0 feet above mean sea level, NGVD29). Lake Corpus Christi has been surveyed several times since impoundment, and many area and capacity tables have been generated in an effort to understand sedimentation within the reservoir (Table 2). Additional information about each survey can be found in the 2012 TWDB survey report (Texas Water Development Board, 2013). Although the TWDB surveyed Lake Corpus Christi in 2012, field conditions prevented a complete survey of the entire reservoir. In 2012, water surface elevations of the reservoir during the survey measured between 81.57 and 82.82 feet (Texas Water Development Board, 2013). At elevation 82.8 feet, less than half the total reservoir surface area is submerged, according to both the 2002 and 2016 TWDB surveys. Therefore, the results of the 2012 TWDB survey were combined with results of the 2002 TWDB survey to generate complete elevation-area-capacity tables. Additionally, the capacity estimate at conservation pool elevation is not compared here, because it is not representative of the lake at a specific time. Because of differences in survey methodologies, any direct comparison of changes in capacity based on this volumetric survey may be unreliable.

The 2002 TWDB survey originally estimated capacity to be 257,260 acre-feet at conservation pool elevation (94.0 feet; Texas Water Development Board, 2002), but in 2013, the data was re-evaluated using the then current procedures for applying anisotropic spatial interpolation, yielding a revised capacity estimate of 262,337 acre-feet (Texas Water Development Board, 2013). In 2016, the 2002 TWDB survey estimate was further revised to correct for flat triangles in the TIN model that were not removed with linear interpolation. Areas between 92.5 and 94.1 feet were linearly interpolated between the computed values, and volumes above 92.5 feet were calculated based on the corrected areas. This 2016 revision of the 2002 surface area estimate resulted in an additional 279 acres at conservation pool elevation (94.0 feet), or a 1.5 percent increase in surface area. Based on this corrected area estimate for the 2002 survey data, capacity is now estimated to be 262,564 acre-feet at conservation pool elevation, an increase of 227 acre-feet, or 0.09 percent. Compared to the area and capacity estimates originally published in 2002, this represents a 2.6 percent increase in area and a 2.1 percent increase in capacity at a conservation pool elevation of 94.0 feet.

The total capacity estimates of Lake Corpus Christi found in Table 2 are plotted in Figure 7 to illustrate how each estimate compares to the other. Further comparison of the capacity estimates derived using differing methodologies are provided in Table 3 for sedimentation rate calculation. Comparison of the current 2016 TWDB capacity estimate with the revised 2002 TWDB capacity estimate indicates Lake Corpus Christi is losing an average of 445 acre-feet of capacity per year.

Table 2. Current and previous survey capacity and surface area estimates for Lake Corpus Christi.

Survey	Surface area (acres)	Total capacity (acre-feet)	Source
U.S. Soil Conservation Service 1948	19,860	292,758	McCaughan & Etheridge, 1973
Reagan & McCaughan 1957	22,050	302,100	TWDB, 1967, McCaughan & Etheridge, 1973
1957 re-calculated	22,050	297,776	McCaughan & Etheridge, 1973
McCaughan & Etheridge 1972	19,336	272,352	McCaughan & Etheridge, 1973
USGS 1987	18,883	266,832	West *and others,* 1987
USGS 1987 re-calculated by HDR Inc. 1991	19,251	241,241	James L. Riley, written commun., 1991, Ken Choffel, written commun., 2002
TWDB 2002	18,286	257,260	Texas Water Development Board, 2002
TWDB 2002 re-calculated	18,487	262,337	Texas Water Development Board, 2013
TWDB 2002 re-calculated[a]	18,766	262,564	Texas Water Development Board, 2016
TWDB 2016	19,748	256,339	

[a] Note: These values have been revised since being re-calculated in 2013 (Texas Water Development Board 2013) to correct for flat triangles generated by the TIN model.

