Volumetric and Sedimentation Survey of LAKE MEXIA

April 2008 Survey

Prepared by:

The Texas Water Development Board

May 2009

Texas Water Development Board

J. Kevin Ward, Executive Administrator

Prepared for:

Bistone Municipal Water Supply District

With Support Provided by:

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

This report was prepared by staff of the Surface Water Resources Division:

Barney Austin, Ph.D., P.E.
Jordan Furnans, Ph.D., P.E.
Jason Kemp, Team Leader
Tony Connell
Holly Weyant
Tyler McEwen
Nathan Brock
James McDonald

STATE OF TEXAS
BARNEY N. AUSTIN
100370
LICENSED
PROFESSIONAL ENGINEER

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STATE OF TEXAS
JORDAN E. FURNANS
97316
LICENSED
PROFESSIONAL ENGINEER

5/14/09

Executive Summary

In February of 2008, the Texas Water Development Board (TWDB) entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, for the purpose of performing a volumetric and sedimentation survey of Lake Mexia. The U.S. Army Corps of Engineers, Fort Worth District, contributed 50 percent of the funding for this survey through their Planning Assistance to States Program, while the Bistone Municipal Water Supply District contributed the remaining 50 percent. This survey was performed using a multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder. The 200 kHz return measures the current bathymetric surface, while the combination of the three frequencies is analyzed for evidence of sediment accumulation throughout the reservoir. Sediment core samples were collected in selected locations and were used both in interpreting the signal returns from the multi-frequency depth sounder and for validation of the sediment accumulation estimates.

Bistone Dam and Lake Mexia are located on the Navasota River in the Brazos River Basin seven miles southwest of Mexia in Limestone County, Texas. Construction of Bistone Dam was completed on June 5, 1961 and provides water supply storage for the City of Mexia and the Mexia State School. TWDB conducted the Lake Mexia survey on April 9, 2008. Sediment cores were collected on November 12, 2008.

The results of the TWDB 2008 Volumetric Survey indicate Lake Mexia has a total reservoir capacity of 4,687 acre-feet and encompasses 1,009 acres at conservation pool elevation (448.3 feet NGVD 29). Results from a TWDB Volumetric Survey of Lake Mexia conducted in 1996 indicate Lake Mexia had a capacity of 4,806 acre-feet. Original estimates indicate Lake Mexia had a capacity of 10,000 acre-feet when impounded. Due to differences in the methodologies used in calculating areas and capacities from this and previous Lake Mexia surveys, comparison of these values is not recommended. The TWDB considers the 2008 survey to be a significant improvement over previous methods and recommends that a similar methodology be used to resurvey Lake Mexia in approximately 10 years or after a major flood event.

The results of the TWDB 2008 Sedimentation Survey indicate Lake Mexia has accumulated 1,021 acre-feet of sediment since impoundment in 1961. Based on this estimated sediment volume and assuming a constant rate of sediment accumulation, Lake Mexia loses approximately 22 acre-feet of capacity per year.

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

Lake Mexia General Information

Bistone Dam and Lake Mexia are located on the Navasota River in the Brazos River Basin, seven miles southwest of Mexia in Limestone County, Texas (Figure 1). Lake Mexia is owned and operated by Bistone Municipal Water Supply District. Construction on Bistone Dam began on July 26, 1960, with deliberate impoundment and completion of the dam occurring on June 5, 1961. Lake Mexia provides water supply storage for municipal and industrial uses for the City of Mexia and the Mexia State School. Additional pertinent data about Bistone Dam and Lake Mexia can be found in Table 1.[1]

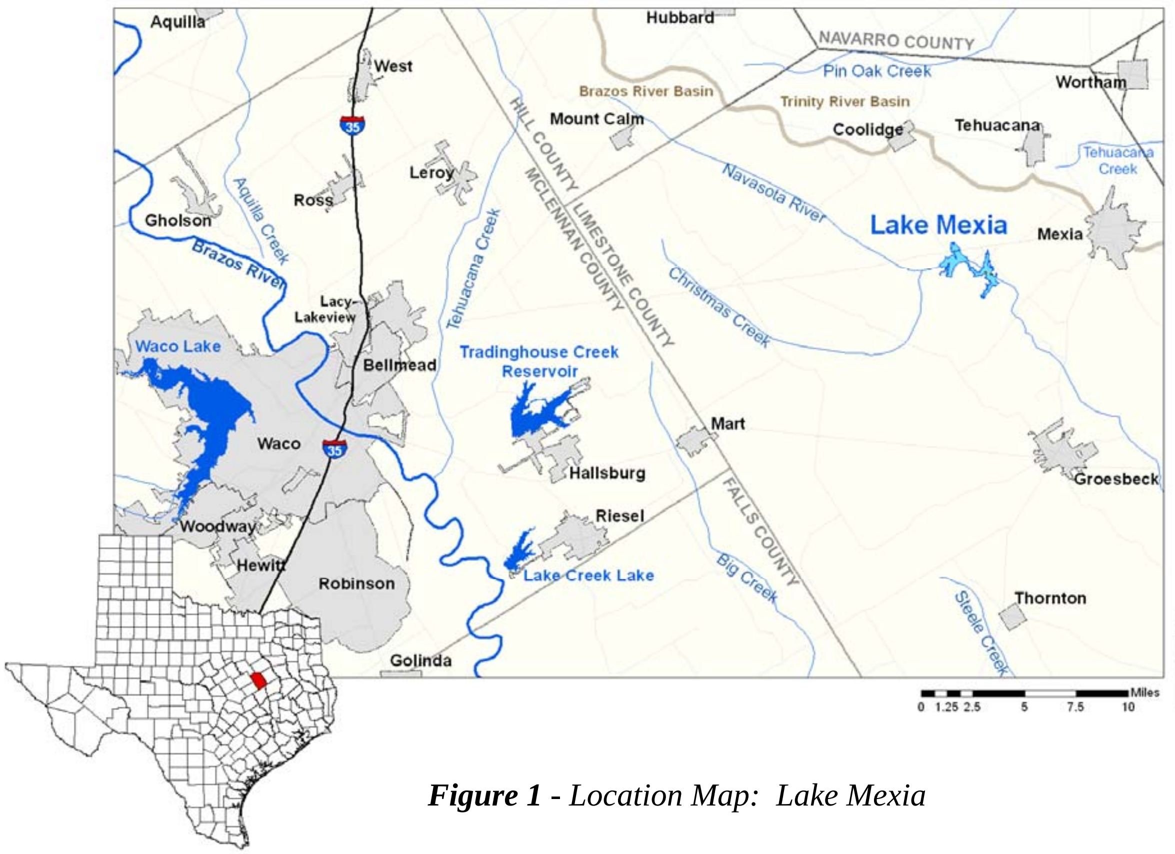

Figure 1 *- Location Map: Lake Mexia*

Table 1. Pertinent Data for Bistone Dam and Lake Mexia[1]

Owner		
	Bistone Municipal Water Supply District. Water is supplied to the City of Mexia, and the Mexia State School.	
Engineer (Design)		
	Koch & Fowler and Grafe, Inc	
Location of Dam		
	On the Navasota River in the Brazos River Basin in Limestone County, 7 miles southwest of Mexia, Texas	
Drainage Area		
	198 square miles	
Dam		
	Type	Earthfill
	Length	1,645 feet
	Height	50 feet
	Top width	20 feet
	Top elevation	462.3 feet above mean sea level (NGVD'29)
Spillway		
	Type	Concrete ogee
	Location	Left end of dam
	Crest length	520 feet
	Crest elevation	448.3 feet above mean sea level (NGVD'29)
Outlet Works		
	Water supply outlet	36-inch pipe
	Water supply invert elevation	425.3 feet above mean sea level (NGVD'29)
	Low flow outlet	24-inch pipe
	Low flow invert elevation	422.1 feet above mean sea level (NGVD'29)

Water Rights

The water rights for Lake Mexia have been appropriated to the Bistone Municipal Water Supply District through Certificate of Adjudication No. 12-5287. Certificate of Adjudication No. 12-5287 authorizes the Bistone Municipal Water Supply District to maintain an existing dam and reservoir on the Navasota River (Lake Mexia), and impound therein a maximum of 9,600 acre-feet of water. Bistone Municipal Water Supply District is authorized to divert and use a maximum of 2,887 acre-feet of water per year for municipal purposes within the City of Mexia and the Mexia State School, and 65 acre-feet of water per year for industrial purposes. The District's priority date for this right is April 15, 1957. The complete certificate is on file in the Records Division of the Texas Commission on Environmental Quality.

Volumetric and Sedimentation Survey of Lake Mexia

The Texas Water Development Board (TWDB) Hydrographic Survey Program was authorized by the state legislature in 1991. 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 February of 2008, the Texas Water Development Board entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, for the purpose of performing a volumetric and sedimentation survey of Lake Mexia. The U.S. Army Corps of Engineers, Fort Worth District, contributed 50 percent of the funding for this survey through their Planning Assistance to States Program, while the Bistone Municipal Water Supply District contributed the remaining 50 percent. This survey was performed using a multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder. In addition, sediment core samples were collected at selected locations and used in interpreting the depth sounder signal returns to derive sediment accumulation estimates. This report presents the results of the Lake Mexia volumetric and sedimentation survey.

Datum

The vertical datum used during this survey is that used by the United States Geological Survey (USGS) for the reservoir elevation gage USGS 08110300 Lk Mexia nr Mexia, TX.[2] The datum for this gage is reported as National Geodetic Vertical Datum 1929 (NGVD'29) or mean sea level, 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 Central Zone (feet).

TWDB Bathymetric Data Collection

TWDB collected data for the volumetric and sedimentation survey of Lake Mexia on April 9, 2008 while the water surface elevation averaged 448.3 feet above mean sea level. For sedimentation data collection, TWDB used a Specialty Devices, Inc., multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder integrated with Differential Global Positioning System (DGPS) equipment. Due to shallow water conditions in the upper reaches of the lake, TWDB was unable to complete the lake survey using the multi-frequency depth sounder, which requires sufficient water depths for accurate readings. In order to survey the upper reaches, TWDB returned to Lake Mexia on May 5, 2008 with a shallow draft boat and a Knudsen Engineering Ltd. single-frequency (200 kHz) depth sounder integrated with DGPS equipment. The water surface elevation on May 5 averaged 448.4 feet above mean sea level. Use of the single frequency depth sounder allowed TWDB to conduct a full volumetric survey of Lake Mexia, yet sediment accumulation estimates are not discernible from the single frequency data. The sediment volume reported herein, therefore, is an extrapolated volume based on the measured sediment volume and the observed sediment distribution along the nearest transect to the Knudsen data in which sedimentation data were collected. Figure 2 shows where data points were collected during the TWDB 2008 survey.

Data collection occurred while navigating along pre-planned range lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 500 feet apart. For all data collection efforts, 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. During the 2008 survey, team members collected over 23,250 data points over cross-sections totaling nearly 33 miles in length.

