Volumetric Survey of LAKE BOB SANDLIN

November 2008 Survey

Prepared by:

The Texas Water Development Board

February 2010

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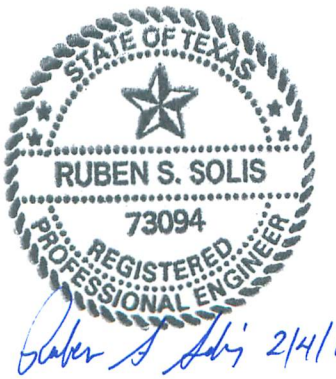

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Executive Summary

In May of 2008, the Texas Water Development Board (TWDB) entered into agreement with the Titus County Fresh Water Supply District No. 1, to perform a volumetric survey of Lake Bob Sandlin. Fort Sherman Dam and Lake Bob Sandlin are located on Big Cypress Creek in Wood, Titus, Franklin, and Camp Counties, five miles southwest of Mount Pleasant.

The survey was performed using multi-frequency and single-frequency depth sounders integrated with Differential Global Positioning System navigation equipment. Bathymetric data collection occurred from November 4th through November 9th of 2008, while the daily average water surface elevation of the lake ranged between 337.17 and 337.04 feet above mean sea level (NGVD 29). Additional data was collected on January 12, 2009, while the water surface elevation averaged 337.35 feet above mean sea level. The conservation pool elevation for the lake is 337.5 feet above mean sea level.

The results of the TWDB 2008 Volumetric Survey indicate Lake Bob Sandlin has a total reservoir capacity of 201,733 acre-feet and encompasses an area of 8,703 acres at conservation pool elevation (337.5 feet above mean sea level, NGVD 29). TWDB previously surveyed Lake Bob Sandlin in February of 1998. Comparison of capacities at conservation pool elevation derived from current and previous surveys suggests Lake Bob Sandlin loses between 324 acre-feet per year and 482 acre-feet per year. Detailed spatial comparisons of survey results from 1998 and 2008 were not performed, yet may provide insight into the locations of active depositional regions within Lake Bob Sandlin. To improve estimation of lake capacity and the sediment accumulation rate, TWDB recommends a combined volumetric and sedimentation survey of Lake Bob Sandlin in approximately 10 years or after a major flood event. In sedimentation surveys, TWDB employs a multi-frequency depth sounder to measure both the water depth and the sediment thickness throughout the lake. In addition to the volumetric survey results similar to those presented within, sedimentation surveys include computed sediment volumes, computed sediment accumulation rates, sediment core samples, and maps identifying the spatial distribution of accumulated sediment throughout the lake.

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

Introduction

Texas Water Development Board's (TWDB) Hydrographic Survey Program was authorized by the state legislature in 1991. Texas Water Code (Chapter 15, Subchapter M) authorizes TWDB to perform surveys to determine reservoir storage capacity, sedimentation levels, rates of sedimentation, and projected water supply availability.

In May of 2008, TWDB entered into agreement[1] with Titus County Fresh Water Supply District No. 1 to perform a volumetric survey of Lake Bob Sandlin. This report describes the methods used to conduct the volumetric survey, including data collection and data processing. It also serves as the final contract deliverable from TWDB to Titus County Fresh Water Supply District No. 1, and contains as deliverables: (1) an elevation-area-capacity table of the lake acceptable to the Texas Commission on Environmental Quality [Appendix A,B], (2) a bottom contour map [Figure 5], and (3) a shaded relief plot of the lake bottom [Figure 4].

Lake Bob Sandlin General Information

Fort Sherman Dam and Lake Bob Sandlin are located on Big Cypress Creek (Cypress Creek Basin) in Wood, Titus, Franklin, and Camp Counties, five miles southwest of Mount Pleasant.[2] (Figure 1). Titus County Fresh Water Supply District No.1 owns and operates the reservoir. The reservoir was originally named Lake Cherokee Trail in reference to the trail the Cherokee Indians used to travel between the Nacogdoches area and Oklahoma. It was renamed in honor of Bob M. Sandlin, a Titus County Fresh Water Supply District No. 1 Board member who worked to make the lake a reality.[3] Construction on Fort Sherman Dam began in 1974.[2] Records indicate deliberate impoundment for Lake Bob Sandlin began August 8, 1977 and the project was officially completed in April of 1978.[4] The reservoir is used primarily as water supply storage for domestic and industrial uses, as well as for recreational activities.[3] Additional pertinent data about Fort Sherman Dam can be found in Table 1.

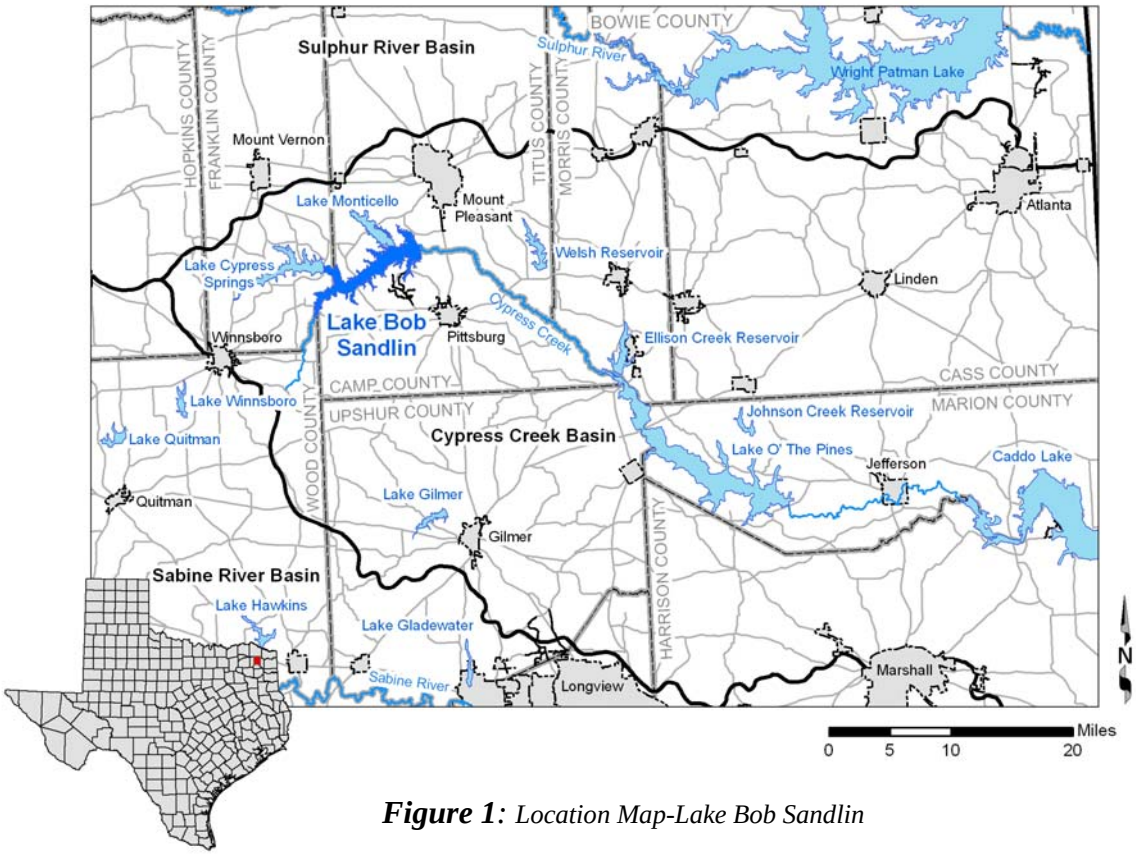


***Figure 1**: Location Map-Lake Bob Sandlin*

Table 1: Pertinent Data for Fort Sherman Dam and Lake Bob Sandlin[2,3,4]

Owner

Titus County Fresh Water Supply District No.1

Engineer (Design)

URS/ Forrest and Cotton Inc.