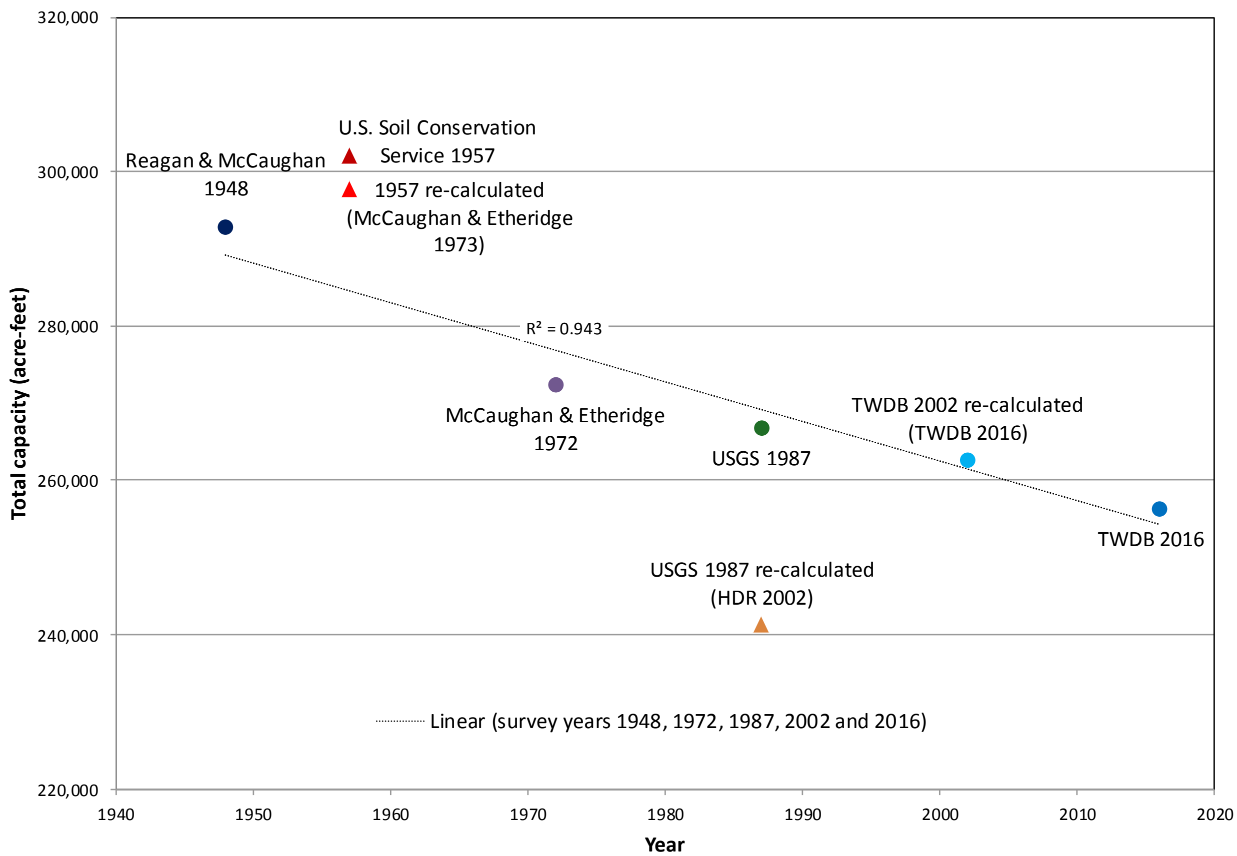


Figure 7. Comparison of total capacity estimates for Lake Corpus Christi.

Table 3. Capacity loss comparisons for Lake Corpus Christi.

Survey	Volume comparisons at conservation pool elevation 94.0 feet (acre-feet)				
1948	292,758	<>	<>	<>	<>
1957 re-calculated by McCaughan & Etheridge	<>	297,776	<>	<>	<>
McCaughan & Etheridge 1972	<>	<>	272,352	<>	<>
USGS 1987	<>	<>	<>	266,832	<>
TWDB 2002 re-calculated[a]	<>	<>	<>	<>	262,564
2016 volumetric survey	256,339	256,339	256,339	256,339	256,339
Volume difference (acre-feet)	36,419 (12.4%)	41,437 (13.9%)	16,013 (5.9%)	10,493 (3.9%)	6,225 (2.4%)
Number of years	68	59	44	29	14
Capacity loss rate (acre-feet/year)	536	702	364	362	445

[a] Note: This value has been revised, as described herein, since being re-calculated in 2013 (Texas Water Development Board 2013) to correct for flat triangles generated by the TIN model.