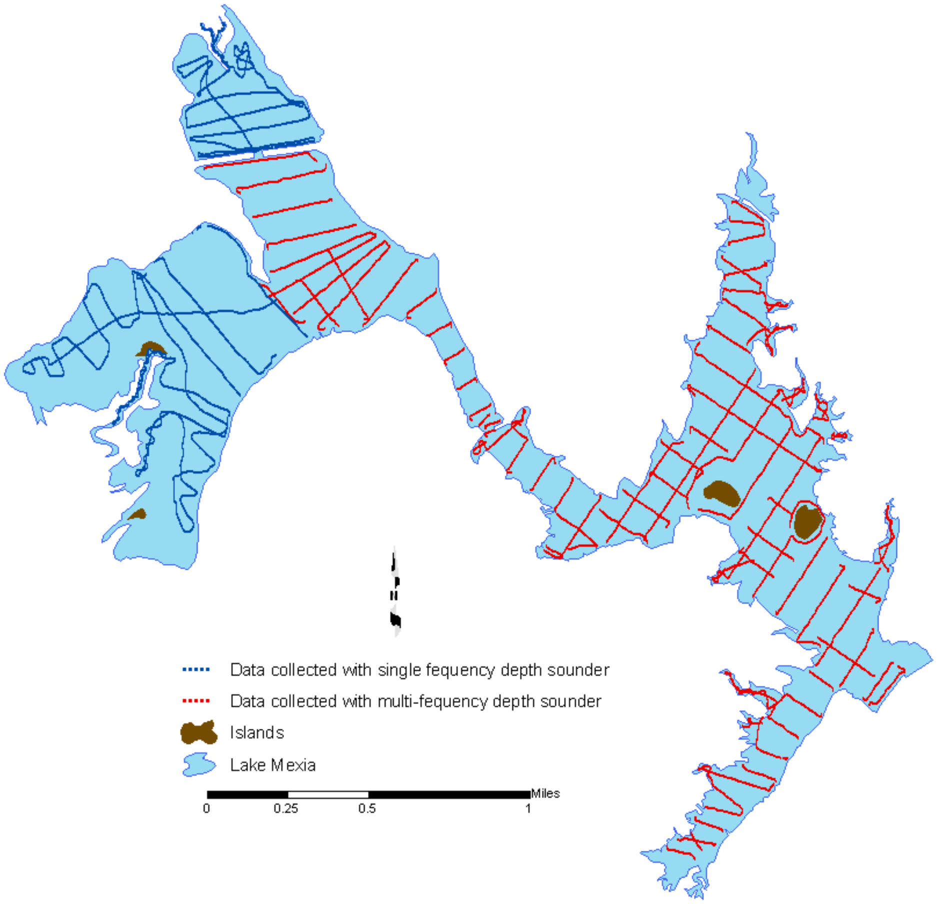

Figure 2 *– TWDB 2008 survey data points for Lake Mexia*

Data Processing

Model Boundaries

The boundary of Lake Mexia was digitized from aerial photographs, or digital orthophoto quarter-quadrangle images (DOQQs)[3], using Environmental Systems Research Institute's (ESRI) ArcGIS 9.1 software. The quarter-quadrangle that covers Lake Mexia is Tehuacana SW. The aerial photo was taken on September 8, 2004 when the water surface elevation in Lake Mexia was 447.43 feet as measured by the United States Geological Survey (USGS) gage 08110300 Lk Mexia nr Mexia, TX.[2] As the DOQQ used in digitizing the boundary is of 1-meter resolution, the physical boundary of Lake Mexia may be within ± 1 meter of the location derived from the manual delineation. For the purposes of this analysis it was assumed that the boundary of the lake at conservation pool elevation is closely represented by the September 8, 2004 DOQQ. Therefore for the purpose of calculating elevation-area-capacity tables, TWDB assigned the digitized boundary an elevation of 448.3 feet.

Triangular Irregular Network (TIN) Model

Upon completion of data collection, the raw data files collected by TWDB were edited using HydroEdit and DepthPic to remove any data anomalies. HydroEdit is used to automate the editing of the 200 kHz frequency signal returns and determine the current bathymetric surface. DepthPic is used to display, interpret, and edit the multi-frequency data to correct any edits HydroEdit has flagged and to manually interpret the pre-impoundment surface. The water surface elevations at the times of each sounding are used to convert sounding depths to corresponding bathymetric elevations. For processing outside of DepthPic and HydroEdit, the sounding coordinates (X,Y,Z) were exported as a MASS points file. TWDB also created additional MASS points files of interpolated and extrapolated data based on the sounding data. Using the "Self-Similar Interpolation" technique (described below), TWDB interpolated bathymetric elevation and sediment thickness data located in-between surveyed cross sections. To better represent reservoir bathymetry in shallow regions, TWDB used the "Line Extrapolation" technique.[4] The point files resulting from both the data interpolation and extrapolation were exported as MASS points files, and were used in conjunction with the sounding and boundary files in creating a Triangulated Irregular Network (TIN) model of the Lake Mexia bathymetry with the 3D Analyst Extension of ArcGIS. The 3D Analyst algorithms use Delaunay's criteria for triangulation to place a triangle between three non-uniformly spaced points, including the boundary vertices.[5]

Using Arc/Info software, volumes and areas are calculated from the TIN model for the entire reservoir at one-tenth of a foot intervals, from elevation 430.3 feet to elevation 448.3 feet. The Elevation-Capacity Table and Elevation-Area Table, updated for 2008, are presented in Appendix A and B, respectively. The Elevation-Area-Capacity Curves are presented in Appendix C.

Within ArcGIS, the bathymetric TIN model was converted to a raster grid using a cell size of 1 foot by 1 foot. The raster was used to produce an Elevation Relief Map representing the topography of the reservoir bottom (Figure 3), a map showing shaded depth ranges for Lake Mexia (Figure 4), and Figure 5, a 1-foot contour map (attached).

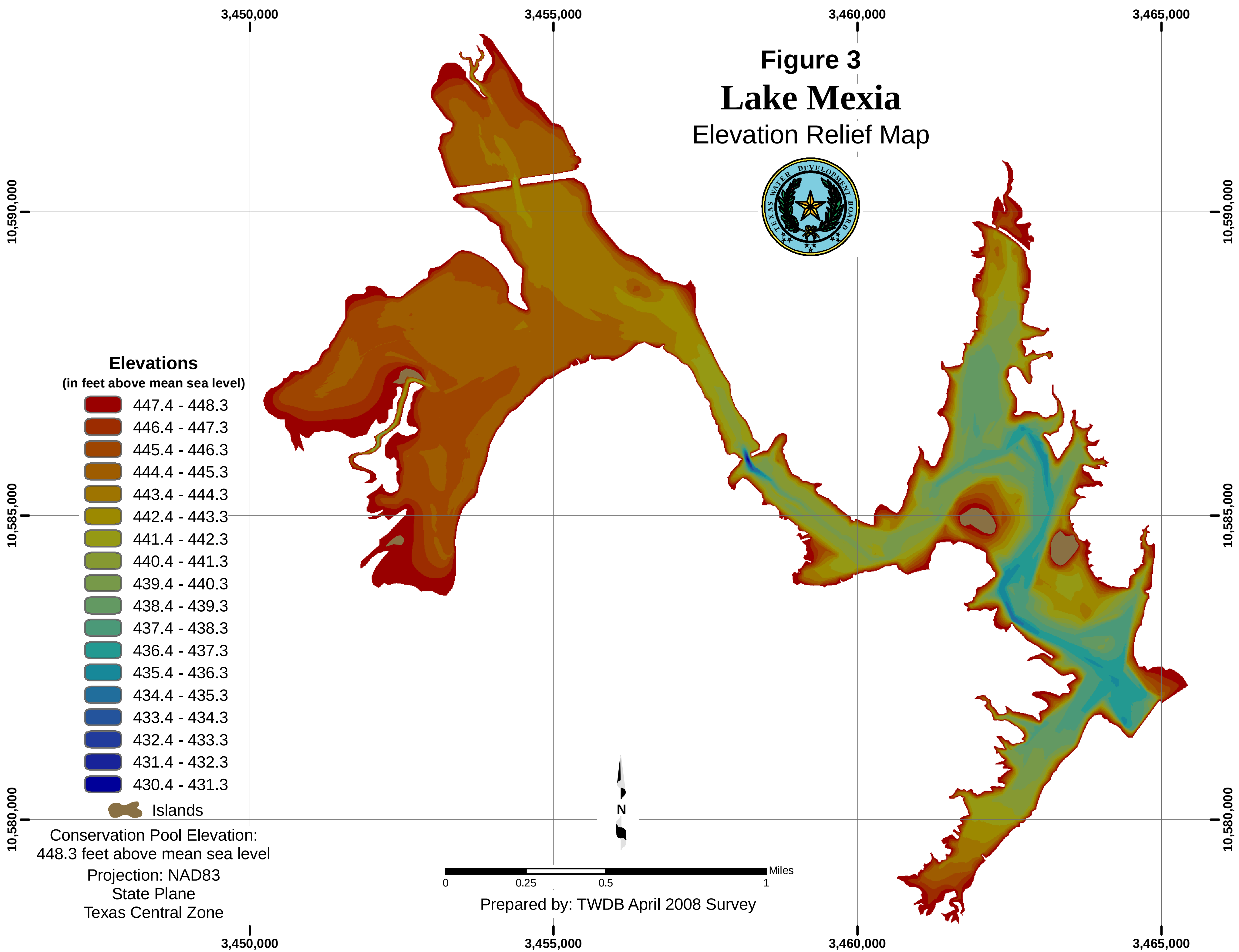
Figure 3
Lake Mexia
Elevation Relief Map
TEXAS WATER DEVELOPMENT BOARD
3,450,000
3,455,000
3,460,000
3,465,000
10,590,000
10,585,000
10,580,000
Elevations
(in feet above mean sea level)
447.4 - 448.3
446.4 - 447.3
445.4 - 446.3
444.4 - 445.3
443.4 - 444.3
442.4 - 443.3
441.4 - 442.3
440.4 - 441.3
439.4 - 440.3
438.4 - 439.3
437.4 - 438.3
436.4 - 437.3
435.4 - 436.3
434.4 - 435.3
433.4 - 434.3
432.4 - 433.3
431.4 - 432.3
430.4 - 431.3
Islands
Conservation Pool Elevation:
448.3 feet above mean sea level
Projection: NAD83
State Plane
Texas Central Zone
N
0
0.25
0.5
1
Miles
Prepared by: TWDB April 2008 Survey