Location of Dam

On Big Cypress Creek in Wood, Titus, Franklin, and Camp Counties, 5 miles southwest of Mount Pleasant.

Drainage Area

Total area above the dam is 239 square miles

Dam

Type	Earthfill
Length (total)	10,800 feet
Maximum height	69 feet
Top width	25 feet
Top elevation	349.0 feet above mean sea level

Spillway (emergency)

Location	Near left end of the dam
Type	Uncontrolled, unpaved, broad crested weir
Crest Length	4,500 feet
Crest elevation	341.3 feet above mean sea level

Spillway (service)

Location	Left abutment
Type	Concrete ogee
Crest Length	160 feet net
Crest elevation	316.5 feet above mean sea level
Control	4 tainter gates, each 22.5 by 40 feet

Outlet (diversion)

Type	Conduit in spillway gate pier
Invert elevation	294.5 feet above mean sea level
Control	Sluice gate 3.5 by 6 feet

Reservoir Data (Capacity and area based on TWDB 2008 Survey)

Feature	**Elevation (feet above mean sea level)**	**Capacity (Acre-feet)**	**Area (Acres)**
Top of Dam	349.0	N/A	N/A
Maximum water (test flood)	345.6	N/A	N/A
Top tainter gates	339.0	N/A	N/A
Top of conservation pool	337.5	201,733*	8,703
Spillway crest	316.5	61,328	4,512
Lowest outlet**	294.5	3,284	930
Usable storage		198,449***	
Streambed	280.0	0	0

*Total Reservoir Capacity

**The sediment pool or dead pool storage is that capacity of water below the invert of the lowest outlet

***Conservation Storage Capacity (Total Reservoir Capacity minus Sediment Pool Storage)

Water Rights

The water rights for Lake Bob Sandlin have been appropriated to Titus County Fresh Water Supply District No. 1 through Certificate of Adjudication No. 04-4564 and to Northeast Texas Municipal Water District through Certificate of Adjudication No. 04-5490. A brief summary of each certificate follows. The complete certificates are on file in the Records Division of the Texas Commission on Environmental Quality.

Certificate of Adjudication No. 04-4564

Priority Dates: December 20, 1971 & March 13, 1978

This certificate of adjudication authorizes Titus County Fresh Water Supply District No. 1 to maintain an existing dam and reservoir on Cypress Creek (Fort Sherman Dam and Lake Bob Sandlin), and impound therein not to exceed 213,350 acre-feet of water. Titus County Fresh Water Supply District No. 1 is authorized to divert and use a maximum of 10,000 acre-feet of water per year from Lake Bob Sandlin for municipal and domestic purposes and divert and use a maximum of 38,500 acre-feet of water per year for industrial purposes. Titus County Fresh Water Supply District No. 1 is authorized to use the water impounded for recreation purposes.

Certificate of Adjudication No. 04-4590

Priority Date: September 16, 1957

This certificate of adjudication authorizes the Northeast Texas Municipal Water District to store 251,000 acre-feet of water in Lake O' the Pines on Cypress Creek. The Northeast Texas Municipal Water District is authorized to divert and use a maximum of 42,000 acre-feet of water per year from Lake O' the Pines and Lake Bob Sandlin for municipal and domestic purposes, of which not more than 1,930 acre-feet of water per year may be diverted from Lake Bob Sandlin by the City of Pittsburg in accordance with an agreement between Titus County Fresh Water Supply District No. 1, the City of Pittsburg, and Northeast Texas Municipal Water District. Northeast Texas Municipal Water District is also authorized to divert and use a maximum of 161,800 acre-feet of water per year from Lake O' the Pines and Lake Bob Sandlin for industrial purposes, of which not more than 10,000 acre-feet of water per year may be diverted from Lake Bob Sandlin.

Volumetric Survey of Lake Bob Sandlin

Datum

The vertical datum used during this survey is that used by the United States Geological Survey (USGS) for the reservoir elevation gage USGS 07344489 Lk Bob Sandlin nr Mount Pleasant, TX.[5] The datum for this gage is reported as National Geodetic Vertical Datum 1929 (NGVD 29), thus elevations reported here are in feet above mean sea level. 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 of 1983 (NAD83), and the horizontal coordinate system is State Plane Texas North Central Zone (feet).

TWDB Bathymetric Data Collection

Primary bathymetric data collection occurred from November 4th through November 9th of 2008, while the daily average water surface elevation of the lake ranged between 337.17 and 337.04 feet above mean sea level (NGVD 29). TWDB used a Specialty Devices, Inc. multi-frequency sub-bottom profiling depth sounder integrated with Differential Global Positioning System (DGPS) equipment for data collection. Although the Specialty Devices, Inc. depth sounder collects data with 200 kHz, 50 kHz, and 24 kHz frequency signals, only data from the 200 kHz frequency signal was used in developing this report. TWDB returned to collect additional data on January 12, 2009 while the water surface elevation averaged 337.35 feet above mean sea level. The additional data was collected with a Knudsen Engineering Ltd. single-frequency (200 kHz) depth sounder integrated with DGPS equipment. All data collection occurred while navigating along pre-planned survey lines oriented perpendicular to the location of the original river channels and spaced approximately 500 feet apart. Data was also collected along some of the survey lines used during the 1998 Lake Bob Sandlin survey conducted by TWDB.

Prior to beginning the survey, each day, TWDB used a weighted tape or stadia rod to physically verify the depth readings recorded by the Specialty Devices, Inc. or Knudsen echosounder. During the 2008 survey, team members collected over 97,200 data points

over cross-sections totaling nearly 160 miles in length. Figure 2 shows where data points were collected during the TWDB 2008 survey.

