Volumetric and Sedimentation Survey of Lake Lyndon B. Johnson

May 2007 Survey

Prepared by:

The Texas Water Development Board

April 2009

Texas Water Development Board

J. Kevin Ward, Executive Administrator

Prepared for:

Lower Colorado River Authority

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Executive Summary

In March of 2007, the Texas Water Development Board (TWDB) entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, for the purpose of conducting an in-depth assessment of TWDB surveying techniques. As part of this project, TWDB performed a volumetric and sedimentation survey of Lake Lyndon Baines Johnson (LBJ) 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 LBJ volumetric and sedimentation survey. A separate report describes the results of the larger project assessing various hydrographic survey techniques utilizing the LBJ survey data.

Lake LBJ, located on the Colorado River, is a part of the Lower Colorado River Authority's Highland Lakes System. Lake LBJ is considered full at elevation 825.68 feet (NAVD 88). TWDB conducted the initial Lake LBJ survey on May 4th, 7th-10th, and 14th-16th of 2007 with additional data collected on August 3rd and October 9th of 2007. During the survey, Lake LBJ water surface elevations ranged between 825.25 and 825.53 feet (NAVD 88). Reservoir capacities were computed based on a combination of the TWDB survey data, TWDB interpolated data, and TWDB extrapolated data.

The results of the TWDB 2007 Volumetric Survey indicate Lake LBJ has a total reservoir capacity of 133,090 acre-feet and encompasses 6,273 acres at conservation pool elevation (825.68 feet NAVD 88). Due to differences in the methodologies used in calculating areas and capacities from this 2007 survey and previous Lake LBJ surveys, comparison of these values is not recommended. The TWDB considers the 2007 survey to be a significant improvement over previous surveys and recommends that a similar methodology be used to resurvey Lake LBJ in approximately 10 years or after a major flood event.

The results of the TWDB 2007 Sedimentation Survey indicate Lake LBJ has accumulated 5,654 acre-feet of sediment since impoundment began in 1951. Based on this measured sediment volume and assuming a constant sediment accumulation rate, Lake LBJ loses approximately 100 acre-feet of capacity per year. The thickest sediment deposits are in the submerged river channel throughout the main lake body. The maximum sediment thickness observed in Lake LBJ was 7.1 feet.

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Lake LBJ General Information

With recurring drought and devastating flooding, early-day residents of Central Texas recognized the value of building dams on the Colorado River. Through the passage of the LCRA Act by the Texas Legislature in 1934, the Lower Colorado River Authority (LCRA) was established as a “conservation and reclamation district” responsible for harnessing the Colorado River and its tributaries and making them productive for the people within its water service area. By 1951, the Lower Colorado River Authority had completed six dams on the Colorado River. The string of lakes is known as the Highland Lakes, and includes (from upstream to downstream) Lake Buchanan, Inks Lake, Lake Lyndon Baines Johnson (LBJ), Lake Marble Falls, Lake Travis, and Lake Austin. All these lakes are owned and operated by the LCRA with the exception of Lake Austin, which is owned by the City of Austin but operated by the Lower Colorado River Authority.[1] The Lower Colorado River Authority’s service area originally consisted of the ten counties that comprise the watershed of the lower Colorado River: Blanco, Burnet, Fayette, Colorado, Llano, Travis, Bastrop, Wharton, San Saba, and Matagorda. Several amendments to the LCRA Act expanded the service area to its current extent (Figure 1).