Recommendations

The TWDB recommends a volumetric and sedimentation survey of Lake Corpus Christi in 10 years or after a major flood event to assess changes in lake capacity and to further improve estimates of sediment accumulation rates.

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:
Hydrosurvey@twdb.texas.gov

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Appendix A

Lake Corpus Christi

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — February 2016 Survey

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 94.0 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
38	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	1	1
40	1	1	1	1	1	1	1	1	2	2
41	2	2	2	2	3	3	3	3	3	4
42	4	4	5	5	5	6	6	6	7	7
43	7	8	8	9	9	10	10	11	11	12
44	12	13	13	14	14	15	16	16	17	18
45	18	19	20	20	21	22	23	23	24	25
46	26	27	28	29	30	31	32	33	34	36
47	37	38	40	41	42	44	45	47	48	50
48	52	53	55	57	59	61	63	65	68	70
49	72	74	77	79	81	84	86	89	91	94
50	96	99	101	104	106	109	112	114	117	120
51	123	126	128	131	134	137	140	143	146	149
52	152	155	158	162	165	168	171	174	178	181
53	184	188	191	195	198	201	205	208	212	216
54	219	223	226	230	234	238	241	245	249	253
55	257	261	265	269	273	278	282	286	291	295
56	299	304	309	313	318	323	327	332	337	342
57	347	352	358	363	368	373	379	384	389	395
58	401	406	412	418	424	431	437	444	451	458
59	465	473	481	489	498	507	516	526	536	546
60	556	567	578	589	600	612	625	637	650	664
61	678	693	708	724	741	759	777	797	817	838
62	860	884	908	934	961	988	1,018	1,048	1,081	1,117
63	1,156	1,198	1,244	1,293	1,345	1,398	1,454	1,511	1,570	1,631
64	1,693	1,756	1,821	1,886	1,953	2,022	2,092	2,163	2,237	2,312
65	2,390	2,470	2,552	2,635	2,721	2,808	2,898	2,989	3,083	3,178
66	3,275	3,374	3,475	3,577	3,682	3,788	3,897	4,008	4,122	4,238
67	4,357	4,478	4,602	4,727	4,854	4,983	5,114	5,246	5,380	5,516
68	5,653	5,792	5,933	6,076	6,221	6,367	6,515	6,665	6,815	6,967
69	7,120	7,274	7,429	7,586	7,743	7,902	8,063	8,225	8,389	8,555
70	8,723	8,892	9,064	9,237	9,412	9,590	9,770	9,953	10,138	10,325
71	10,514	10,706	10,901	11,098	11,299	11,503	11,711	11,923	12,138	12,357
72	12,579	12,805	13,035	13,269	13,507	13,751	14,002	14,261	14,531	14,812
73	15,104	15,406	15,715	16,034	16,360	16,697	17,044	17,402	17,771	18,151
74	18,540	18,937	19,343	19,757	20,181	20,616	21,060	21,513	21,974	22,445
75	22,924	23,410	23,903	24,403	24,908	25,419	25,937	26,459	26,988	27,522
76	28,063	28,609	29,162	29,720	30,285	30,854	31,430	32,012	32,601	33,197
77	33,799	34,406	35,021	35,642	36,269	36,902	37,540	38,185	38,836	39,494
78	40,160	40,835	41,517	42,208	42,906	43,611	44,322	45,040	45,764	46,494
79	47,231	47,975	48,726	49,483	50,247	51,017	51,794	52,578	53,368	54,166
80	54,971	55,784	56,605	57,435	58,275	59,125	59,986	60,856	61,737	62,627
81	63,527	64,437	65,356	66,286	67,224	68,172	69,128	70,094	71,068	72,050
82	73,041	74,041	75,050	76,068	77,094	78,131	79,177	80,232	81,298	82,373
83	83,458	84,552	85,655	86,768	87,889	89,019	90,160	91,311	92,472	93,643
84	94,825	96,016	97,217	98,429	99,651	100,882	102,123	103,373	104,633	105,902
85	107,181	108,470	109,768	111,076	112,393	113,719	115,055	116,400	117,754	119,118
86	120,491	121,874	123,267	124,670	126,081	127,501	128,931	130,369	131,815	133,270
87	134,734	136,207	137,687	139,175	140,670	142,172	143,682	145,198	146,723	148,255
88	149,794	151,341	152,896	154,458	156,028	157,605	159,190	160,783	162,385	163,995
89	165,614	167,241	168,877	170,521	172,173	173,834	175,504	177,182	178,868	180,563
90	182,266	183,978	185,698	187,427	189,164	190,909	192,663	194,426	196,197	197,976
91	199,764	201,561	203,365	205,177	206,995	208,819	210,649	212,485	214,326	216,174
92	218,027	219,887	221,752	223,623	225,500	227,383	229,272	231,167	233,068	234,975
93	236,887	238,806	240,730	242,661	244,597	246,539	248,488	250,442	252,402	254,368
94	256,339									