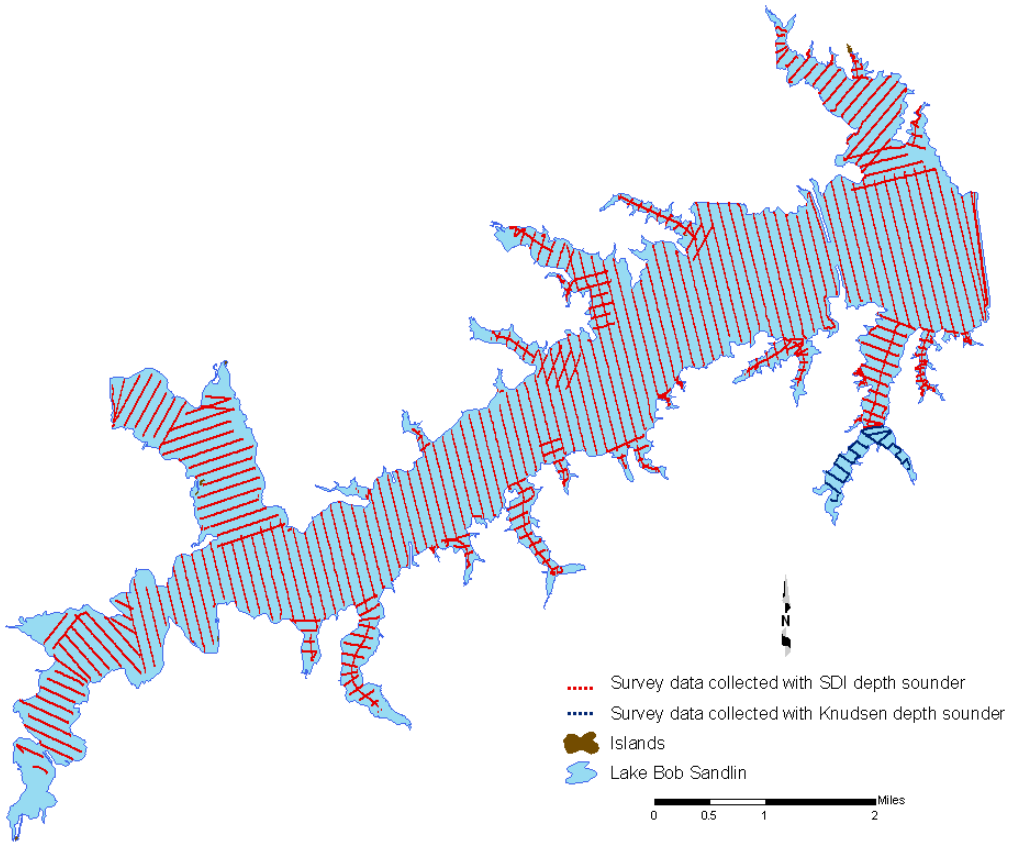


Figure 2: *Map of Data Collected during TWDB 2008 Survey*

Data Processing

Model Boundaries

The reservoir boundary was digitized from aerial photographs known as digital ortho quarter-quadrangle images (DOQQs),[6] obtained from the Texas Natural Resources Information System (TNRIS),[7] using Environmental Systems Research Institute's (ESRI) ArcGIS 9.1 software. The DOQQs that cover Lake Bob Sandlin are Monticello NW, Monticello NE, Monticello SW, Monticello SE, and New Hope SE. The Lake Bob Sandlin boundary was digitized from DOQQs that were photographed on August 18, 2004, while the water surface elevation was 336.63 feet above mean sea level, within 0.87 vertical feet of the conservation pool elevation. The 2004 DOQQs are of 1-meter resolution; therefore, the physical lake boundary accuracy is within ± 1 horizontal meter

of the location derived from the manual delineation. The delineated boundary was given an elevation of 337.5 feet to facilitate calculating the area-capacity tables up to the conservation pool elevation.

Triangular Irregular Network (TIN) Model

Upon completion of the data collection effort, the raw data files collected by TWDB were edited using HydroEdit,[8] DepthPic,[9] and customized MATLAB scripts to remove any data anomalies. Specifically, HydroEdit applies a median filter to the raw survey data and removes individual data anomalies or points with incorrect GPS coordinates. HydroEdit also uses the water surface elevations at the times of each sounding to convert sounding depths to corresponding bathymetric elevations. DepthPic is used to display, interpret, and manually edit the multi-frequency data, while the MATLAB processing scripts are used to visually inspect each of the filtered single-frequency cross-sections to identify and rectify any series of data anomalies that were not edited using the HydroEdit filters. For processing outside of MATLAB and HydroEdit, the sounding coordinates (X,Y,Z) are exported as a MASS points file. Using the "Self-Similar Interpolation" technique (described below), TWDB interpolated bathymetric elevation data between surveyed cross sections. To better represent reservoir bathymetry in shallow regions, TWDB used the "Line Extrapolation" technique (described below).[8]

To create a surface representation of the Lake Bob Sandlin bathymetry, TWDB used the 3D Analyst Extension of ArcGIS (ESRI, Inc.). This extension allows for the creation of a triangulated irregular network (TIN) model of the reservoir bathymetry. Within the TIN model MASS points and boundary nodes become vertices of interconnected triangles that when combined represent the reservoirs bathymetry, simulating the reservoir bottom surface.[10] Using the 3D Analyst Extension and the TIN model, reservoir capacity and surface area are calculated at one-tenth of a foot (0.1 foot) intervals, from the deepest elevation recorded within the lake, 283 feet, to the conservation pool elevation, 337.5 feet.

The Elevation-Capacity and Elevation-Area Tables, updated for 2008, are presented in Appendices A and B, respectively. Tables are provided with elevations referenced to the NGVD 29 datum. The Area-Capacity Curves are presented in Appendix C.

The Lake Bob Sandlin TIN model was converted to an equivalent raster representation using a cell size of 1 foot by 1 foot. The raster data was used to produce an Elevation Relief Map (Figure 3) representing the topography of the reservoir bottom, a Depth Range Map (Figure 4) showing shaded depth ranges for Lake Bob Sandlin, and a 5-foot Contour Map (Figure 5 - attached). The reservoir extent, depicted in these figures, is the lake digitized from the 2004 DOQQs, approximately 337.5 feet above mean sea level.

Self-Similar Interpolation

The 3D Analyst extension utilizes the Delaunay method for triangulation. A limitation of the Delaunay method for triangulation when creating TIN models results in artificially-curved contour lines extending into the reservoir where the reservoir walls are steep and the reservoir is relatively narrow. These curved contours are likely a poor representation of the true reservoir bathymetry in these areas. Also, if the surveyed cross sections are not perpendicular to the centerline of submerged river channel (the location of which is often unknown until after the survey), then the TIN model is not likely to well-represent the true channel bathymetry.

To ameliorate these problems, a Self-Similar Interpolation routine (developed by TWDB) was used to interpolate the bathymetry between the 500 foot-spaced survey cross sections. The Self-Similar Interpolation technique increases the density of points input into the TIN model, and assists the TIN interpolation to better represent the unknown reservoir topography between cross sections.[8] In the case of Lake Bob Sandlin, the application of Self-Similar Interpolation helped represent the lake morphology near the banks and improved the representation of the submerged river channel (Figure 6). In areas where obvious geomorphic features indicate a high-probability of cross-sectional shape changes (e.g. incoming tributaries, significant widening/narrowing of channel, etc.), the assumptions used in applying the Self-Similar Interpolation technique are not likely to be valid. Therefore, Self-Similar Interpolation was not used in areas of Lake Bob Sandlin where a high probability of change between cross-sections exists.[8] Figure 6 illustrates typical results of the application of the Self-Similar Interpolation routine in Lake Bob Sandlin, and the bathymetry shown in Figure 6C was used in computing reservoir capacity and area tables (Appendix A, B).