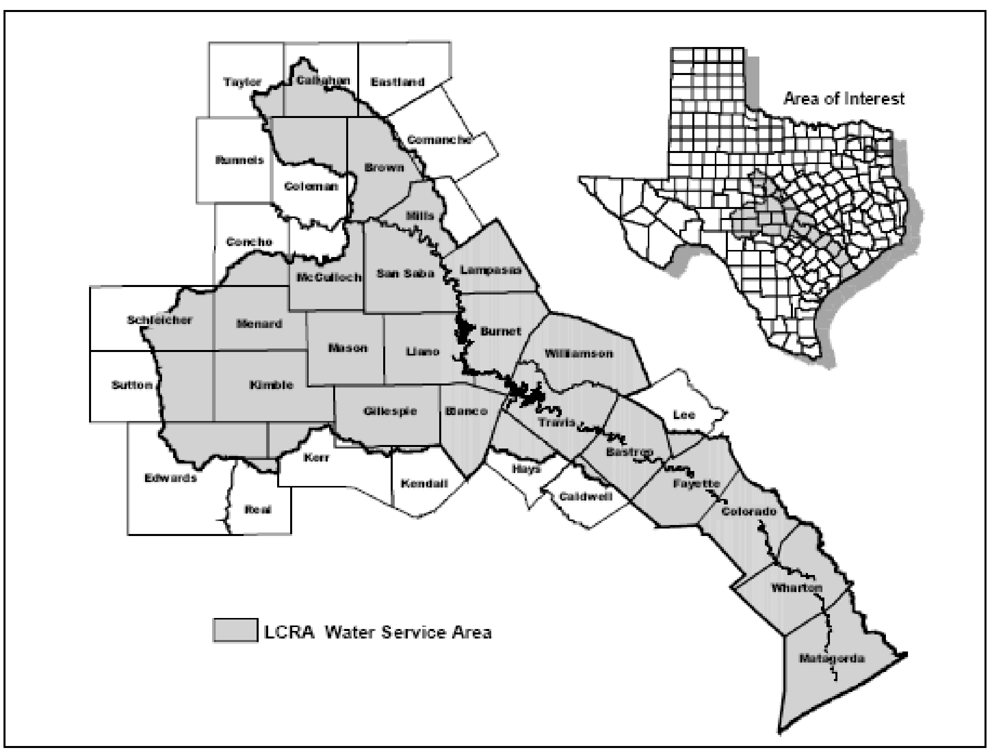

Figure 1. *Lower Colorado River Authority Water Service Areas as of January 1, 2003.*
Source: Lower Colorado River Authority Water Management Plan 2003[2].

The Lower Colorado River Authority operates the Highland Lakes as a system. Lakes Buchanan and Travis are water storage reservoirs, while Inks Lake, Lake LBJ, Lake Marble Falls, and Lake Austin are pass-through reservoirs. Lake Travis is the only lake in the system truly designed for flood control purposes. The Lower Colorado River Authority maintains a Water Management Plan as a blueprint for how it will operate the Highland Lakes System. Water availability is based on the Combined Firm Yield of Lakes Buchanan and Travis. The Combined Firm Yield is the annual dependable water supply that can be obtained from Lakes Buchanan and Travis during a repetition of the drought of record. Any water available for use in excess of the combined firm yield is considered interruptible water and is sold annually subject to availability. Availability of interruptible water is projected by the Lower Colorado River Authority each November. The projected supply depends on the amount of expected combined water storage in Lakes Buchanan and Travis on January 1, anticipated inflows for the subsequent months through the irrigation season, and the current demands for firm water.[2] The majority of interruptible water is sold for use in irrigation in the lower Colorado River basin.

The Water Management Plan and a system-operation approach to their water rights and reservoirs allows the Lower Colorado River Authority to optimize and conserve available water to meet existing and future water needs while being a steward of the water and land of the lower Colorado River Basin.[3] The complete Lower Colorado River Authority Water Management Plan is available through the Lower Colorado River Authority website at http://www.lcra.org/water/wmp.html.

Alvin Wirtz Dam and Lake Lyndon Baines Johnson (LBJ) are located on the Colorado River in Llano and Burnet Counties, five miles west of Marble Falls, Texas[4] (Figure 2). Originally named Granite Shoals Dam and Granite Shoals Lake, dam construction began in September of 1949, in tandem with Starke Dam and Lake Marble Falls downstream. The dam was completed in November of 1951, with deliberate impoundment beginning in May of 1951. Power generation commenced on June 27, 1951.[4] In 1952, the dam was renamed for Alvin J. Wirtz who was instrumental in the creation of the Lower Colorado River Authority and served as its first general counsel. In 1965, the lake was renamed in honor of Lyndon Baines Johnson, the 36th president of the United States and area resident.[5] Although the lake's primary purpose is hydroelectric power, the lake also provides cooling water for the Lower Colorado River Authority's

Thomas C. Ferguson Power Plant along Horseshoe Bay. The Thomas C. Ferguson Power Plant is a single-unit gas fired plant built in 1974 and can generate up to 420 megawatts of electricity during times of peak energy demand.[6] While Lake LBJ is considered full at elevation 825.68 feet (NAVD 88), its normal operating range is 825.08 feet to 825.68 feet (NAVD 88).[5] Additional pertinent data about Wirtz Dam and Lake LBJ can be found in Table 1.[4,5]