Note: Capacities above elevation 88.5 feet calculated from interpolated areas

Appendix B

Lake Corpus Christi

RESERVOIR AREA TABLE

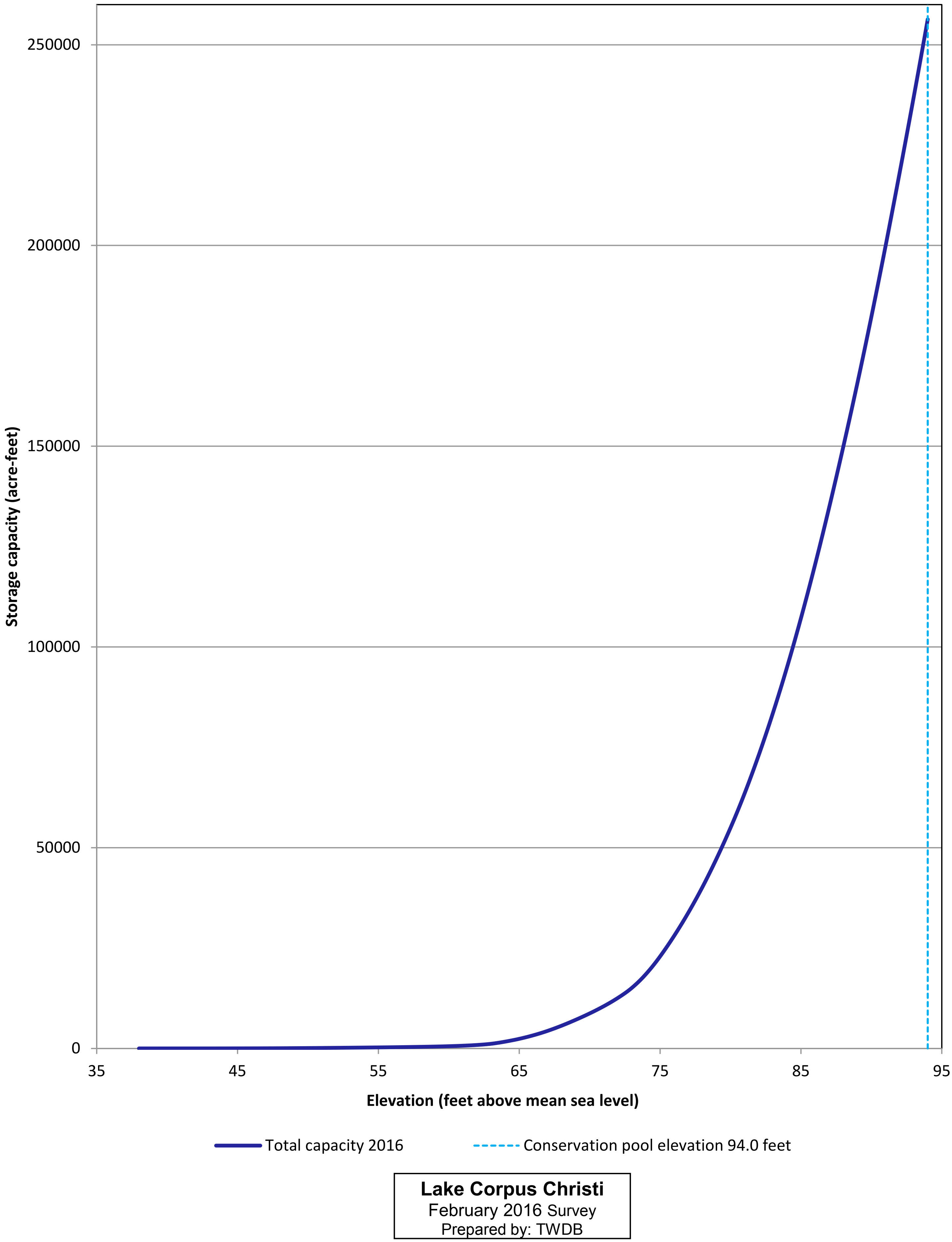
TEXAS WATER DEVELOPMENT BOARD — February 2016 Survey