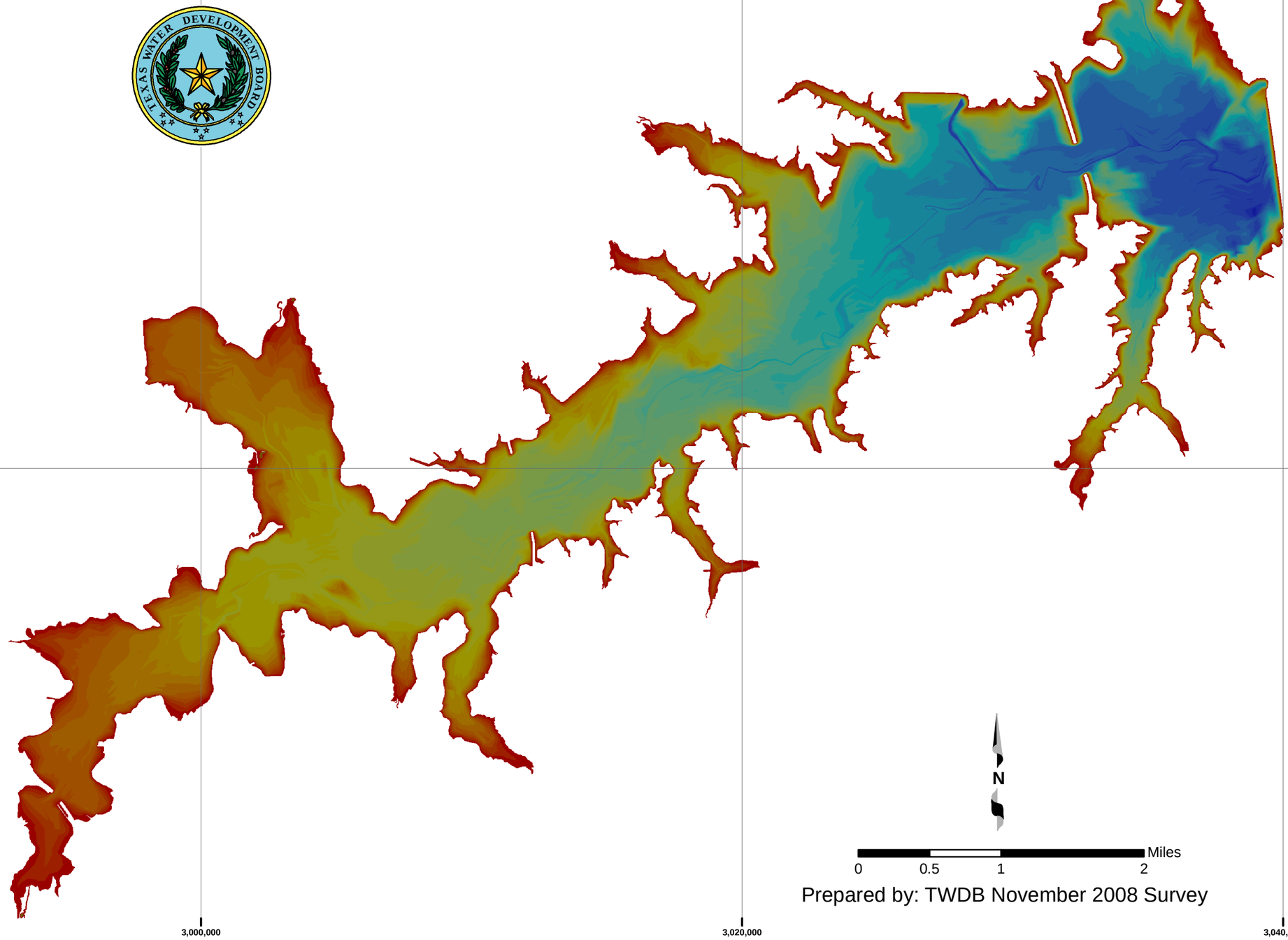
Figure 3

Lake Bob Sandlin

Elevation Relief Map

3,000,000 3,020,000 3,040,000

7,100,000 7,080,000



N

0 0.5 1 2 Miles

Prepared by: TWDB November 2008 Survey

Elevations
(in feet above mean sea level)

- 336.1 - 337.5
- 334.1 - 336
- 332.1 - 334
- 330.1 - 332
- 328.1 - 330
- 326.1 - 328
- 324.1 - 326
- 322.1 - 324
- 320.1 - 322
- 318.1 - 320
- 316.1 - 318
- 314.1 - 316
- 312.1 - 314
- 310.1 - 312
- 308.1 - 310
- 306.1 - 308
- 304.1 - 306
- 302.1 - 304
- 300.1 - 302
- 298.1 - 300
- 296.1 - 298
- 294.1 - 296
- 292.1 - 294
- 290.1 - 292
- 288.1 - 290
- 286.1 - 288
- 284.1 - 286
- 282.1 - 284
- 281.3 - 282
- Islands

Projection: NAD83
State Plane
Texas North Central Zone

Conservation Pool Elevation:
337.5 feet above mean sea level

Figure 4

Lake Bob Sandlin

Depth Ranges Map

3,000,000
3,020,000
3,040,000
7,100,000
7,080,000

Depth Ranges
(in feet)

- 0 - 5'
- 5 - 10'
- 10 - 15'
- 15 - 20'
- 20 - 25'
- 25 - 30'
- 30 - 35'
- 35 - 40'
- 40 - 45'
- 45 - 50'
- 50 - 55'
- > 55'
- Islands