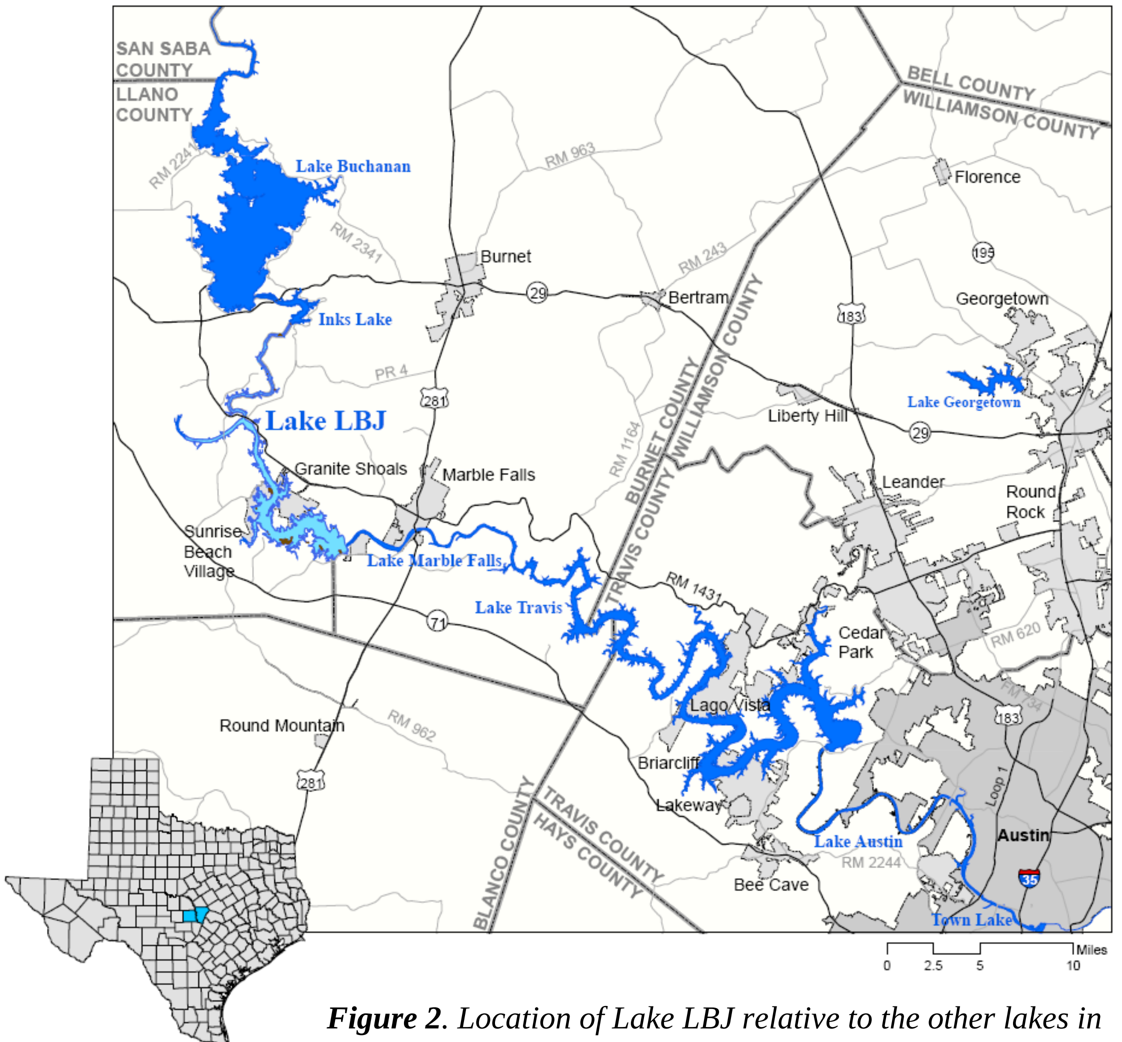

Figure 2. Location of Lake LBJ relative to the other lakes in the Highland Lakes System

Table 1: Pertinent Data for Wirtz Dam and Lake LBJ[4,5]

Owner: Lower Colorado River Authority
Engineer: (Design): Fargo Engineering Company
Location: On the Colorado River in Burnet County, 5 miles west of Marble Falls, Texas, 387 river miles from the Gulf of Mexico. Lake shoreline is in Burnet and Llano Counties.
Drainage Area: 36,290 square miles, of which 11,900 square miles is probably noncontributing. River flow is regulated by upstream storage and plant operation.

Dam:

Type	Concrete and earthfill
Length	5,491.4 feet
Height	118.3 feet
Top Width	12 feet
Top Width of earth section	26 feet
Base Width	80 feet

Spillway:

Type	Concrete ogee
Length (net)	450 feet
Crest Elevation	796.68 feet**
Control	10 floodgates (9 tainter gates, each 50 by 30 feet)

Outlet Works: None. Water is released through the turbine operation.
Power Features: Two generating units, 56 megawatts total capacity
Reservoir Data (Based on TWDB 2007 Survey)

Feature	**Elevation** (feet)**	**Capacity (Acre-feet)**	**Area (Acres)**
Top of Dam	838.68	237,903	9,911
Normal Operating Level	825.68	133,090	6,273
Invert to penstock elevation	793.68	19,767	1,471

*** Elevations converted to NAVD88 datum*

Water Rights

The water rights for Lake LBJ have been appropriated to the Lower Colorado River Authority through Certificate of Adjudication No. 14-5480. A brief summary of the certificate follows. The complete certificate is on file in the Records Division of the Texas Commission on Environmental Quality.

Certificate of Adjudication No. 14-5480 Issued: June 28, 1989

Authorizes the Lower Colorado River Authority to maintain an existing dam and reservoir (Wirtz Dam and Lake LBJ) and impound therein a maximum of 138,500 acre feet of water. The Lower Colorado River Authority is authorized to divert, circulate and re-circulate water from Lake LBJ for industrial (power plant cooling) purposes at its Thomas C. Ferguson Power Plant, and to consumptively use up to 15,700 acre-feet of water per year in forced evaporation. The Lower Colorado River Authority is also authorized to use Lake LBJ for recreation and may divert and use water through Wirtz

Dam for hydroelectric power generation, subject to certain conditions. The priority date for impounding water, recreation, and hydroelectric power generation is March 29, 1926. The priority date for diversion and use of water for cooling purposes is August 24, 1970.