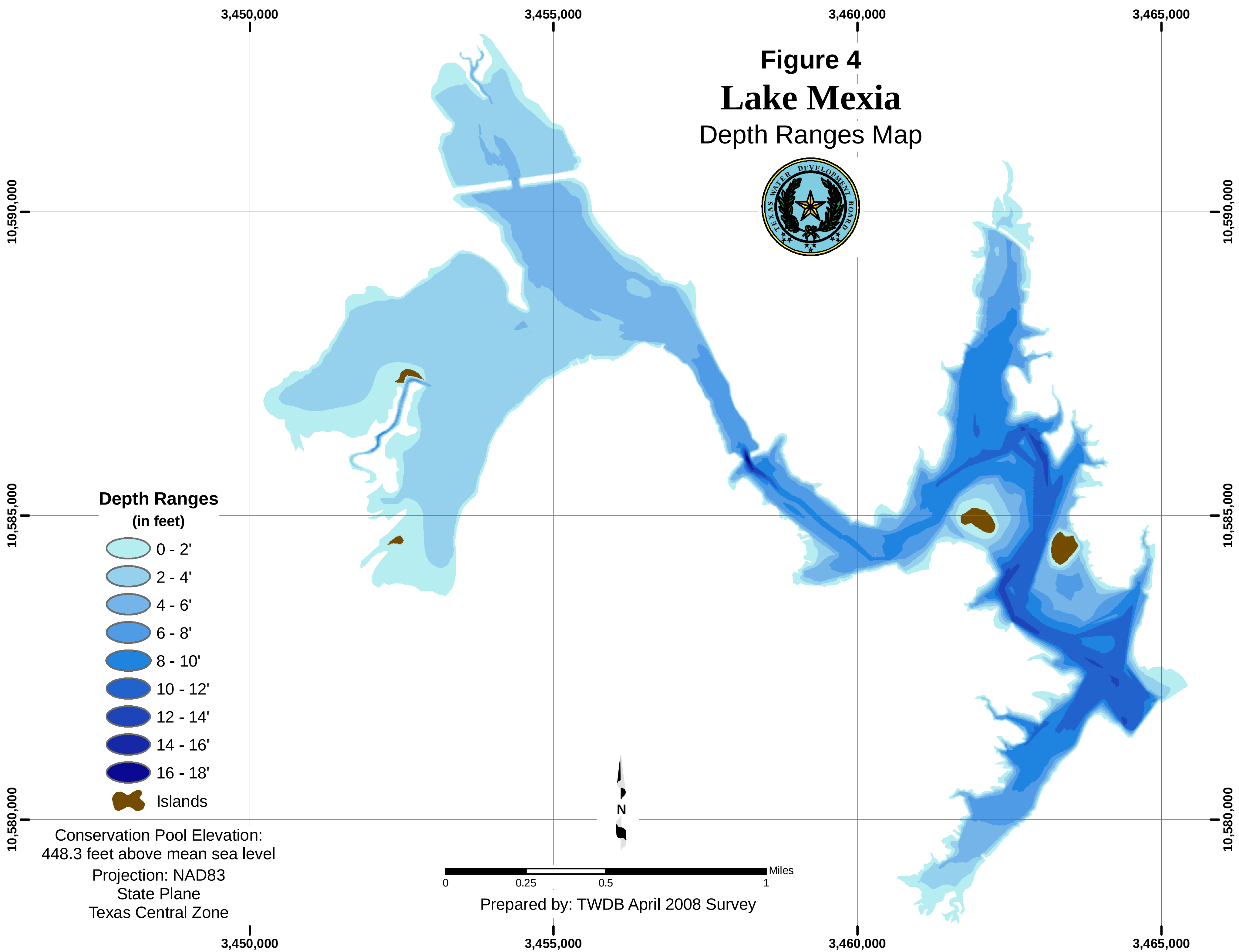

Figure 4
Lake Mexia
Depth Ranges Map
TEXAS WATER DEVELOPMENT BOARD
3,450,000
3,455,000
3,460,000
3,465,000
10,590,000
10,585,000
10,580,000
Depth Ranges
(in feet)
0 - 2'
2 - 4'
4 - 6'
6 - 8'
8 - 10'
10 - 12'
12 - 14'
14 - 16'
16 - 18'
Islands
Conservation Pool Elevation:
448.3 feet above mean sea level
Projection: NAD83
State Plane
Texas Central Zone
N
0
0.25
0.5
1
Miles
Prepared by: TWDB April 2008 Survey

Self-Similar Interpolation

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 the 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 in between survey lines. The Self-Similar Interpolation technique effectively increases the density of points input into the TIN model, and directs the TIN interpolation to better represent the reservoir topography.[4] In the case of Lake Mexia, 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-section 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 Mexia where a high probability of change between cross-sections exists.[4] Figure 6 illustrates typical results of the application of the Self-Similar Interpolation routine in Lake Mexia, and the bathymetry shown in Figure 6C was used in computing reservoir capacity and area tables (Appendix A, B).

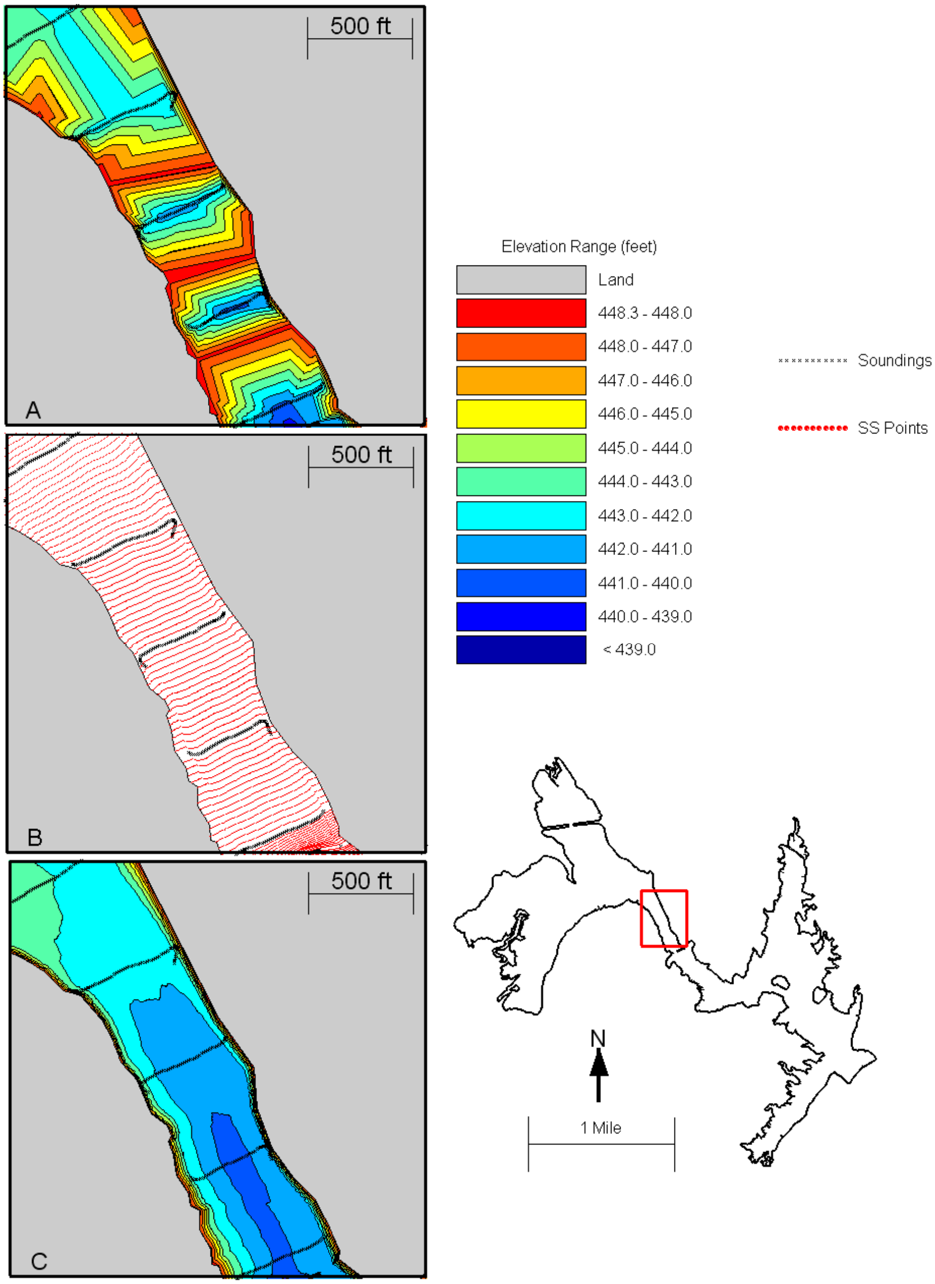

***Figure 6** - Application of the Self-Similar Interpolation technique to Lake Mexia sounding data – A) bathymetric contours without interpolated points, B) Sounding points (black) and interpolated points (red) with reservoir boundary shown at elevation 448.3 feet (black), C) bathymetric contours with the interpolated points. Note: In 6A the steep banks and deep channel indicated by the surveyed cross sections are not represented for the areas in-between the cross sections. This is an artifact of the TIN generation routine when data points are too far apart relative to the width of the lake. Inclusion of the interpolated points (6C) corrects this and smoothes the bathymetric contours.*

Survey Results

Volumetric Survey

The results of the TWDB 2008 Volumetric Survey indicate Lake Mexia has a total reservoir capacity of 4,687 acre-feet and encompasses 1,009 acres at conservation pool elevation (448.3 feet above mean sea level). Original estimates indicate Lake Mexia had a capacity of 10,000 acre-feet when impounded (1961). Results from a 1996 TWDB Volumetric Survey of Lake Mexia indicate Lake Mexia had a capacity of 4,806 acre-feet (Table 2). Due to differences in the methodologies used in calculating areas and capacities from this and previous Lake Mexia surveys, comparison of these values is not recommended.

TWDB acknowledges that the 1996 volume estimate was derived using similar survey methods as the 2008 survey. However, direct comparisons were not made because different data processing techniques were used and self-similar interpolation was not applied to the data used in computing the results reported in 1996. The TWDB considers the 2008 survey to be a significant improvement over previous methods and recommends that a similar methodology be used to resurvey Lake Mexia in approximately 10 years or after a major flood event.

Table 2. Area and Volume Comparisons of Lake Mexia

Feature	Bistone Municipal Water Supply District[1]	TWDB Volumetric Survey	TWDB Volumetric and Sedimentation Survey
Year	1961	1996	2008
Area (acres)	1,200	1,048	1,009
Capacity (acre-feet)	10,000	4,806	4,687

Sedimentation Survey

The 200 kHz, 50 kHz, and 24 kHz frequency data were used to interpret sediment distribution and accumulation throughout Lake Mexia. To assist in the interpretation of post-impoundment sediment accumulation, ancillary data was collected in the form of five core samples. Sediment cores were collected on November 12, 2008 using a Specialty Devices, Inc. VibraCore system. In the upper reaches of the lake where shallow conditions prevented the use of the multi-frequency depth sounder, TWDB extrapolated sediment thicknesses by assuming that cross-sections surveyed with the Knudsen echosounder would have sediment thickness profiles similar in shape to those of nearby cross-sections measured with the multi-frequency depth sounder.