Projection: NAD83
State Plane
Texas North Central Zone

Conservation Pool Elevation:
337.5 feet above mean sea level

N

0 0.5 1 2 Miles

Prepared by: TWDB November 2008 Survey

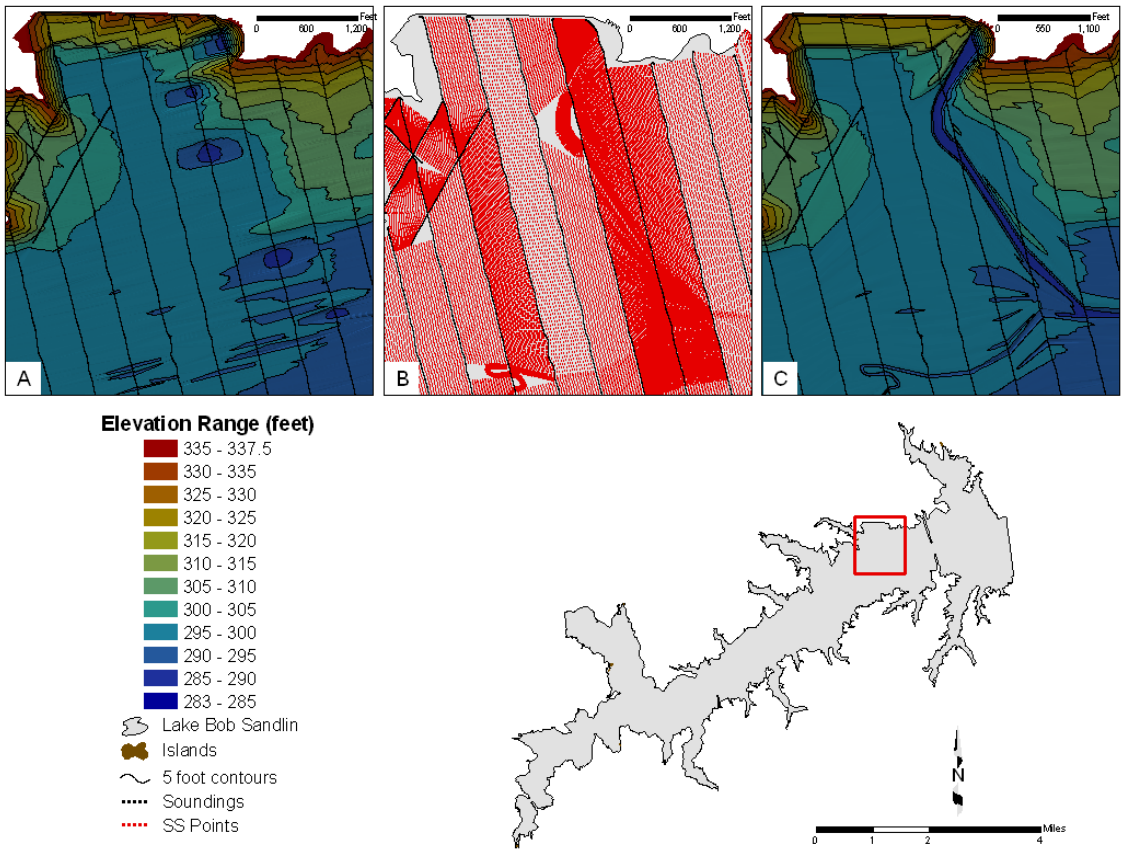


Figure 6: *Application of the Self-Similar Interpolation technique to Lake Bob Sandlin sounding data – A) bathymetric contours without interpolated points, B) Sounding points (black) and interpolated points (red) with reservoir boundary shown at elevation 337.5 feet (black), C) bathymetric contours with the interpolated points. Note: In 6A the deeper channels indicated by the surveyed cross sections are not continuously represented in the areas in-between the cross sections. This is an artifact of the TIN generation routine, rather than an accurate representation of the physical bathymetric surface. Inclusion of the interpolated points (6C) corrects this and smoothes the bathymetric contours.*

Line Extrapolation

In order to estimate the bathymetry within the small coves and other un-surveyed portions of Lake Bob Sandlin, TWDB applied the Line Extrapolation technique,[8] which is similar to the Self-Similar Interpolation technique discussed above. TWDB uses the Line Extrapolation technique to extrapolate bathymetries in small coves where water depths are too shallow to allow boat passage. The Line Extrapolation technique requires the user to define (1) a longitudinal axis approximately bisecting the small cove, (2) the elevation at the beginning of the longitudinal axis, (3) the number of cross sections along the longitudinal axis, and (4) the number of points between the longitudinal axis and the cove boundary. The starting elevation of the longitudinal axis is typically assumed equivalent to

the elevation of the TIN model near the beginning of the longitudinal line or estimated based on the nearest surveyed depth.

The Line Extrapolation technique assumes a V-shaped profile for cross-sections within the extrapolation area, with the deepest section of the profile located along the longitudinal axis. Elevations along the longitudinal axis are interpolated linearly based on the distance along the axis from the start (nearest the reservoir interior) to the end (where the axis crosses the reservoir boundary). The elevations at points along each extrapolated cross-section are linearly interpolated from an elevation on the longitudinal axis (at the intersection with the cross-section) and the elevation at the extrapolation area boundary. Figure 7 illustrates the Line Extrapolation technique as applied to Lake Bob Sandlin.

The inherent assumption of the Line Extrapolation technique is that a V-shaped cross section is a reasonable approximation of the actual unknown cross-section within the extrapolated area. As of yet, TWDB has been unable to test this assumption, and therefore can only assume that the results of the usage of the Line Extrapolation technique are more accurate than those derived without line extrapolation. The use of a V-shaped extrapolated cross-section likely provides a conservative estimate of the water volume in un-surveyed areas, as most surveyed cross-sections within Lake Bob Sandlin had shapes more similar to U-profiles than to V-profiles. The V-profiles are thus conservative in that a greater volume of water is implied by a U-profile than a V-profile. Further information on the Line Extrapolation technique is provided in the HydroEdit User's Manual.[8]

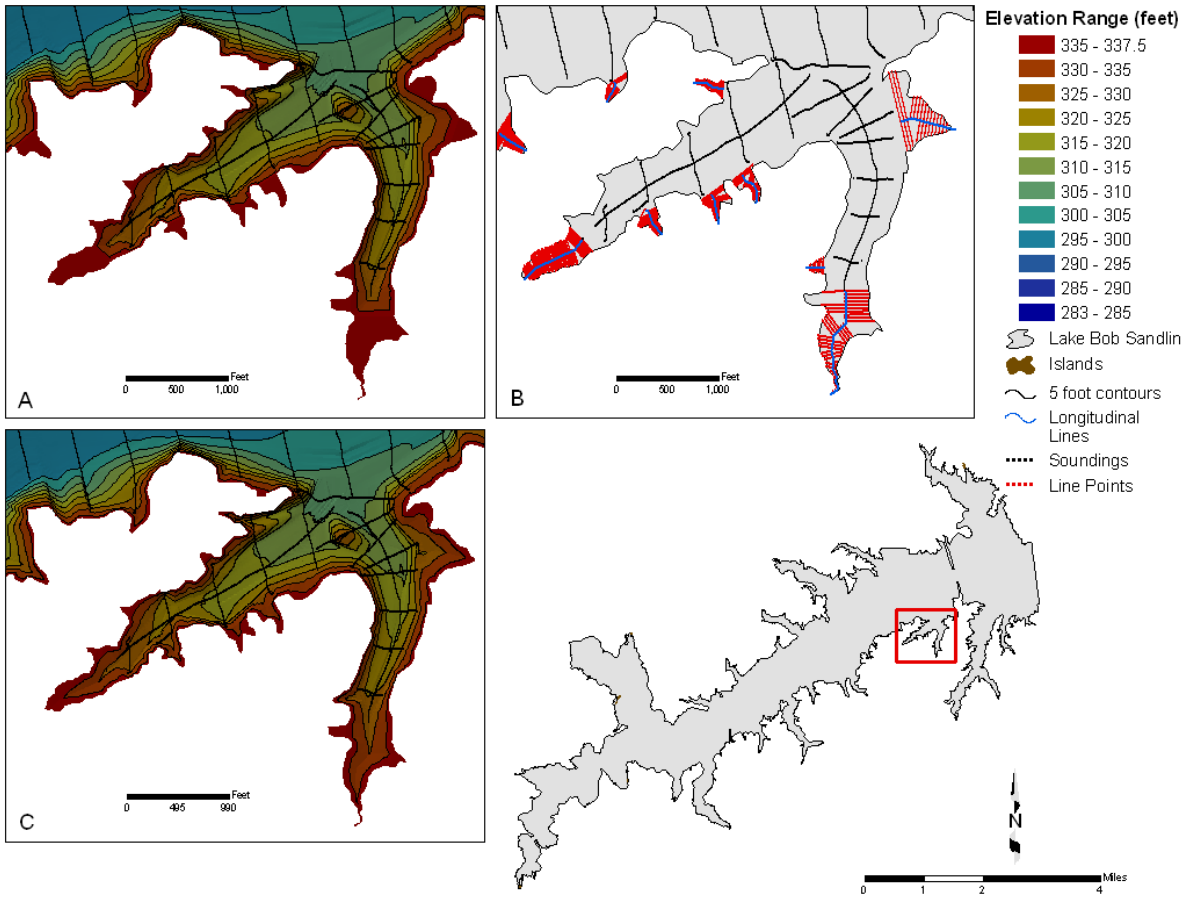


Figure 7 *- Application of the Line Extrapolation technique to Lake Bob Sandlin sounding data – A) bathymetric contours without extrapolated points, B) Sounding points (black) and extrapolated points (red) with reservoir boundary shown at elevation 337.5 feet (black), and C) bathymetric contours with the extrapolated points. Note: In 7A the bathymetric contours do not extend into the un-surveyed area and "flat" triangles are formed connecting the nodes of the reservoir boundary. This is an artifact of the TIN generation routine when data points are too far apart or are absent from portions of the reservoir. Inclusion of the extrapolated points (7C) corrects this and smoothes the bathymetric contours.*