Volumetric and Sedimentation Survey of Lake LBJ

The Texas Water Development Board's (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 March of 2007, the Texas Water Development Board (TWDB) entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, for the purpose of conducting an in-depth assessment of TWDB surveying techniques. As part of this assessment project, TWDB performed a volumetric and sedimentation survey of Lake Lyndon Baines Johnson (LBJ) 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 LBJ volumetric and sedimentation survey. A separate report describes the results of the larger project assessing various hydrographic survey techniques utilizing the LBJ survey data.

Datum

The vertical datum used during this survey is North American Vertical Datum 1988 (NAVD 88), as requested by the LCRA. Water surface elevations cited in this report were obtained from the United States Geological Survey (USGS) for the reservoir elevation gage TX071 08152500, named "LCRA Lk LBJ nr Marble Falls, TX[7]" located at Wirtz Dam. The datum for this gage is reported as 795 feet above mean sea level per the National Geodetic Vertical Datum 1929 (NGVD 29)[7], which is 0.68 feet below the NAVD 88 datum as determined by LCRA.[8] **Water surface elevations reported here were derived by adding 0.68 feet to the elevations recorded at the USGS gage TX071 08152500.** This datum conversion is only valid for water levels recorded at Wirtz Dam. The horizontal datum used for this report is the North American Datum of 1983 (NAD83), and the horizontal coordinate system is State Plane Texas Central Zone (feet).

TWDB Bathymetric Data Collection

TWDB conducted the initial Lake LBJ survey on May 4th, 7th-10th, and 14th-16th of 2007 with additional data collected on August 3rd and October 9th of 2007. During the survey, Lake LBJ water surface elevations ranged between 825.25 and 825.53 feet (NAVD 88). For 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. 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. 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 2007 survey, team members collected approximately 149,000 data points over cross-sections totaling nearly 146 miles in length. Figure 3 shows where data points were collected during the TWDB 2007 survey.

Data Processing

Model Boundaries

The reservoir boundary was digitized from aerial photographs, also known as digital orthophoto quarter-quadrangle images (DOQQs)[9,10], using Environmental Systems Research Institute’s (ESRI) ArcGIS 9.1 software. The quarter-quadrangles that cover Lake LBJ are Kingsland NW, NE, SW, and SE, Dunman Mountain NW, NE, SW, and SE, and Marble Falls NW and SW. These images were photographed on December 7, 2004 during which time the water surface elevation at Lake LBJ measured 825.45 feet (NAVD 88). Although the water surface elevation measured slightly below conservation pool elevation at the time of the photos, TWDB determined that there was not a significant difference in lake area between 825.45 feet and 825.68 feet, as discernable from the photographs and given the photographs have a 1-meter resolution. Therefore, the boundary was digitized from the land water interface in the photos and labeled 825.68 feet to allow area and volume to be calculated to the top of conservation pool elevation.