The results of the TWDB 2008 Sedimentation Survey indicate Lake Mexia has accumulated approximately 1,021 acre-feet of sediment since impoundment in 1961. TWDB measured approximately 718 acre-feet of sediment with the multi-frequency depth sounder. Using data extrapolation techniques, TWDB estimates that 303 acre-feet of sediment are present within the upper reaches of the lake where the survey was performed with the single-frequency Knudsen echosounder. Figure 7 shows the measured distribution and thickness of sediment in the lake.

Based on this estimated sediment volume and assuming a constant rate of sediment accumulation, Lake Mexia loses approximately 22 acre-feet of capacity per year. The thickest measured sediment deposits are in the channel upstream of where Farm-To-Market Road 3437 crosses the lake. There is also above-average sediment accumulation near the dam. The maximum sediment thickness observed in Lake Mexia was 3.9 feet. The average sediment thickness (in areas where sediment was measured) is 0.7 feet.

A complete description of the sediment measurement methodology, data extrapolation methodology, and sample results is presented in Appendix D.

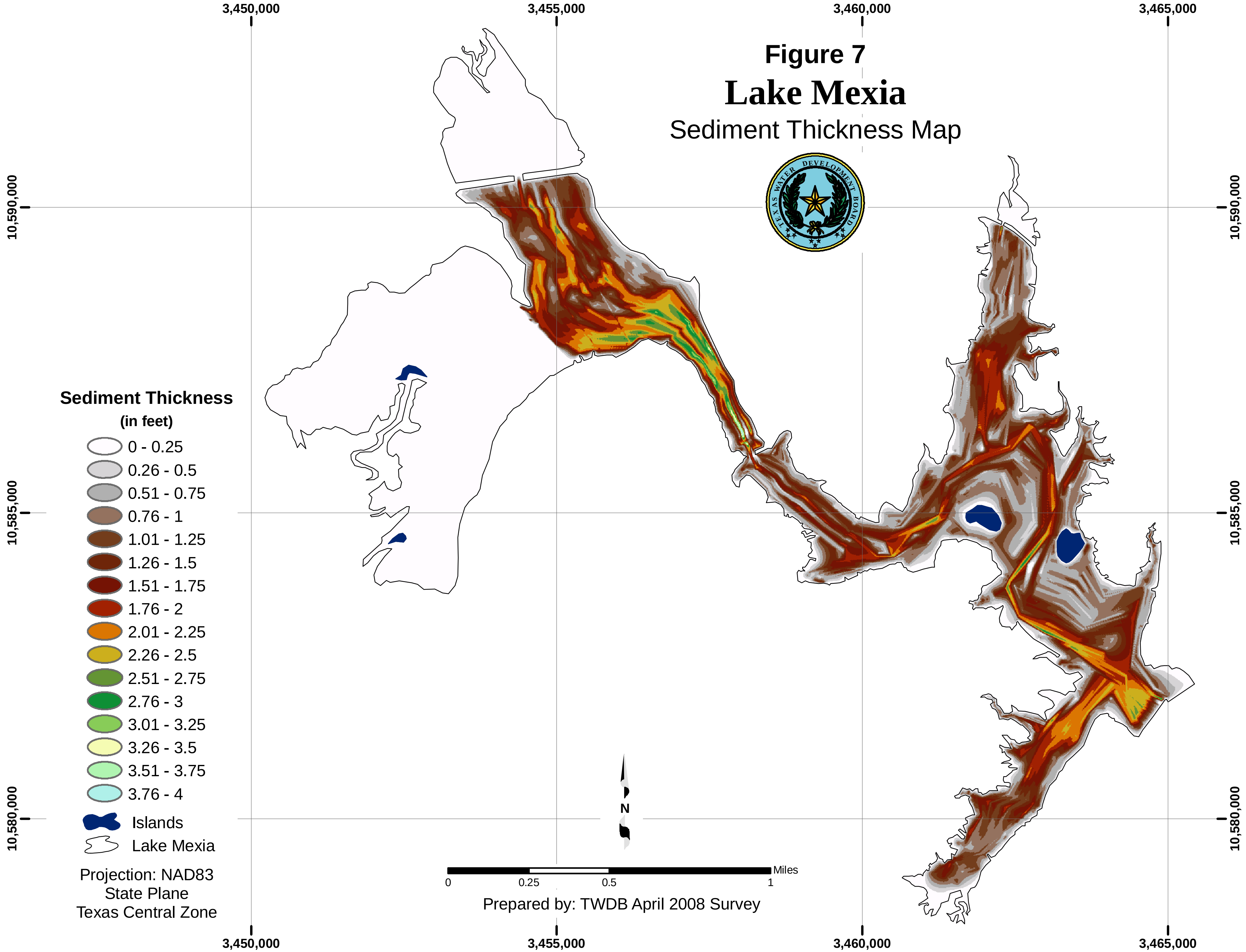

Figure 7
Lake Mexia
Sediment Thickness Map

Sediment Range Lines

Although the TWDB survey results from 2008 were not compared to the results of the 1996 survey, cross-sectional plots exhibiting the 2008 bathymetry, 1996 bathymetry, and pre-impoundment bathymetry (as determined from the 2008 survey data) are plotted in Appendix E for informational purposes. It is not clear from the Volumetric Survey Report of Lake Mexia, 1996 survey results, if these sediment range lines were established prior to impoundment or as sample cross-sections defined in 1996 by TWDB.

Cross-sections were extracted from ArcGIS TIN models of the lake bathymetry using standard GIS techniques[6]. Cross-sections of the approximate pre-impoundment (1961) bathymetry were derived by subtracting sediment-thickness values from the 2008 bathymetric elevations. TIN models from which the pre-impoundment (1961) and 2008 cross-sections were derived were adjusted using the Self-Similar Interpolation technique as described in the section titled “Self-Similar Interpolation.” **Note: the TIN model used in producing the 1996 cross-section data was not rectified using the Self-Similar Interpolation technique. Some of the discrepancies between the 1996 data and the 2008/ pre-impoundment data (as identified in the cross-sectional plots in Appendix E) are due to the lack of data interpolation in the 1996 data and TIN model.

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:

Barney Austin, Ph.D., P.E.
Director of the Surface Water Resources Division
Phone: (512) 463-8856
Email: Barney.Austin@twdb.state.tx.us

Or

Jason Kemp
Team Leader, TWDB Hydrographic Survey Program
Phone: (512) 463-2465
Email: Jason.Kemp@twdb.state.tx.us

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6. Furnans, J., Austin, B., Hydrographic survey methods for determining reservoir volume, Environmental Modelling & Software (2007), doi: 10.1016/j.envsoft.2007.05.011

Appendix A

Lake Mexia

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — APRIL 2008 SURVEY

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 448.3 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
430	0	0	0	0	0	0	0	0	0	0
431	0	0	0	0	0	0	0	0	0	0
432	0	0	0	0	0	0	0	0	0	0
433	0	0	0	0	0	0	0	0	0	0
434	0	0	1	1	1	1	1	1	1	1
435	1	1	1	1	1	1	2	2	2	2
436	3	3	4	4	5	6	7	9	10	12
437	14	17	20	23	26	30	34	39	44	49
438	54	60	67	74	82	90	98	108	117	128
439	139	150	162	174	187	201	215	229	245	261
440	277	294	311	329	348	366	386	406	427	449
441	471	493	517	540	564	589	614	639	665	692
442	719	746	775	803	833	863	893	924	955	988
443	1,020	1,054	1,088	1,123	1,158	1,195	1,232	1,270	1,310	1,351
444	1,393	1,438	1,483	1,530	1,577	1,625	1,675	1,727	1,781	1,838
445	1,897	1,959	2,023	2,090	2,159	2,231	2,306	2,382	2,461	2,541
446	2,622	2,704	2,787	2,870	2,954	3,038	3,123	3,209	3,296	3,383
447	3,471	3,560	3,649	3,740	3,831	3,922	4,015	4,108	4,202	4,297
448	4,393	4,490	4,588	4,687						