Volumetric Survey Results

The results of the TWDB 2008 Volumetric Survey indicate Lake Bob Sandlin has a total reservoir capacity of 201,733 acre-feet and encompasses 8,703 acres at conservation pool elevation (337.5 feet above mean sea level, NGVD 29).

Based on information provided by Titus County Fresh Water Supply District No. 1, the original capacity, calculated prior to impoundment, of Lake Bob Sandlin, was 213,350 acre-feet at conservation pool elevation .[2] TWDB subsequently surveyed Lake Bob Sandlin in February of 1998. Differences in past, present, and future methodologies makes direct comparison of volumetric surveys potentially unreliable. To properly

compare results from TWDB surveys of Lake Bob Sandlin, TWDB applied the 2008 data processing techniques to the survey data collected in 1998. Specifically, TWDB applied the Self-Similar Interpolation and Line Extrapolation techniques[8] to the 1998 survey dataset. A comparison of the original and revised 1998 survey capacities for Lake Bob Sandlin, at conservation pool elevation, are presented in Table 2. TWDB revised the 1998 survey and created a new TIN model using the boundary from the original 1998 survey. The 1998 survey boundary was created from 7.5 minute USGS quadrangle maps, with a stated accuracy of ± ½ the contour interval[11], or within ± 5 feet of the elevations.

Theoretically, comparing lake volumes from multiple lake surveys allows for calculation of capacity loss rates, and if all lost capacity is due to sediment accumulation, then comparisons of lake volumetric surveys would yield sediment accumulation rates. In practice, however, the differences in methodologies used in each lake survey may yield greater differences in computed lake volumes than physical volume differences due to sediment accumulation over time. In addition, because volumetric surveys are not exact, small sedimentation rates may be masked by the imprecision of the computed volumes. For this reason, TWDB prefers to estimate sediment accumulation rates through sedimentation surveys, which directly measure the sediment layer thicknesses throughout the reservoir. The sediment accumulation rates derived from such surveys reflect the average rate of sediment accrual since the time of impoundment. To estimate temporal trends in sediment accumulation, multiple sedimentation surveys would be beneficial.

Table 2: Results of 1998 Survey Revision

1998 Survey	Area (acres)	Volume (acre-feet)	Volume Difference (ΔV)	
			Acre-Feet	% of Original
Original	9,004	204,678	<>	<>
Revised	8,889	206,554	1,876	0.9

As presented in Table 2, revision of the 1998 survey data using current TWDB data processing methods resulted in an increase in reservoir capacity of approximately 0.9%. Such an increase is typical for lakes of similar size and shape as Lake Bob Sandlin, and is due to the improved representation of the lake bathymetry between adjacent cross sections and within small coves obtained with Self-Similar Interpolation and Line Extrapolation.

Comparisons of the capacities at conservation pool elevation from pre-impoundment to 1998 and from 1998 to 2008 (Table 3) suggest Lake Bob Sandlin loses between 324 acre-feet per year and 482 acre-feet per year. Comparison between the

original pre-impoundment capacity estimate and the 2008 capacity estimate suggests Lake Bob Sandlin loses an average of 375 acre-feet per year. Comparison of the most recent TWDB surveys of Lake Bob Sandlin, from 1998 to 2008, suggests Lake Bob Sandlin is currently losing capacity at the higher rate of 482 acre-feet per year. TWDB did not investigate the methodology used or accuracy of the pre-impoundment capacity of Lake Bob Sandlin, and comparisons are provided here for informational purposes only. TWDB notes that the lake areas at conservation pool elevation are different for the compared surveys, and that some of the reported volume differences are directly attributable to the area differences.

Table 3: Volume Comparisons for Lake Bob Sandlin

	Volume Comparisons @ CPE (acre-feet)		
Survey	Comparison #1	Comparison #2	Comparison #3
Pre-Impoundment*	213,350		213,350
1998 Revised	206,554	206,554	
2008		201,733	201,733
ΔVolume	6,796	4,821	11,617
# of Years	21	10	31
Capacity Loss Rate (acre-feet/ year)	324	482	375

*Impoundment began on August 8, 1977

Recommendations

To improve estimates of capacity loss rates, TWDB recommends resurveying Lake Bob Sandlin in approximately 10 years or after a major flood event. To further improve estimates of sediment accumulation, TWDB recommends conducting a combined volumetric and sedimentation survey. For sedimentation surveys, TWDB employs a multi-frequency depth sounder to measure both the water depth and the sediment thickness throughout the lake. TWDB also collects sediment core samples as direct spot-measurements of accumulated sediment. These measurements are used in assessing the multi-frequency sounding data and deriving lake-wide sediment thickness datasets. Results from sedimentation surveys include current reservoir capacities, computed sediment volumes, and maps identifying the spatial distribution of sediment throughout the lake.

Additional information detailing sediment accumulation within Lake Bob Sandlin may be derived through detailed spatial comparisons of survey results from 1998 and

2008. Such comparisons may provide insight into the locations of active depositional environments and/or locations of scour within Lake Bob Sandlin.

TWDB Contact Information

More information about the Hydrographic Survey Program can be found at:

http://www.twdb.state.tx.us/assistance/lakesurveys/volumetricindex.asp

Any questions regarding the TWDB Hydrographic Survey Program may be addressed to:

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Director of the Surface Water Resources Division
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Email: Ruben.Solis@twdb.state.tx.us