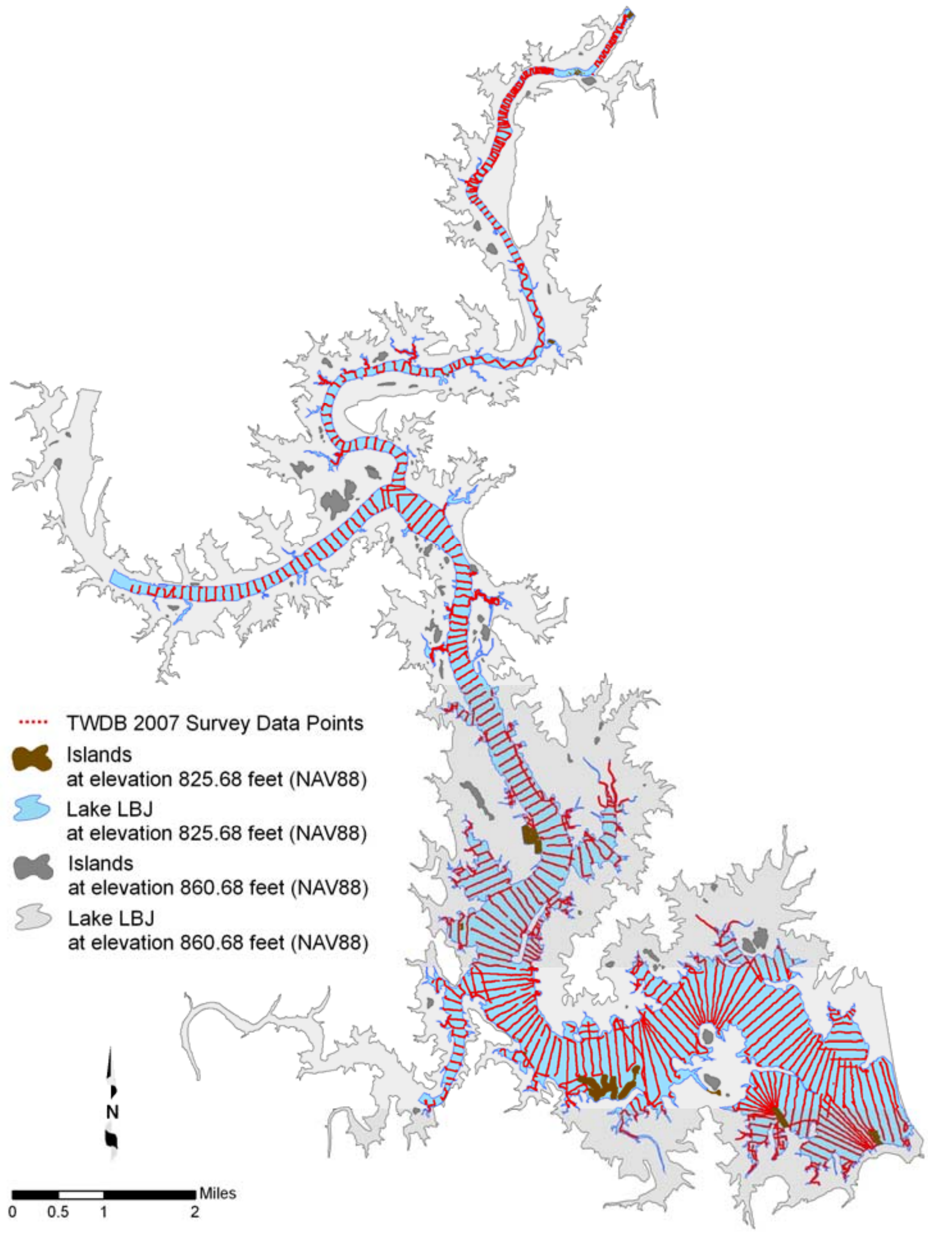

Figure 3. *Spatial extent of data used in creating the Lake LBJ TIN model*

At the request of the Lower Colorado River Authority, surface areas and capacities were calculated to elevation 845 feet (NAVD 88), or 19.32 feet above conservation pool elevation. For use in describing the topography around Lake LBJ up to elevation 845 feet (NAVD 88), the LCRA provided high-resolution LiDAR data collected on January 2, 2007 when the water surface elevation for Lake LBJ was approximately 825.56 feet (NAVD 88). The model boundary at elevation 845 feet was developed from a combination of the 860.68-foot contour (NAVD 88) from the digital hypsography (1:24,000 scale)[9] and the LCRA-provided LiDAR data. For modeling purposes only, the

860.68-foot contour was closed across the tops of both Inks Dam and Wirtz Dam, and therefore does not reflect the true elevations near the either dam crest. Figure 3 shows the 860.68-foot contour in the vicinity of Lake LBJ.

Triangulated 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 and determine the current bathymetric surface. DepthPic is used to display, interpret, and edit the multi-frequency data 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, the sounding coordinates (X,Y,Z) were exported as a MASS points file. A similar MASS points file was created from the LCRA-provided LiDAR data, although only data outside of the 825.68-foot Lake LBJ boundary were used (See Figure 3). TWDB also created additional MASS points files of interpolated and extrapolated data based on the sounding data. Using the "Self-Similar Interpolation" technique (described in a later section), TWDB interpolated bathymetric elevation data located in-between surveyed cross sections. To better represent reservoir bathymetry in shallow regions, TWDB used the "Line Extrapolation" technique (described in a later section). 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, LiDAR, and boundary files in creating a Triangulated Irregular Network (TIN) model 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 boundary vertices.[11]

Using Arc/Info software, volumes and areas were calculated from the TIN model for the entire reservoir at one-tenth of a foot intervals, from elevation 751.0 feet to elevation 845.0 feet (NAVD 88). The Elevation-Capacity Table and Elevation-Area Table, updated for 2007, are presented in Appendix A and B, respectively. The Area-Capacity Curves are presented in Appendix C. The TIN model was interpolated and averaged using a cell size of 1 foot by 1 foot and converted to a raster. The raster was used to produce an Elevation Relief Map (Figure 4) representing the topography of the reservoir bottom up to conservation pool elevation (CPE), a map showing shaded depth ranges for Lake LBJ (Figure 5), and a 10-foot contour map (Figure 6 - attached).

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. 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 represent the true channel bathymetry very well.

To ameliorate these problems, a Self-Similar Interpolation routine (developed by TWDB) was used to interpolate the bathymetry 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.[12] In the case of Lake LBJ, the application of Self-Similar Interpolation helped represent the lake morphology near the banks and improved the representation of the submerged river channel (Figure 7). 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 LBJ where a high probability of change between cross-sections exists.[12] Figure 7 illustrates typical results of the application of the Self-Similar Interpolation routine in Lake LBJ, and the bathymetry shown in Figure 7C was used in computing reservoir capacity and area tables (Appendix A, B).