AREA IN ACRES — Conservation Pool Elevation 94.0 feet NGVD29

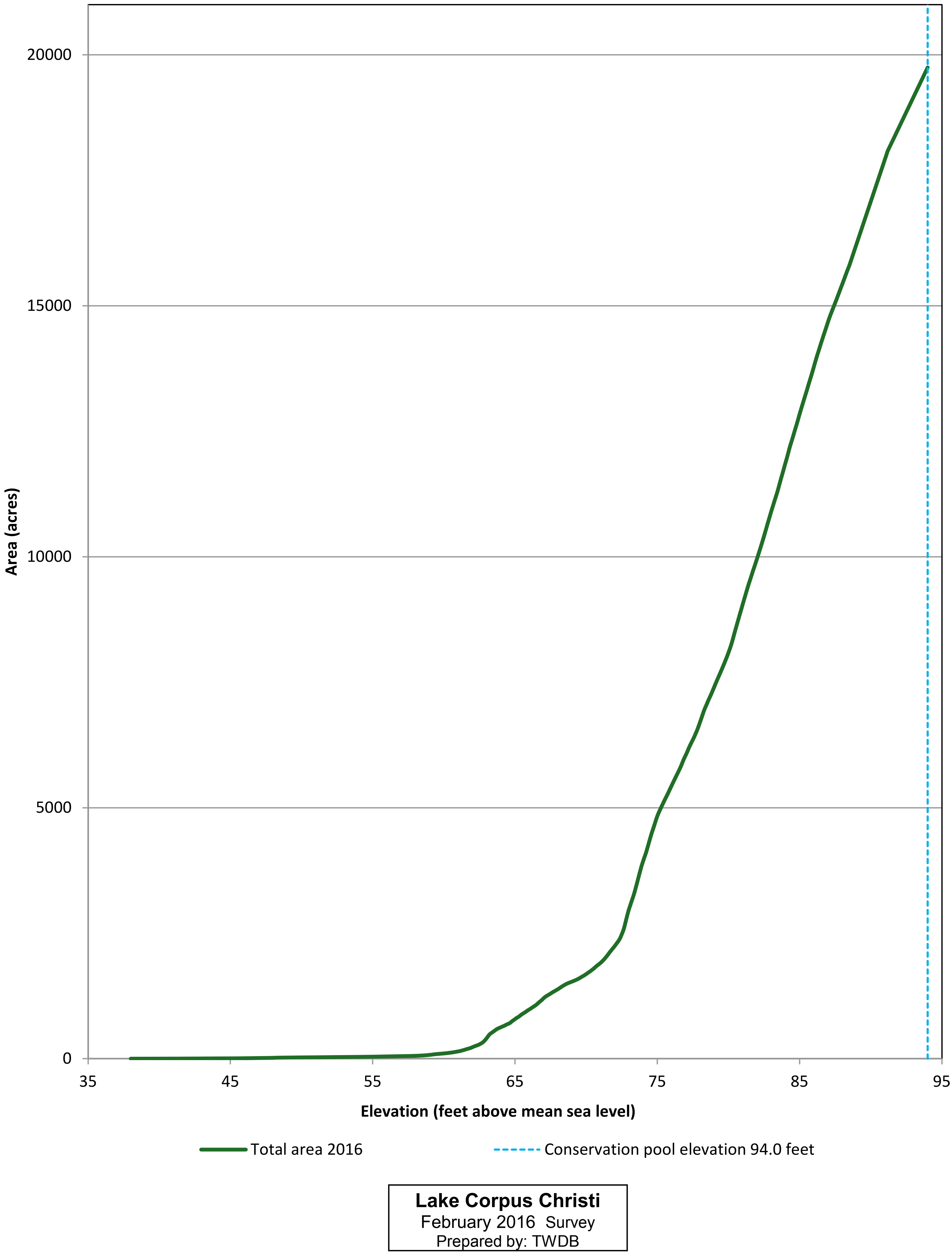
ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
38	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	1	1	1	1	1	1
40	1	1	1	1	1	1	1	1	1	1
41	2	2	2	2	2	2	2	2	3	3
42	3	3	3	3	3	3	3	3	4	4
43	4	4	4	5	5	5	5	5	5	5
44	6	6	6	6	6	6	6	6	6	7
45	7	7	7	7	7	8	8	8	8	9
46	9	9	10	10	11	11	11	12	12	13
47	13	13	14	14	14	15	15	15	16	16
48	17	18	19	20	20	21	21	21	22	22
49	22	23	23	23	24	24	24	25	25	25
50	25	26	26	26	26	27	27	27	28	28
51	28	28	29	29	29	29	30	30	30	31
52	31	31	32	32	32	32	33	33	33	33
53	33	34	34	34	34	35	35	35	36	36
54	36	36	37	37	37	38	38	39	39	39
55	40	40	41	41	42	42	43	43	44	45
56	45	46	46	47	47	48	48	49	50	50
57	51	51	52	52	53	53	54	55	55	56
58	57	58	59	61	62	64	65	67	70	73
59	75	79	82	86	89	92	95	97	99	102
60	104	107	110	113	117	121	125	129	135	140
61	144	150	156	165	172	181	190	198	206	215
62	228	240	251	262	272	285	300	318	341	371
63	404	444	480	504	523	544	565	585	600	613
64	626	638	650	664	680	691	704	722	748	767
65	788	808	825	844	867	887	906	923	943	962
66	980	997	1,017	1,036	1,055	1,074	1,100	1,126	1,149	1,172
67	1,201	1,225	1,246	1,263	1,280	1,297	1,316	1,333	1,348	1,365
68	1,382	1,400	1,419	1,438	1,456	1,472	1,487	1,501	1,512	1,524
69	1,535	1,546	1,558	1,570	1,584	1,598	1,615	1,633	1,648	1,666
70	1,685	1,705	1,725	1,744	1,766	1,788	1,812	1,838	1,860	1,883
71	1,906	1,931	1,960	1,991	2,025	2,060	2,099	2,136	2,170	2,206
72	2,241	2,279	2,317	2,358	2,408	2,477	2,545	2,641	2,756	2,866