Or

Jason Kemp
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Appendix A

Lake Bob Sandlin

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — NOVEMBER 2008 SURVEY

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 337.5 Feet NGVD 29

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
283	0	0	0	0	0	0	0	0	0	1
284	1	1	1	1	2	2	2	3	3	4
285	4	5	5	6	6	7	8	8	9	10
286	11	12	13	14	15	16	18	20	22	24
287	26	29	32	35	39	43	47	52	57	63
288	70	78	86	96	108	120	134	149	165	182
289	200	220	241	263	286	310	336	363	391	421
290	452	484	517	551	586	623	661	700	741	784
291	829	877	926	978	1,031	1,086	1,142	1,200	1,258	1,318
292	1,379	1,441	1,503	1,567	1,632	1,698	1,766	1,834	1,904	1,976
293	2,048	2,122	2,197	2,273	2,350	2,429	2,508	2,589	2,671	2,754
294	2,839	2,924	3,012	3,101	3,192	3,284	3,378	3,473	3,570	3,668
295	3,767	3,868	3,971	4,075	4,181	4,289	4,398	4,510	4,623	4,738
296	4,854	4,973	5,094	5,216	5,341	5,468	5,597	5,727	5,860	5,994
297	6,129	6,267	6,406	6,546	6,689	6,833	6,978	7,126	7,274	7,424
298	7,575	7,728	7,882	8,038	8,194	8,353	8,512	8,674	8,836	9,001
299	9,167	9,335	9,505	9,676	9,848	10,022	10,197	10,374	10,551	10,730
300	10,911	11,093	11,276	11,461	11,648	11,836	12,026	12,217	12,410	12,604
301	12,800	12,997	13,195	13,394	13,595	13,797	14,000	14,205	14,410	14,617
302	14,826	15,036	15,247	15,460	15,675	15,891	16,108	16,327	16,548	16,770
303	16,994	17,220	17,447	17,676	17,906	18,138	18,371	18,606	18,843	19,081
304	19,320	19,562	19,805	20,049	20,295	20,542	20,791	21,041	21,292	21,545
305	21,799	22,054	22,311	22,569	22,828	23,088	23,350	23,614	23,878	24,145
306	24,412	24,681	24,951	25,223	25,496	25,771	26,046	26,324	26,602	26,882
307	27,163	27,446	27,730	28,016	28,303	28,592	28,883	29,175	29,469	29,764
308	30,061	30,359	30,658	30,959	31,260	31,563	31,868	32,173	32,480	32,788
309	33,097	33,408	33,720	34,033	34,348	34,663	34,981	35,299	35,619	35,941
310	36,264	36,588	36,914	37,241	37,570	37,901	38,232	38,565	38,900	39,236
311	39,574	39,914	40,255	40,598	40,943	41,289	41,638	41,989	42,341	42,696
312	43,053	43,412	43,773	44,136	44,502	44,869	45,239	45,612	45,986	46,363
313	46,742	47,123	47,507	47,892	48,279	48,669	49,061	49,455	49,851	50,250
314	50,650	51,054	51,459	51,866	52,275	52,687	53,100	53,516	53,934	54,354
315	54,775	55,199	55,624	56,052	56,481	56,912	57,345	57,780	58,217	58,656
316	59,096	59,539	59,984	60,430	60,878	61,328	61,781	62,235	62,691	63,150
317	63,610	64,073	64,537	65,004	65,474	65,946	66,421	66,899	67,380	67,865
318	68,352	68,842	69,335	69,830	70,328	70,828	71,331	71,837	72,345	72,856
319	73,369	73,884	74,402	74,923	75,445	75,970	76,497	77,026	77,557	78,090
320	78,625	79,162	79,702	80,243	80,786	81,332	81,880	82,430	82,981	83,535
321	84,091	84,648	85,208	85,770	86,333	86,898	87,466	88,035	88,605	89,178
322	89,752	90,328	90,906	91,485	92,067	92,650	93,234	93,821	94,409	94,999
323	95,591	96,184	96,780	97,376	97,975	98,575	99,177	99,781	100,386	100,994
324	101,602	102,213	102,826	103,440	104,056	104,674	105,295	105,917	106,541	107,167
325	107,795	108,425	109,057	109,691	110,327	110,965	111,605	112,248	112,893	113,540
326	114,189	114,841	115,495	116,151	116,810	117,471	118,135	118,801	119,470	120,140
327	120,813	121,488	122,166	122,845	123,527	124,211	124,898	125,588	126,279	126,973
328	127,670	128,368	129,069	129,771	130,476	131,183	131,893	132,604	133,318	134,034
329	134,752	135,472	136,194	136,917	137,643	138,371	139,100	139,832	140,565	141,300
330	142,037	142,775	143,516	144,258	145,001	145,746	146,493	147,241	147,991	148,742
331	149,494	150,248	151,004	151,760	152,519	153,278	154,039	154,802	155,566	156,331
332	157,098	157,866	158,635	159,406	160,179	160,953	161,728	162,505	163,283	164,062
333	164,843	165,626	166,410	167,195	167,982	168,770	169,560	170,351	171,144	171,938
334	172,734	173,532	174,331	175,132	175,934	176,739	177,544	178,352	179,161	179,972
335	180,785	181,599	182,415	183,233	184,053	184,875	185,698	186,523	187,350	188,180
336	189,011	189,844	190,679	191,516	192,355	193,196	194,040	194,885	195,733	196,583
337	197,435	198,290	199,147	200,006	200,868	201,733				

Appendix B

Lake Bob Sandlin

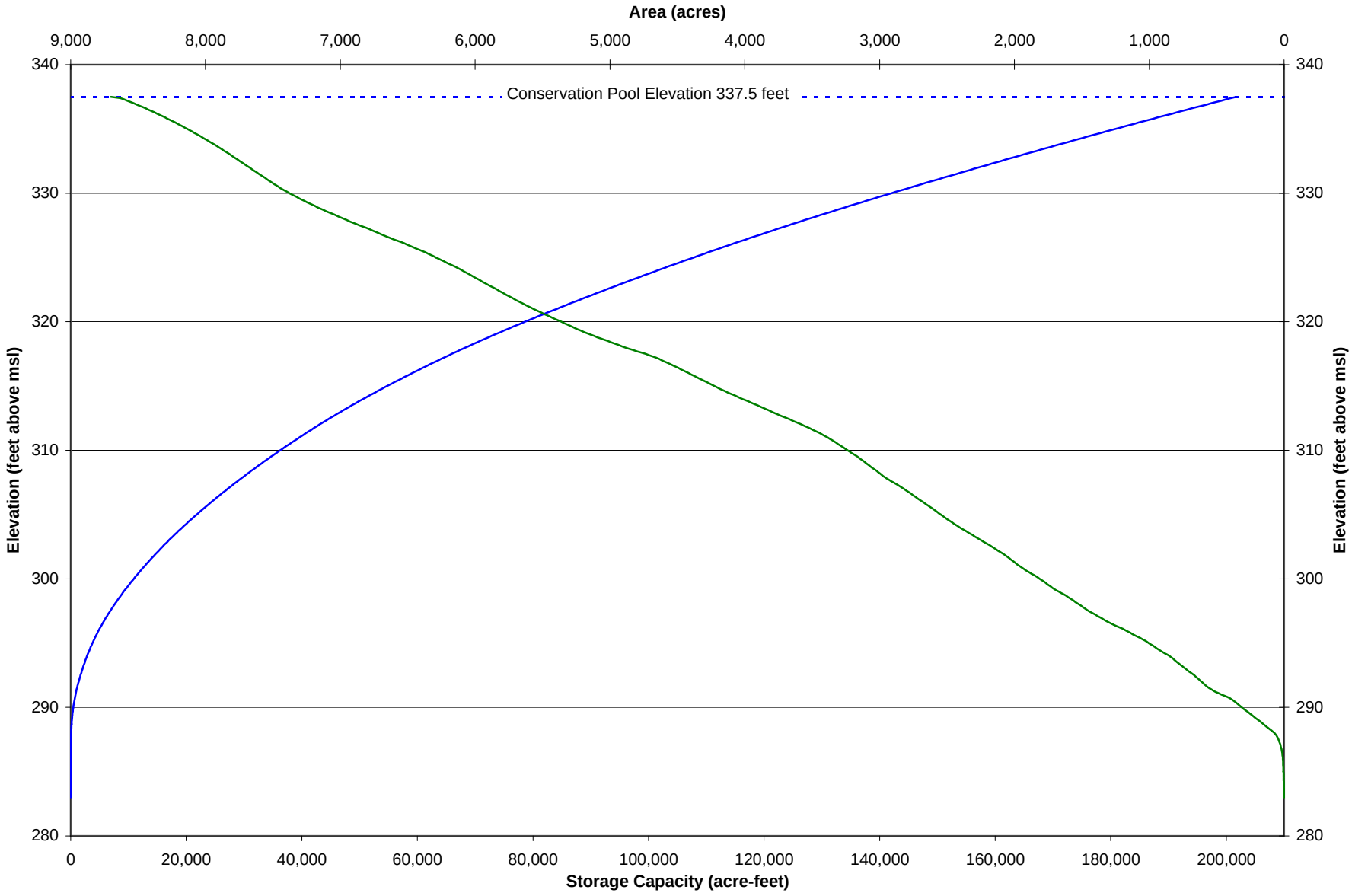
RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD — NOVEMBER 2008 SURVEY