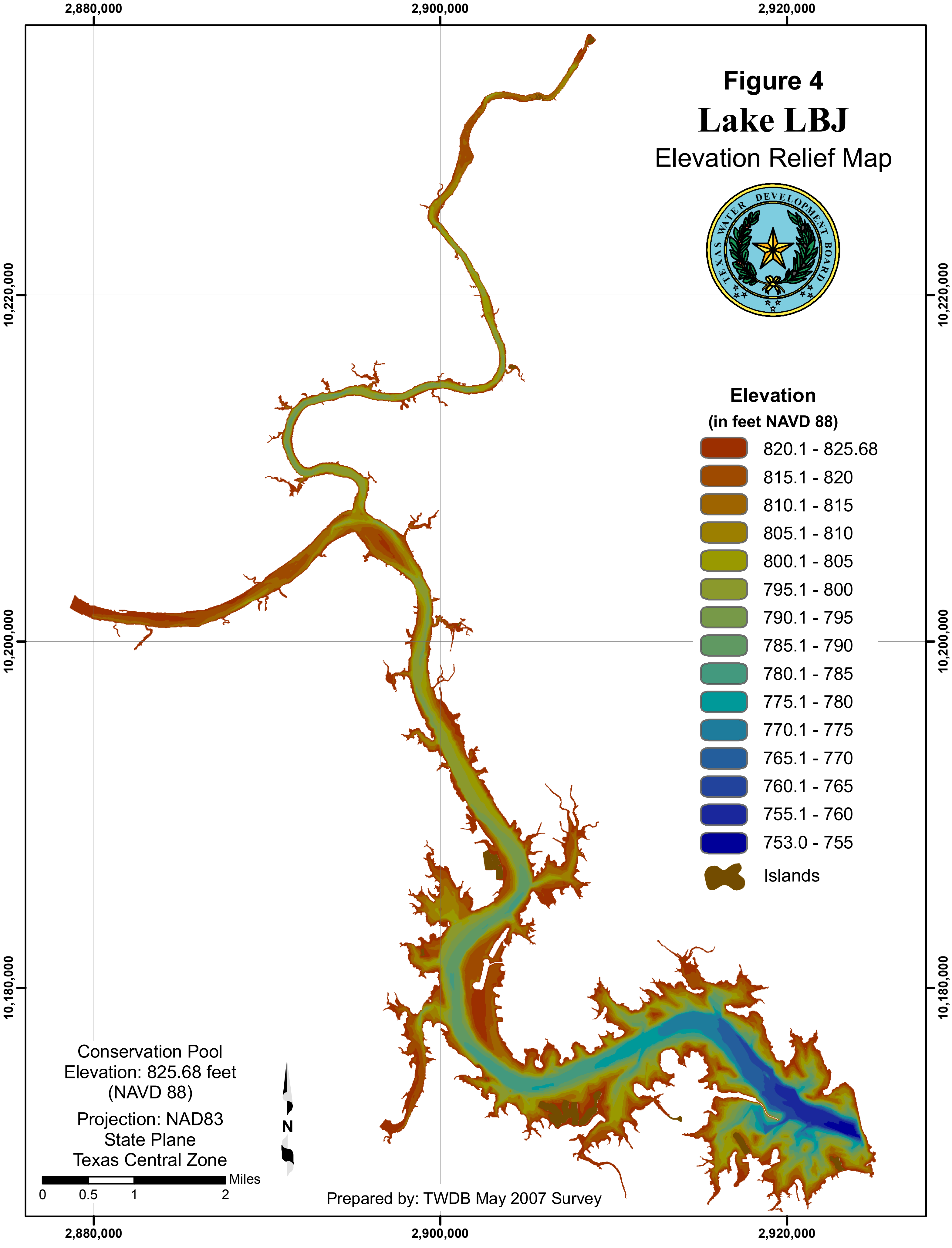

Figure 4
Lake LBJ
Elevation Relief Map
TEXAS WATER DEVELOPMENT BOARD
Elevation
(in feet NAVD 88)
820.1 - 825.68
815.1 - 820
810.1 - 815
805.1 - 810
800.1 - 805
795.1 - 800
790.1 - 795
785.1 - 790
780.1 - 785
775.1 - 780
770.1 - 775
765.1 - 770
760.1 - 765
755.1 - 760
753.0 - 755
Islands
Conservation Pool
Elevation: 825.68 feet
(NAVD 88)
Projection: NAD83
State Plane
Texas Central Zone
0 0.5 1 2 Miles
N
Prepared by: TWDB May 2007 Survey
2,880,000
2,900,000
2,920,000
10,220,000
10,200,000
10,180,000