73	2,970	3,055	3,141	3,224	3,315	3,420	3,526	3,635	3,741	3,843
74	3,932	4,016	4,097	4,192	4,293	4,392	4,488	4,573	4,658	4,749
75	4,830	4,901	4,962	5,024	5,083	5,143	5,200	5,256	5,315	5,376
76	5,435	5,496	5,555	5,613	5,670	5,729	5,788	5,852	5,924	5,989
77	6,048	6,109	6,179	6,241	6,298	6,356	6,414	6,480	6,546	6,622
78	6,702	6,782	6,866	6,946	7,014	7,079	7,147	7,208	7,270	7,338
79	7,405	7,474	7,541	7,605	7,670	7,736	7,802	7,870	7,941	8,012
80	8,089	8,167	8,253	8,350	8,454	8,556	8,654	8,755	8,854	8,950
81	9,050	9,148	9,244	9,339	9,434	9,522	9,607	9,698	9,782	9,865
82	9,954	10,043	10,133	10,224	10,316	10,410	10,508	10,606	10,705	10,799
83	10,896	10,989	11,078	11,168	11,258	11,354	11,459	11,561	11,661	11,761
84	11,863	11,961	12,066	12,173	12,267	12,359	12,455	12,549	12,642	12,741
85	12,841	12,937	13,030	13,124	13,216	13,307	13,404	13,496	13,589	13,683
86	13,783	13,882	13,979	14,068	14,158	14,250	14,337	14,425	14,508	14,595
87	14,682	14,765	14,841	14,914	14,986	15,058	15,131	15,207	15,281	15,357
88	15,432	15,507	15,584	15,661	15,735	15,806	15,891	15,976	16,060	16,145
89	16,229	16,314	16,399	16,483	16,568	16,652	16,737	16,821	16,906	16,991
90	17,075	17,160	17,244	17,329	17,414	17,498	17,583	17,667	17,752	17,837
91	17,921	18,006	18,090	18,150	18,209	18,268	18,327	18,386	18,446	18,505
92	18,564	18,623	18,682	18,742	18,801	18,860	18,919	18,979	19,038	19,097
93	19,156	19,215	19,275	19,334	19,393	19,452	19,511	19,571	19,630	19,689
94	19,748									