AREA IN ACRES — Conservation Pool Elevation 337.5 Feet NGVD 29

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
283	0	0	0	0	0	1	1	1	1	2
284	2	2	2	3	3	3	4	4	4	4
285	5	5	5	6	6	7	7	7	8	8
286	9	10	11	12	13	15	17	19	21	23
287	25	28	31	35	38	41	46	50	56	63
288	71	82	94	106	118	131	143	154	165	177
289	190	202	215	227	239	251	264	277	289	301
290	314	325	337	348	359	372	385	400	419	441
291	464	487	507	524	541	556	569	580	592	602
292	612	623	634	645	656	667	680	693	706	718
293	731	743	755	767	779	792	803	814	825	837
294	851	866	884	901	915	930	945	959	973	987
295	1,002	1,017	1,032	1,050	1,068	1,087	1,105	1,123	1,141	1,159
296	1,176	1,195	1,216	1,237	1,258	1,280	1,297	1,315	1,331	1,348
297	1,365	1,382	1,399	1,415	1,432	1,449	1,465	1,479	1,492	1,505
298	1,519	1,534	1,548	1,562	1,576	1,589	1,604	1,619	1,636	1,654
299	1,672	1,689	1,704	1,718	1,732	1,745	1,757	1,770	1,784	1,798
300	1,813	1,827	1,841	1,857	1,873	1,890	1,906	1,921	1,935	1,949
301	1,963	1,976	1,989	2,001	2,013	2,025	2,038	2,050	2,064	2,077
302	2,092	2,107	2,123	2,137	2,152	2,167	2,183	2,200	2,216	2,232
303	2,248	2,264	2,279	2,294	2,309	2,325	2,342	2,358	2,374	2,390
304	2,406	2,421	2,437	2,451	2,465	2,480	2,494	2,507	2,520	2,533
305	2,546	2,560	2,572	2,585	2,599	2,613	2,627	2,641	2,654	2,668
306	2,682	2,696	2,710	2,724	2,738	2,751	2,764	2,778	2,791	2,806
307	2,820	2,835	2,850	2,865	2,881	2,897	2,914	2,931	2,946	2,960
308	2,973	2,986	2,998	3,011	3,023	3,036	3,049	3,062	3,075	3,087
309	3,100	3,113	3,125	3,138	3,151	3,164	3,178	3,193	3,208	3,223
310	3,237	3,252	3,266	3,281	3,296	3,310	3,324	3,339	3,354	3,370
311	3,387	3,404	3,421	3,438	3,457	3,477	3,496	3,516	3,536	3,558
312	3,579	3,601	3,622	3,644	3,666	3,688	3,711	3,735	3,758	3,779
313	3,801	3,822	3,843	3,863	3,885	3,907	3,929	3,951	3,974	3,998
314	4,020	4,041	4,061	4,082	4,105	4,127	4,147	4,168	4,188	4,208
315	4,227	4,245	4,263	4,282	4,302	4,321	4,340	4,359	4,378	4,398
316	4,416	4,436	4,455	4,474	4,493	4,512	4,532	4,553	4,574	4,595
317	4,615	4,635	4,657	4,681	4,708	4,736	4,767	4,799	4,830	4,860
318	4,887	4,913	4,939	4,965	4,991	5,016	5,042	5,068	5,095	5,120
319	5,143	5,168	5,192	5,215	5,237	5,259	5,279	5,299	5,320	5,341
320	5,361	5,382	5,404	5,425	5,446	5,466	5,487	5,507	5,527	5,548
321	5,567	5,587	5,606	5,625	5,644	5,663	5,680	5,699	5,716	5,734
322	5,752	5,770	5,787	5,804	5,821	5,838	5,855	5,873	5,891	5,910
323	5,927	5,944	5,961	5,978	5,994	6,012	6,029	6,045	6,062	6,080
324	6,098	6,115	6,133	6,153	6,173	6,193	6,212	6,232	6,251	6,271
325	6,289	6,309	6,329	6,349	6,370	6,392	6,415	6,438	6,461	6,483
326	6,504	6,527	6,550	6,575	6,602	6,627	6,651	6,673	6,695	6,717
327	6,740	6,762	6,784	6,806	6,831	6,856	6,882	6,907	6,929	6,951
328	6,972	6,995	7,017	7,038	7,060	7,083	7,104	7,126	7,149	7,169
329	7,188	7,208	7,228	7,248	7,267	7,287	7,305	7,324	7,342	7,359
330	7,377	7,395	7,412	7,428	7,444	7,459	7,474	7,489	7,503	7,518
331	7,532	7,546	7,561	7,575	7,589	7,603	7,617	7,632	7,646	7,660
332	7,674	7,688	7,703	7,717	7,731	7,746	7,760	7,774	7,789	7,803
333	7,817	7,832	7,846	7,861	7,876	7,890	7,905	7,921	7,936	7,952
334	7,968	7,984	8,000	8,016	8,033	8,049	8,066	8,083	8,100	8,118
335	8,135	8,153	8,171	8,189	8,207	8,225	8,244	8,263	8,282	8,301
336	8,321	8,341	8,361	8,381	8,402	8,423	8,444	8,466	8,488	8,511
337	8,534	8,557	8,582	8,607	8,634	8,703				



Lake Bob Sandlin
November 2008 Survey
Prepared by: TWDB

Appendix C: Area and Capacity Curves

Figure 5

Lake Bob Sandlin

5' - Contour Map

CONTOURS

(in feet above mean sea level)

- 285
- 290
- 295
- 300
- 305
- 310
- 315
- 320
- 325
- 330
- 335

Islands

Lake Bob Sandlin

Conservation Pool Elevation:
337.5 feet above mean sea level

Projection: NAD83
State Plane
Texas North Central Zone

Wood, Titus, Franklin, and Camp 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 Bob Sandlin. The Texas Water Development Board makes no representations nor assumes any liability.

3,000,000 3,020,000 3,040,000

7,100,000

7,080,000

N

0 0.5 1 2 Miles

Prepared by: TEXAS WATER DEVELOPMENT BOARD November 2008 Survey