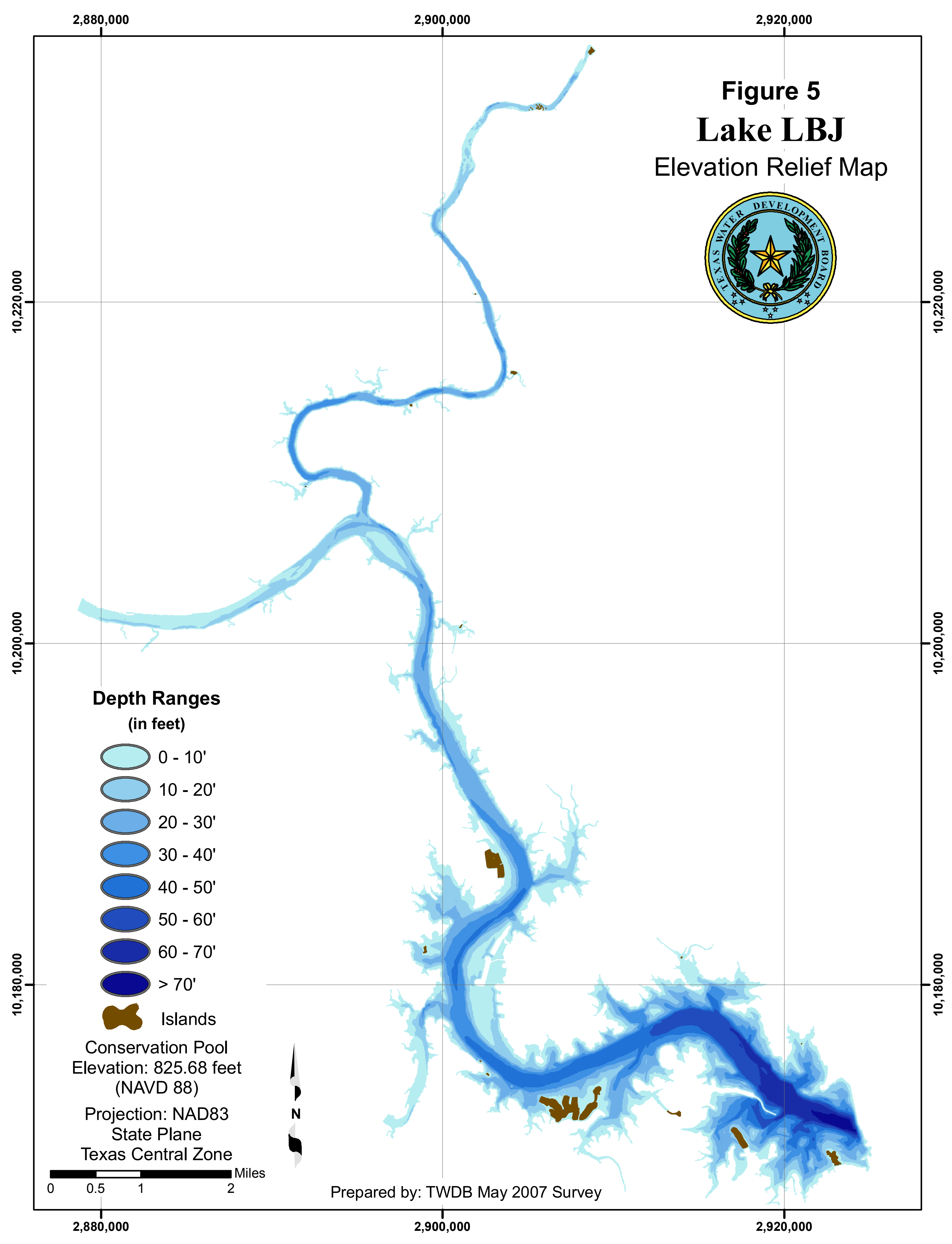

Figure 5
Lake LBJ
Elevation Relief Map
TEXAS WATER DEVELOPMENT BOARD
2,880,000
2,900,000
2,920,000
10,220,000
10,200,000
10,180,000
Depth Ranges
(in feet)
0 - 10'
10 - 20'
20 - 30'
30 - 40'
40 - 50'
50 - 60'
60 - 70'
> 70'
Islands
Conservation Pool
Elevation: 825.68 feet
(NAVD 88)
Projection: NAD83
State Plane
Texas Central Zone
N
Miles
0
0.5
1
2
Prepared by: TWDB May 2007 Survey