Appendix B

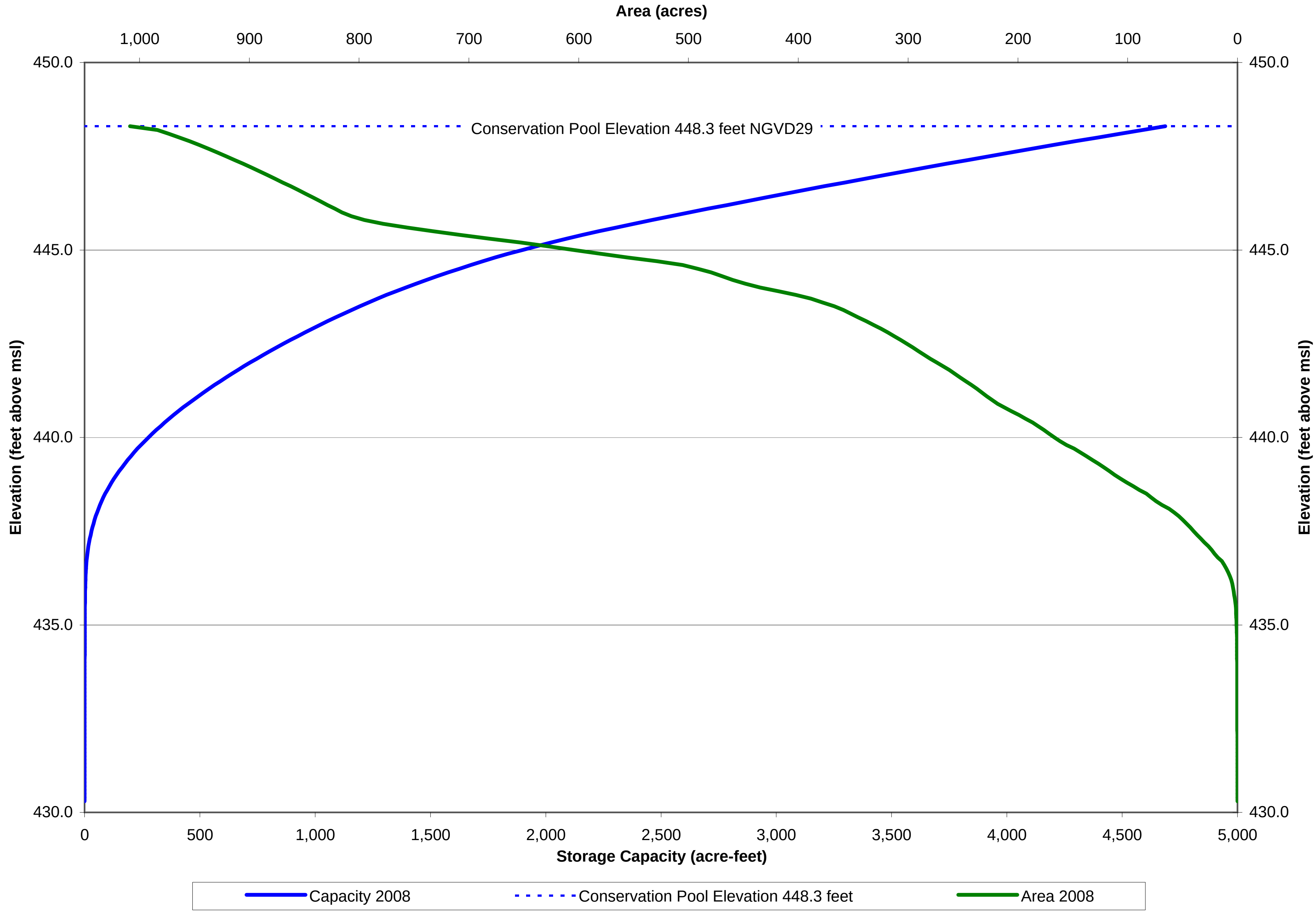
Lake Mexia

RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD
AREA IN ACRES
ELEVATION INCREMENT IS ONE TENTH FOOT

APRIL 2008 SURVEY
Conservation Pool Elevation 448.3 NGVD29

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
430	0	0	0	0	0	0	0	0	0	0
431	0	0	0	0	0	0	0	0	0	0
432	0	0	0	0	0	0	0	0	0	0
433	0	0	0	0	0	0	0	0	0	0
434	0	0	0	0	0	0	0	0	1	1
435	1	1	1	1	1	2	2	2	3	4
436	4	5	6	7	8	10	12	14	18	21
437	23	27	30	33	37	40	43	46	50	54
438	58	62	69	74	79	83	89	95	101	107
439	112	117	121	127	132	138	143	149	156	161
440	167	172	176	181	186	193	199	206	213	218
441	223	228	233	237	242	247	252	257	263	268
442	274	280	285	290	296	301	307	313	318	325
443	331	338	346	352	359	367	378	388	402	418
444	435	448	460	469	479	491	505	529	556	581
445	604	628	653	681	708	733	756	778	795	807
446	816	822	829	835	842	849	856	862	869	876
447	884	891	898	906	913	921	929	937	946	954
448	964	973	984	1,009						



Lake Mexia
April 2008 Survey
Prepared by: TWDB

Appendix C: Area and Capacity Curves

Appendix D

Analysis of Sediment Accumulation Data from Lake Mexia

Executive Summary

Based on data collected during the 2008 Sedimentation Survey, the Texas Water Development Board (TWDB) estimates Lake Mexia has accumulated approximately 1,021 acre-feet of sediment since impoundment in 1961. This estimate includes 718 acre-feet of sediment measured within the main body of the lake and an estimated 303 acre-feet of sediment within the upper reaches of the lake. Estimation of sediment accumulation in the upper reaches of the lake was necessary as water depths during the survey were too shallow to allow for accurate sediment thickness measurements. Based on this total estimated sediment volume and assuming a constant rate of sediment accumulation over the 47 years since impoundment, Lake Mexia loses approximately 22 acre-feet of capacity per year. Although sediment is deposited throughout the lake, the thickest sediment deposits measured are in the submerged river channel upstream of the Farm-To-Market Road 3437 crossing. There is also above average sediment accumulation in the channels and near the dam. The maximum sediment thickness observed in Lake Mexia was 3.9 feet.

Introduction

This appendix includes the results of the 2008 sedimentation survey of Lake Mexia conducted by the Texas Water Development Board (TWDB). TWDB conducted this survey using a multi-frequency depth sounder and sediment coring apparatus. Through careful analysis and interpretation of the multi-frequency signal returns, it is possible to discern the pre-impoundment bathymetric surface, as well as the current surface and sediment thickness. Such interpretations are aided and validated through comparisons with sediment core samples which provide independent measurements of sediment thickness. The remainder of this appendix presents a discussion of the results from and methodology used in the core sampling and multi-frequency data collection efforts, followed by a composite analysis of sediment measured in Lake Mexia.

Data Collection

TWDB collected data for the volumetric and sedimentation survey of Lake Mexia on April 9, 2008. For sedimentation survey collection efforts, TWDB used a Specialty Devices, Inc. (SDI), multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder integrated with Differential Global Positioning System (DGPS) equipment. Due to shallow water conditions in the upper reaches of the lake, TWDB was unable to complete the lake survey using the multi-frequency depth sounder, which requires sufficient water depths for accurate readings. In order to survey the upper reaches, TWDB returned to Lake Mexia on May 5, 2008 with a shallow draft boat and a Knudsen Engineering Ltd. single-frequency (200 kHz) depth sounder integrated with DGPS equipment. Sediment accumulation estimates are not discernible from the single frequency data, therefore, TWDB estimated sediment thicknesses in the upper reaches of Lake Mexia. The estimation methodology is described in the section titled "Sediment Thickness Estimation."

All data collection occurred while navigating along pre-planned range lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 500 feet apart. For all data collection efforts, 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. During the 2008 survey, team members collected over 23,250 data points over cross-sections totaling nearly 33 miles in length. Figure D1 shows where data points were collected during the TWDB 2008 Lake Mexia survey, as well as the areas in which sediment thickness estimates were made.

Core samples collected by TWDB were collected at locations where sounding data had been previously collected (Figure D1). All cores were collected with a custom-coring boat and SDI VibraCore system. Cores were analyzed by TWDB, and both the sediment thickness and the distance the core penetrated the pre-impoundment boundary were recorded. The coordinates and a description of each core sample are provided in Table D1. Figure D2 shows the cross-section of sediment core M2. At this location, TWDB collected 22 inches of sediment, with the upper sediment layer (Figure D2) having high water content, consisting of silty loam material and having no organic matter. The pre-impoundment boundary was evident from this core at a distance of 6 inches above the core base; above this location, the moisture content in the sediment greatly increases (Figure D2).

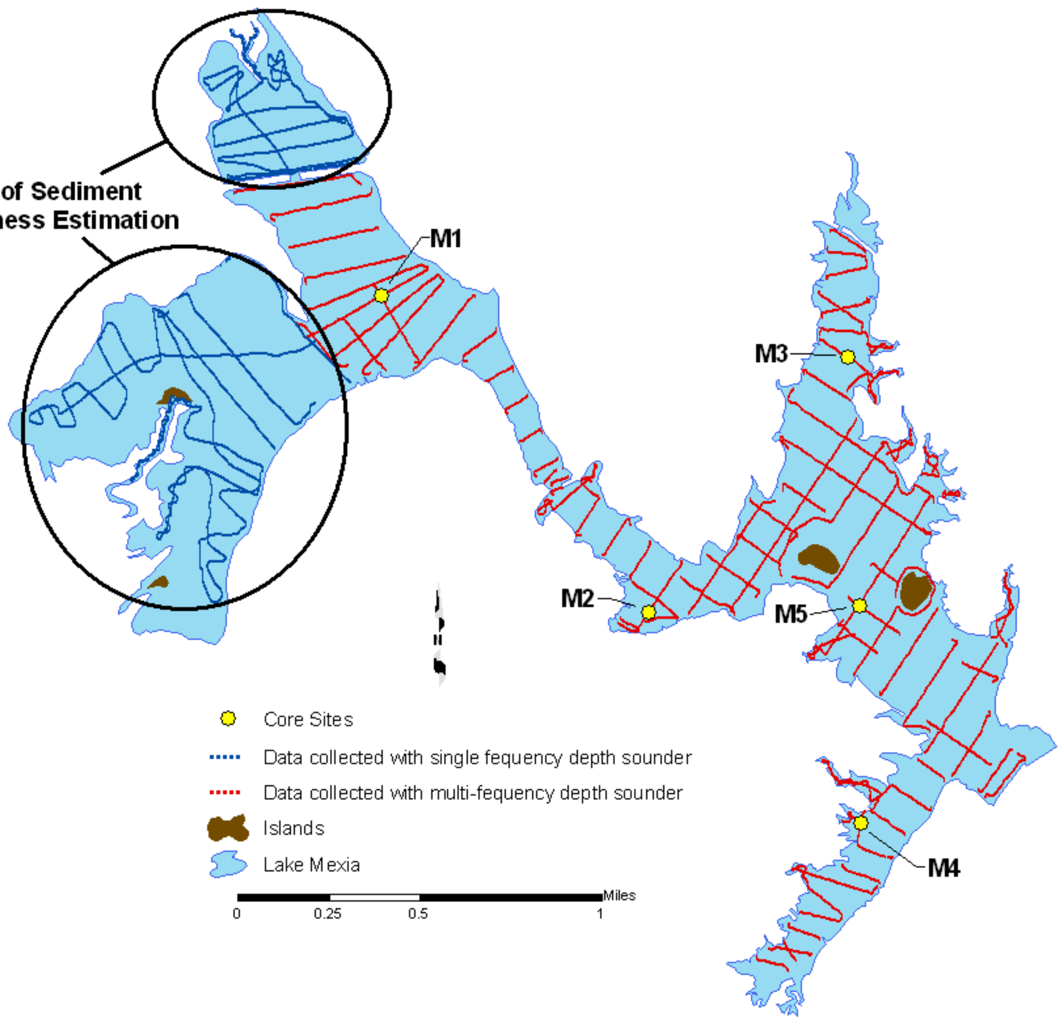


Figure D1 *– TWDB 2008 survey data points and core sites for Lake Mexia.*

Table D1 – Core Sampling Analysis Data – Lake Mexia

Core	Easting** (ft)	Northing** (ft)	Description
M1	3455636.232	10588736.436	34" of clay/loam sediment with no plant material visible.
M2	3459534.245	10584134.136	22" of silty loam sediment with no plant material visible.
M3	3462418.560	10587859.442	21" of silty loam sediment with no plant material visible
M4	3462603.757	10581066.176	25" of silty loam sediment with no plant material visible
M5	3462587.648	10584240.275	21" of silty loam sediment with no plant material visible.