Note: Areas between elevations 88.5 and 91.2 feet and 91.2 and 94.0 feet linearly interpolated



Appendix C: Capacity curve

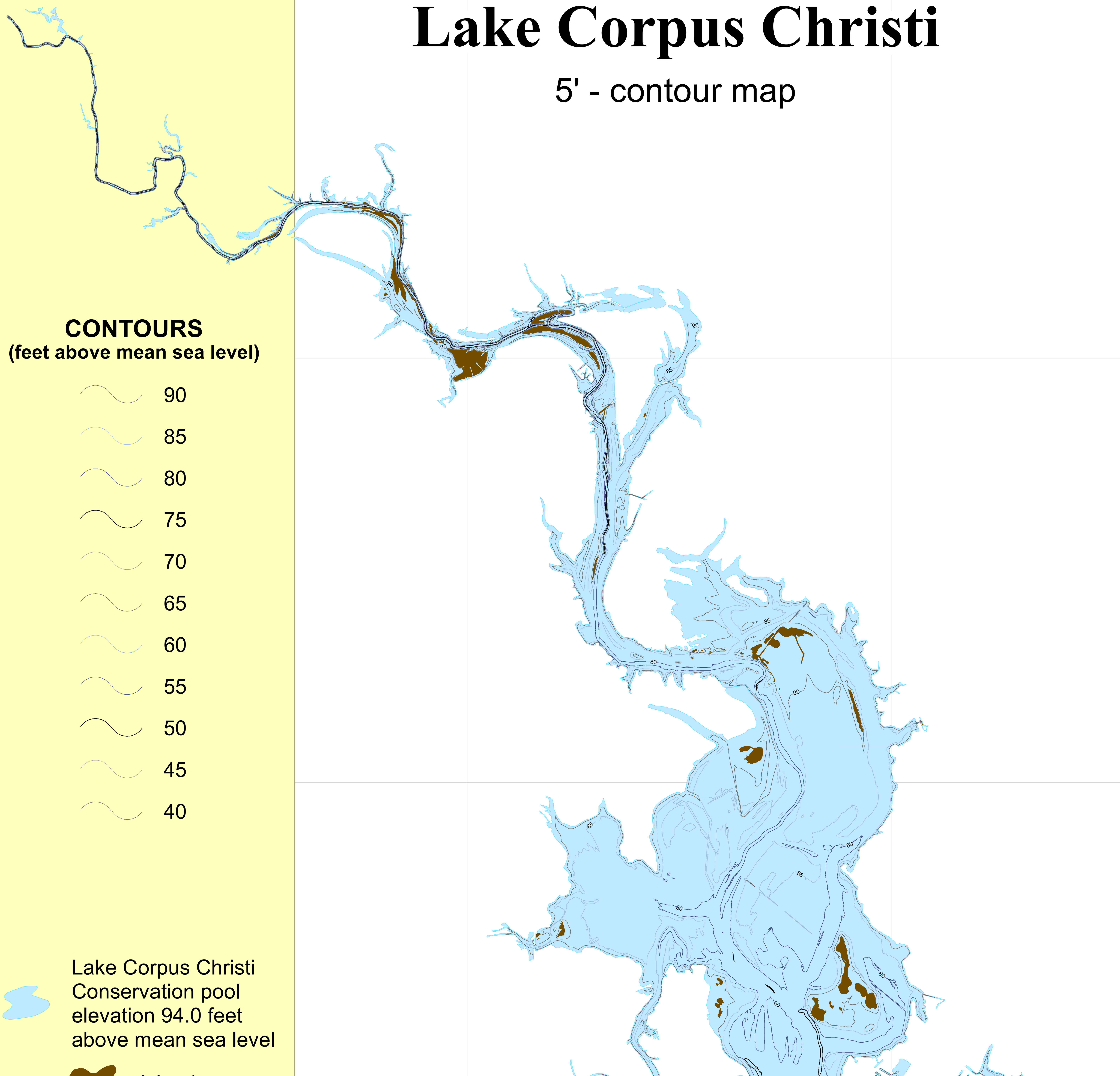


Appendix D: Area curve

Figure 6

Lake Corpus Christi

5' - contour map



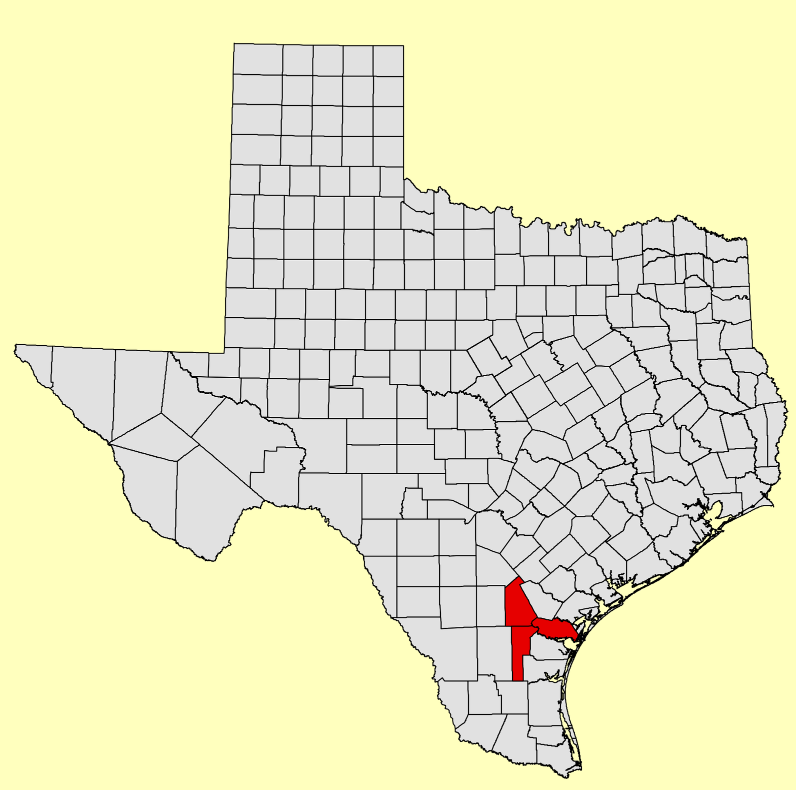
CONTOURS
(feet above mean sea level)

- 90
- 85
- 80
- 75
- 70
- 65
- 60
- 55
- 50
- 45
- 40

Lake Corpus Christi Conservation pool elevation 94.0 feet above mean sea level

Islands

Projection: NAD83
State Plane
Texas South Central Zone



San Patricio, Jim Wells, and Live Oak Counties

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

Texas Water Development Board

February 2016 survey