** Coordinates are based on NAD 1983 State Plane Texas Central system

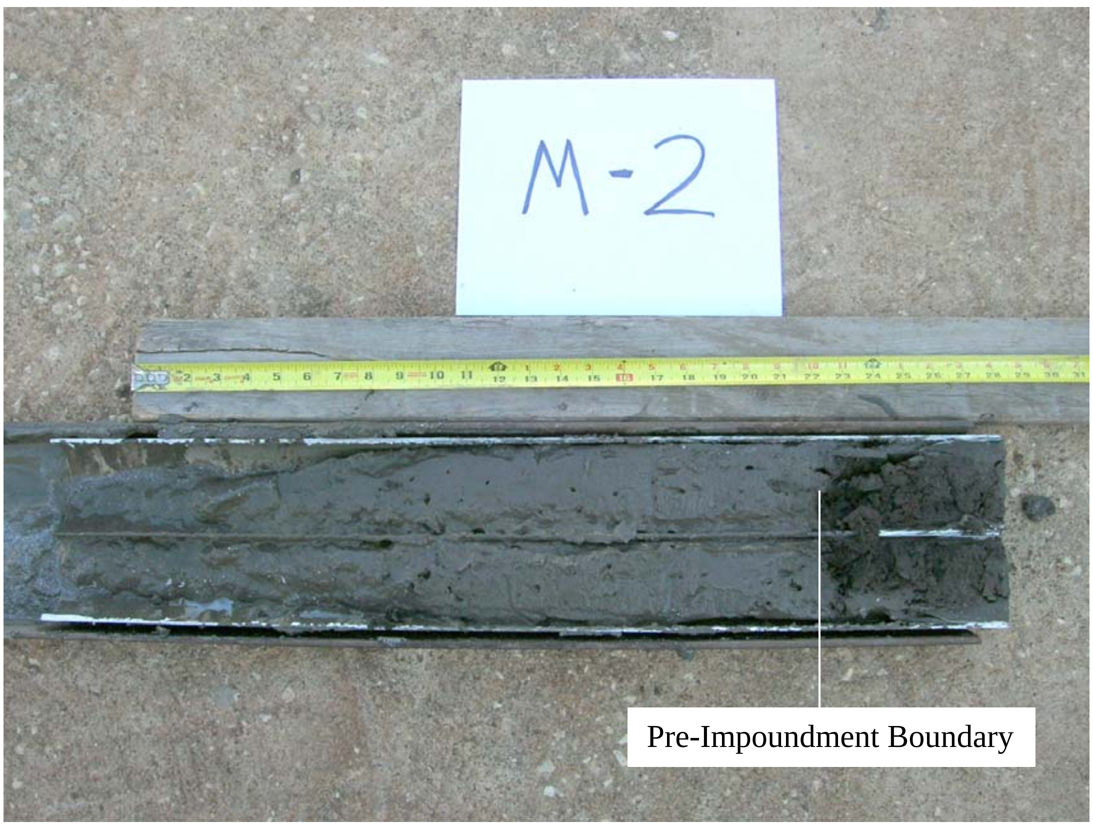


Figure D2 *– Sediment Core M2 from Lake Mexia, showing the pre-impoundment boundary 6 inches above the base of the core (right). The pre-impoundment boundary is marked by the change in sediment moisture content below and above the area 6 inches up from the core base.*

Data Processing

All sounding data is processed using the DepthPic software, within which both the pre-impoundment and current bathymetric surfaces are identified and digitized manually. These surfaces are first identified along cross-sections for which core samples have been collected – thereby allowing the user to identify color bands in the DepthPic display that correspond to the sediment layer(s) observed in the core samples. This process is illustrated in Figure D3 where core sample M2 is shown with its corresponding sounding data. Core sample M2 contained 22 inches of sediment above the pre-impoundment boundary, as indicated by the yellow box in Figure D3. The top of the green box represents the pre-impoundment boundary identified in the core sample in Figure D2. The pre-impoundment surface is usually identified within the core sample by one of the following methods: (1) a visual examination of the core for in-place terrestrial materials, such as leaf litter, tree bark, twigs, intact roots, etc., concentrations of which tend to occur on or just below the pre-impoundment surface, (2) changes in texture from well sorted, relatively fine-grained sediment to poorly sorted mixtures of coarse and fine-grained materials, and (3) variations in the physical properties of the sediment, particularly sediment water content and penetration resistance with depth.

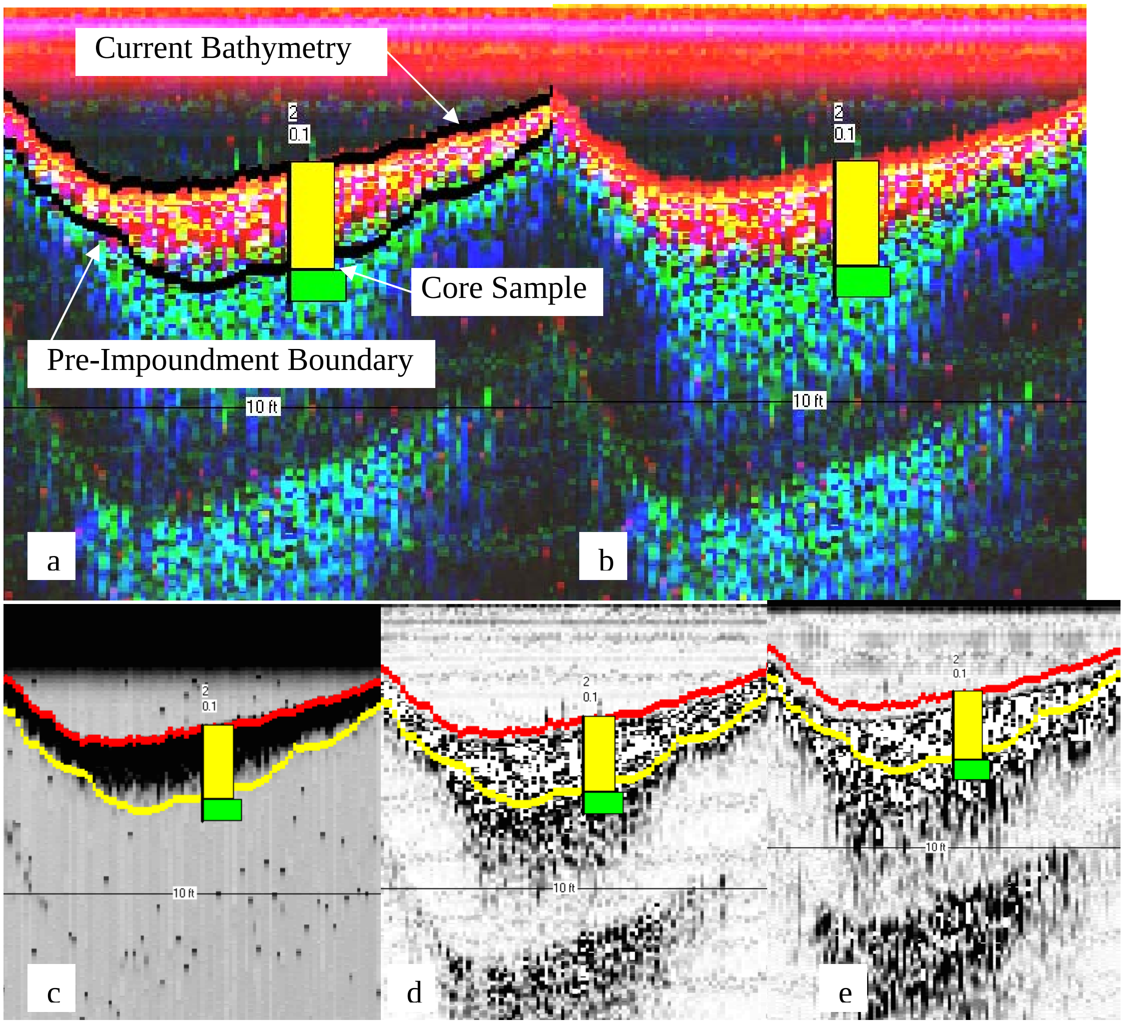


Figure D3 *– Correlation of Core M2 and co-located acoustic records as viewed in DepthPic. (a) Composite display of 200, 50, and 24 kHz signals showing current bathymetric surface, pre-impoundment surface, and core sample. (b) Composite of three frequencies and core sample without bathymetric surfaces (c) 200 kHz frequency only with bathymetric surfaces and core sample (d) 50 kHz frequency (e) 24 kHz frequency. The post-impoundment sediment measured in Core M2 correlated well with the 50 kHz signal return.*

Within DepthPic, the current surface is automatically determined based on the signal returns from the 200 kHz transducer and is readily identified as the top of the upper-most layer of red-yellow pixels (Figure D3). The pre-impoundment surface must be determined visually based on the pixel color display and any available core sample data. Based on core sample M2, it is clear that the upper bound on the sediment layer is denoted by the layer of red and yellow pixels. The pre-impoundment bathymetric surface for this cross-section is identified by the thin blue layer of pixels below the red and yellow pixels and above the turquoise pixels in the DepthPic display (Figure D3).

In analyzing data from cross-sections where core samples were not collected, the assumption is made that sediment layers may be identified in a similar manner as when core sample data is available. To improve the validity of this assumption, core samples are collected at regularly spaced intervals within the lake, or at locations where interpretation of the DepthPic display would be difficult without site-specific core data. For this reason, all sounding data is collected and reviewed before core sites are selected and cores are collected. Delineation of the pre-impoundment surface is conducted after review and verification of the core samples.

Sediment Thickness Estimation

As shown in Figure D1, two areas of Lake Mexia were surveyed using the Knudsen Engineering, Ltd. single-frequency depth sounder. For descriptive purposes herein, these areas will be denoted as the “upper reaches” of Lake Mexia. Sediment thickness values are not discernible from the single-frequency signal returns, therefore sediment thicknesses were not measured the upper reaches. To estimate sediment thickness values in these areas, TWDB assumed that cross-sections surveyed with the Knudsen echosounder would have sediment thickness profiles similar in shape to those of nearby cross-sections measured with the multi-frequency depth sounder. TWDB used the nearby multi-frequency derived sediment thickness profile as a data-extrapolation template, or base cross-section, and applied the base sediment thickness values to the Knusden surveyed cross-sections on a normalized-distance basis. By this scheme, sediment thicknesses measured along the base cross-section were applied to equal locations along the extrapolated cross sections. For example, if the measured sediment thickness at the point 50 percent along the width of the base cross section was 1.0 feet, then the sediment thickness at the point 50 percent along the width of the Knudsen-surveyed cross section would also be 1.0 feet. TWDB did not correct for variations in water depth between the base and Knudsen cross-sections.

Sediment Thickness TIN Model

After manually digitizing the pre-impoundment surface from all cross-sections surveyed with the multi-frequency depth sounder and extrapolating the pre-impoundment surface within the upper reaches, both the pre-impoundment and current bathymetric surfaces are exported as X-,Y-,Z- coordinates into text files suitable for use in ArcGIS. Within ArcGIS, the sounding points are then processed into TIN models following standard GIS techniques[2]. The accumulated sediment volume for Lake Mexia was calculated from a sediment thickness TIN model created in ArcGIS. Sediment thicknesses were computed as the difference in elevations between the current and pre-impoundment bathymetric surfaces. For the purposes of the TIN model creation, TWDB assumed 0-feet sediment thicknesses at the model boundaries (defined as the 448.3 foot NGVD29 elevation contour). TWDB created two separate TIN models to describe the sediment thickness in Lake Mexia: 1) TIN including only the sediment thicknesses measured from the multi-frequency sounding data (Figure D4), and 2) TIN including both the measured and estimated sediment thickness data (Figure D5). Sediment thicknesses in both TIN models were interpolated between surveyed cross-sections using the TWDB Self-Similar Interpolation technique[1].

Results

The results of the TWDB 2008 Sedimentation Survey indicate Lake Mexia has accumulated approximately 1,021 acre-feet of sediment since impoundment in 1961. This estimate includes approximately 718 acre-feet of sediment measured with the multi-frequency depth sounder, plus 303 acre-feet of sediment estimated to be in the upper reaches. Although sediment is deposited throughout the lake, the thickest sediment deposits measured are in the channel upstream of the Farm-To-Market Road 3437 crossing. There is also above-average sediment accumulation in the channels and near the dam. The maximum sediment thickness observed in Lake Mexia was 3.9 feet. Figures D4 and D5 depict the sediment thickness in Lake Mexia without and with inclusion of the extrapolated sediment thickness values, respectively.

Based on the estimated sediment volume in Lake Mexia and assuming a constant rate of sediment accumulation over the 47 years since impoundment, Lake Mexia loses approximately 22 acre-feet of capacity per year. To improve the sediment accumulation rate estimates, TWDB recommends Lake Mexia be re-surveyed using similar methods in approximately 10 years or after a major flood event. Sediment accumulation estimates would be further improved if the lake were re-surveyed when the water level is significantly above conservation pool elevation. This would allow for surveying of a greater percentage of the lake area with the multi-frequency depth sounder and would eliminate the need for extrapolation of sediment thickness data.

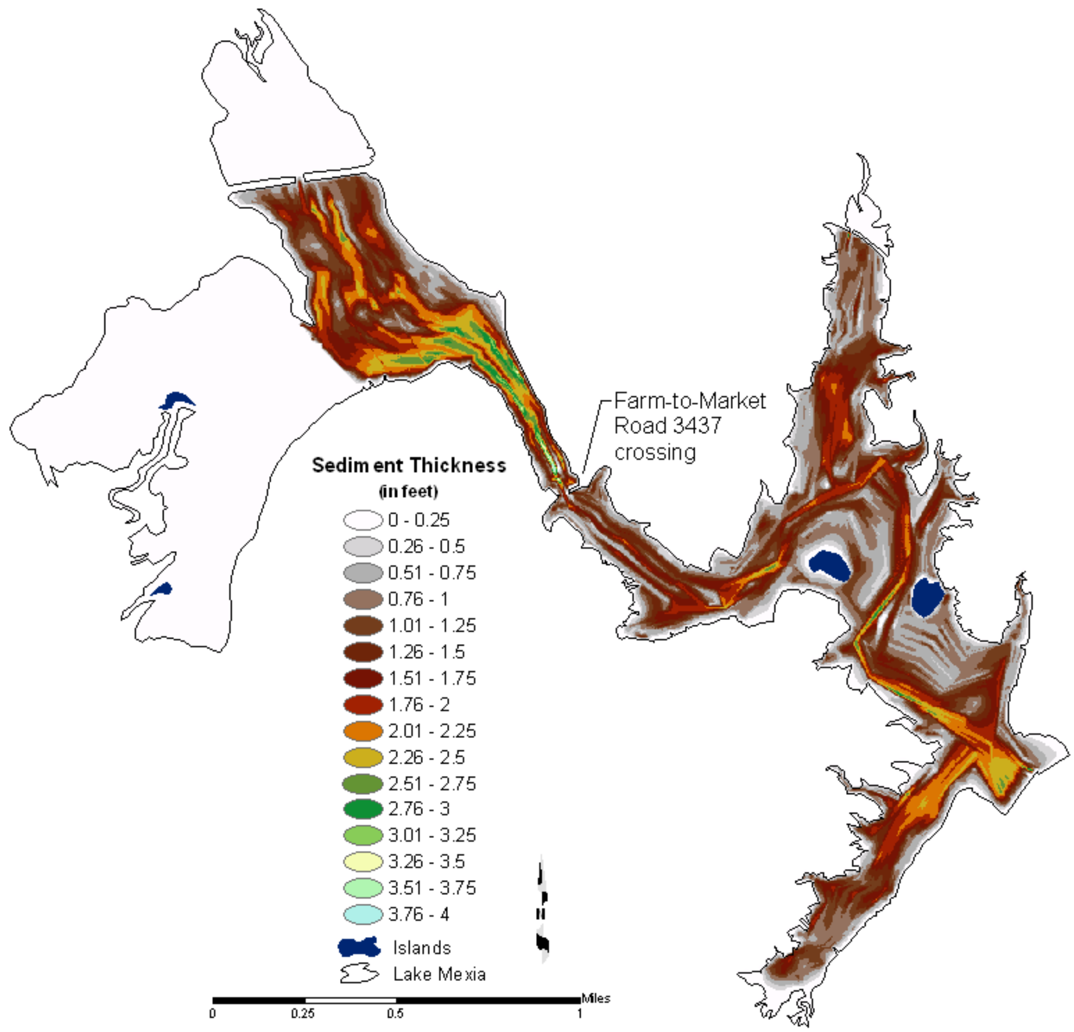


***Figure D4** - Sediment thicknesses in Lake Mexia derived from multi-frequency sounding data.*

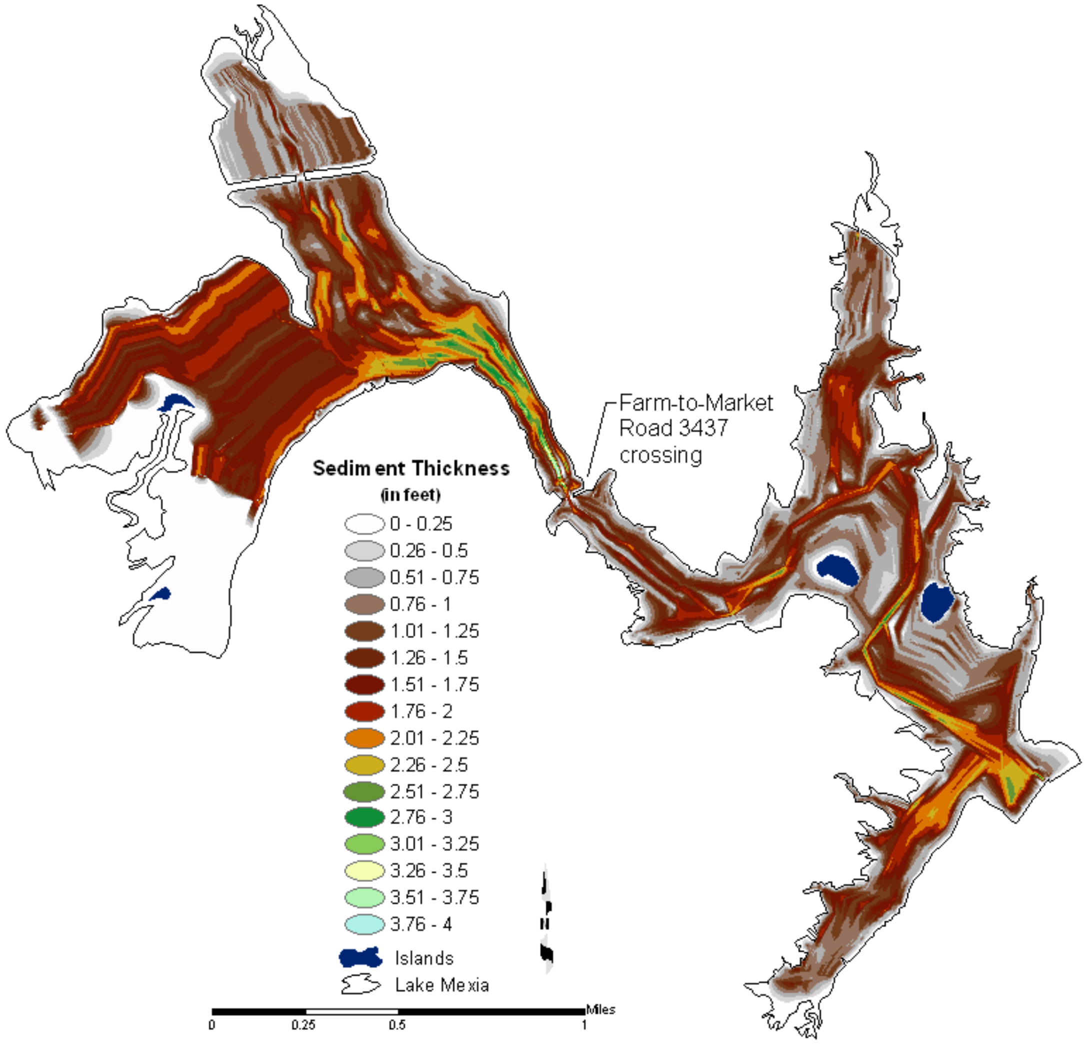


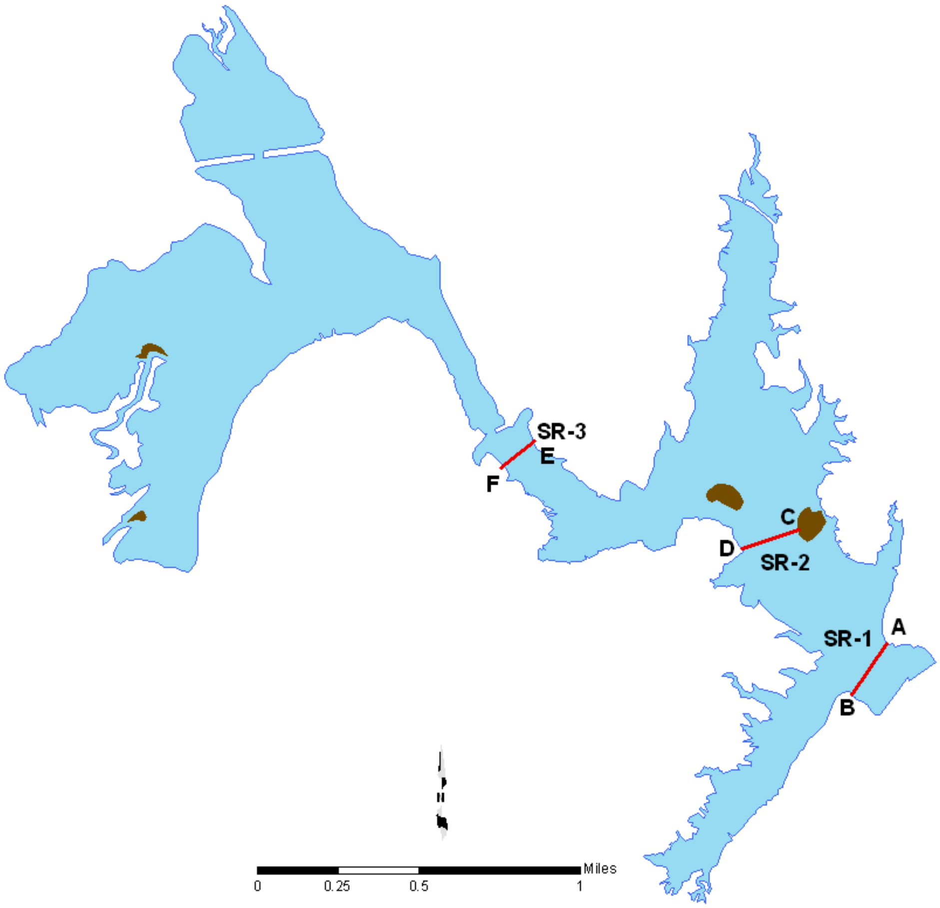
Figure D5 *- Sediment thicknesses in Lake Mexia derived from multi-frequency sounding data and data extrapolation into the upper reaches of the lake.*

References

1. Furnans, J., Austin, B., Hydrographic survey methods for determining reservoir volume, Environmental Modelling & Software (2007), doi: 10.1016/j.envsoft.2007.05.011
2. Furnans, Jordan. Texas Water Development Board. 2006. "HydroEdit User's Manual."

Appendix E

Sediment Range Lines: Lake Mexia

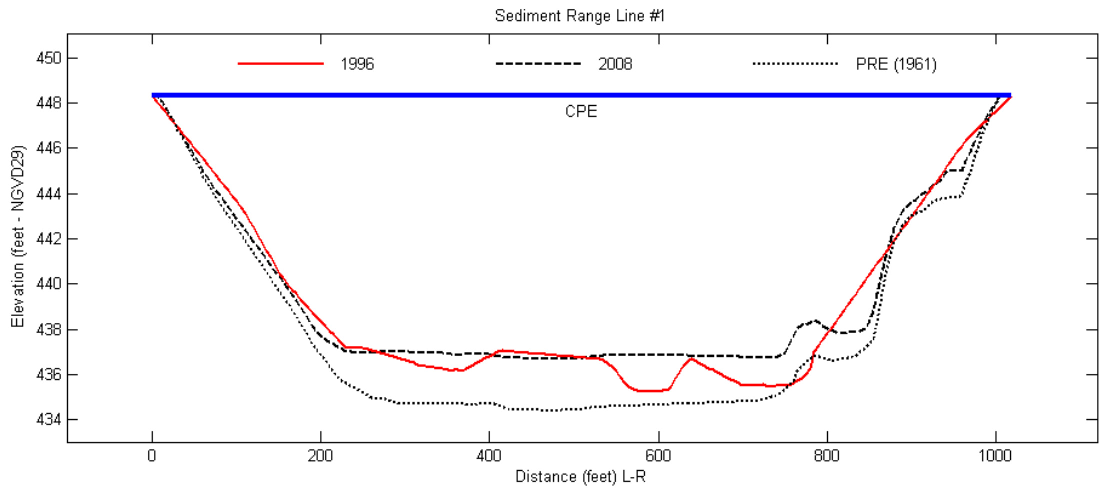


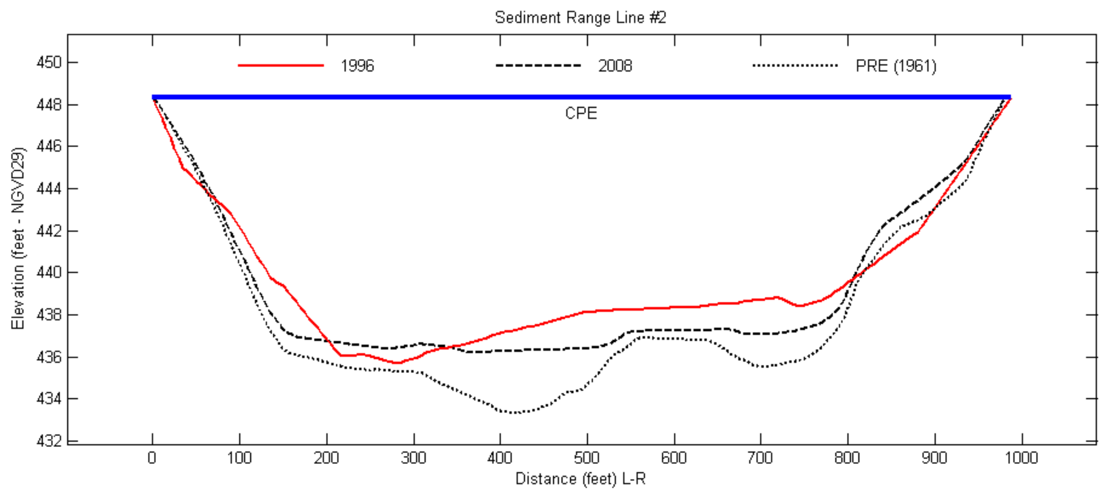
Sediment Range Line Coordinates for Lake Mexia

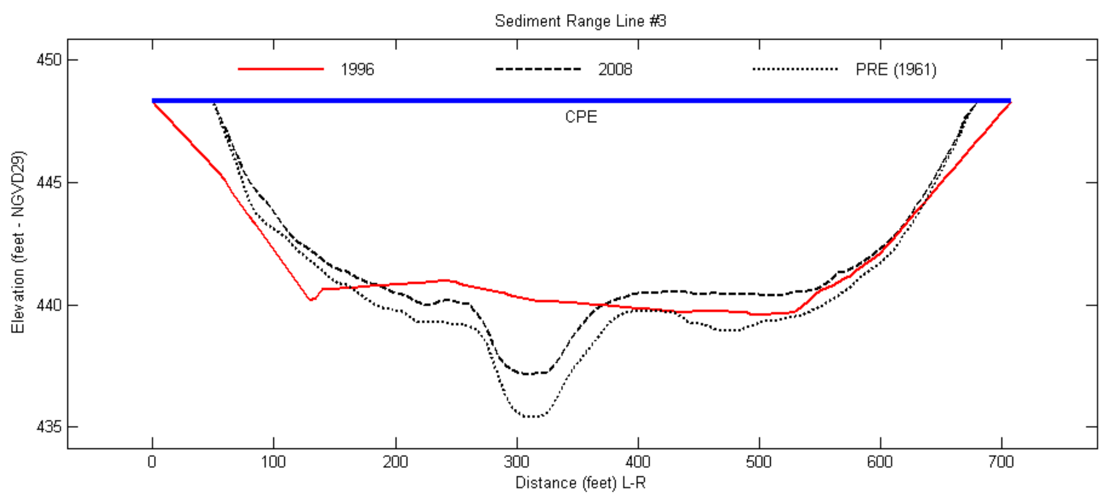
	Start Point (feet)		End Point (feet)		
Range Line	Northing	Easting	Northing	Easting	Labels^^
SR-1	10581681.90	3464056.90	10582515.10	3464642.86	(A,B)
SR-2	10584063.93	3462258.14	10584363.74	3463199.11	(C,D)
SR-3	10585379.53	3458335.65	10585820.90	3458888.88	(E,F)

*** Coordinates referenced to the State Plane (NAD83-Feet) Texas Central System*

^^ *Labels are referenced to map above and are listed as (start point, end point)*







**Note: the TIN model used in producing the 1996 cross-section data was not rectified using the Self-Similar Interpolation technique. Some of the discrepancies between the 1996 data and the 2008/ pre-impoundment data (as identified in the cross-sectional plots in Appendix E) are due to the lack of data interpolation in the 1996 data and TIN model.

Figure 5

CONTOURS
(in feet above mean sea level)

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Islands
Lake Mexia

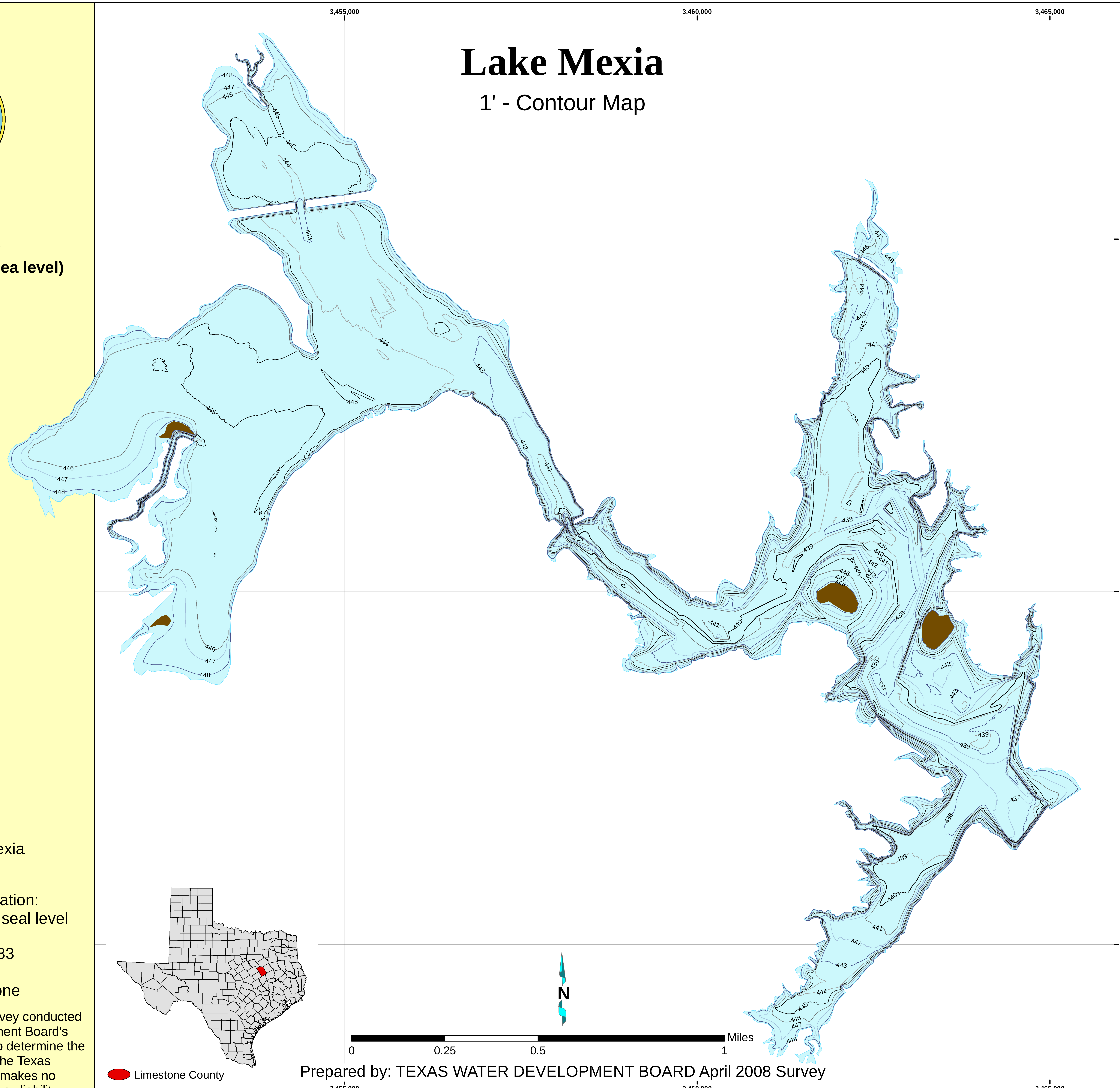
Conservation Pool Elevation:
448.3 feet above mean seal level

Projection: NAD83
State Plane
Texas Central Zone

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 Mexia. The Texas Water Development Board makes no representation or assumes any liability.

Lake Mexia

1' - Contour Map



Prepared by: TEXAS WATER DEVELOPMENT BOARD April 2008 Survey