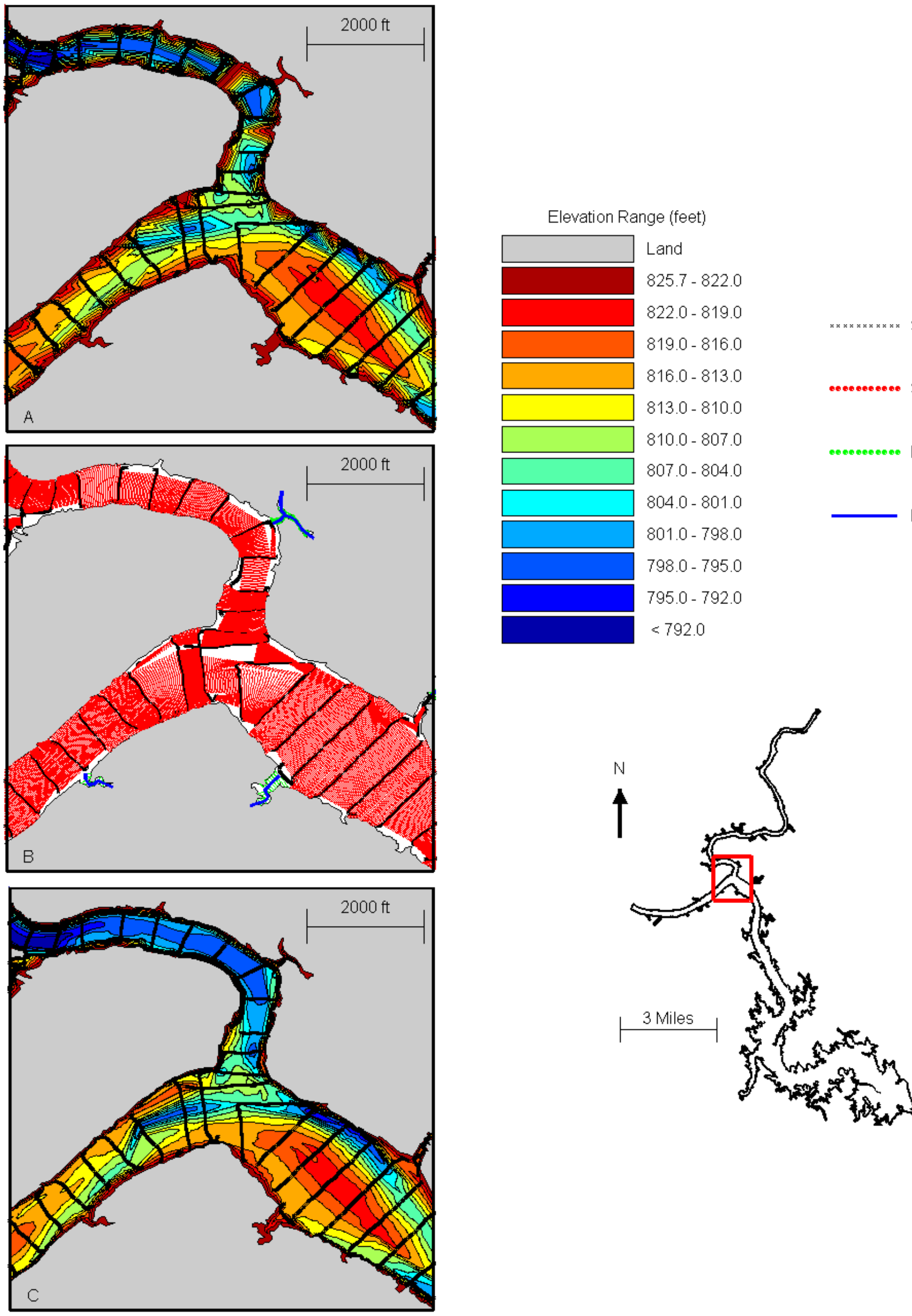

Figure 7. *Application of the Self-Similar Interpolation technique to Lake LBJ sounding data – A) bathymetric contours without interpolated points, B) Sounding points (black) and interpolated points (red) with reservoir boundary shown at elevation 825.68 feet (black), C) bathymetric contours with the interpolated points. Note: In 7A the contours near the boundary bow out into the reservoir and the river channel is not continuous. This is an artifact of the TIN generation routine, rather than an accurate representation of the physical bathymetric surface. Inclusion of the interpolated points (7C) corrects this and smoothes the bathymetric contours.*

Line Extrapolation

In order to estimate the bathymetry in inaccessible portions of Lake LBJ, TWDB applied a line extrapolation technique[12] similar to the Self-Similar interpolation technique discussed above. The line extrapolation method is often used by TWDB in extrapolating bathymetries in shallow coves near the upstream ends of reservoirs, where the water is often too shallow to allow boat passage. The method assumes that cross-sections within the “extrapolation area” have a “V-shaped” profile, with the deepest section located along a line drawn along the longitudinal axis of the area. Elevations along this “longitudinal line” are interpolated linearly based on the distance along the line from the line’s start (nearest the reservoir interior) to the line’s end (where the line crosses the reservoir boundary). The elevations at points along each extrapolated cross-section are linearly interpolated from an elevation on the longitudinal line (at the intersection with the cross-section) and the elevation at the extrapolation area boundary. The line extrapolation method requires that the user specify the position of the longitudinal line and the elevation at the beginning of the longitudinal line. This elevation is usually assumed equivalent to the elevation of the TIN model near the beginning of the longitudinal line. As shown in Figure 8, the line extrapolation method for Lake LBJ was implemented using the 825.68-foot contour (derived from the 2004 DOQQs) as the boundary of the extrapolation areas.

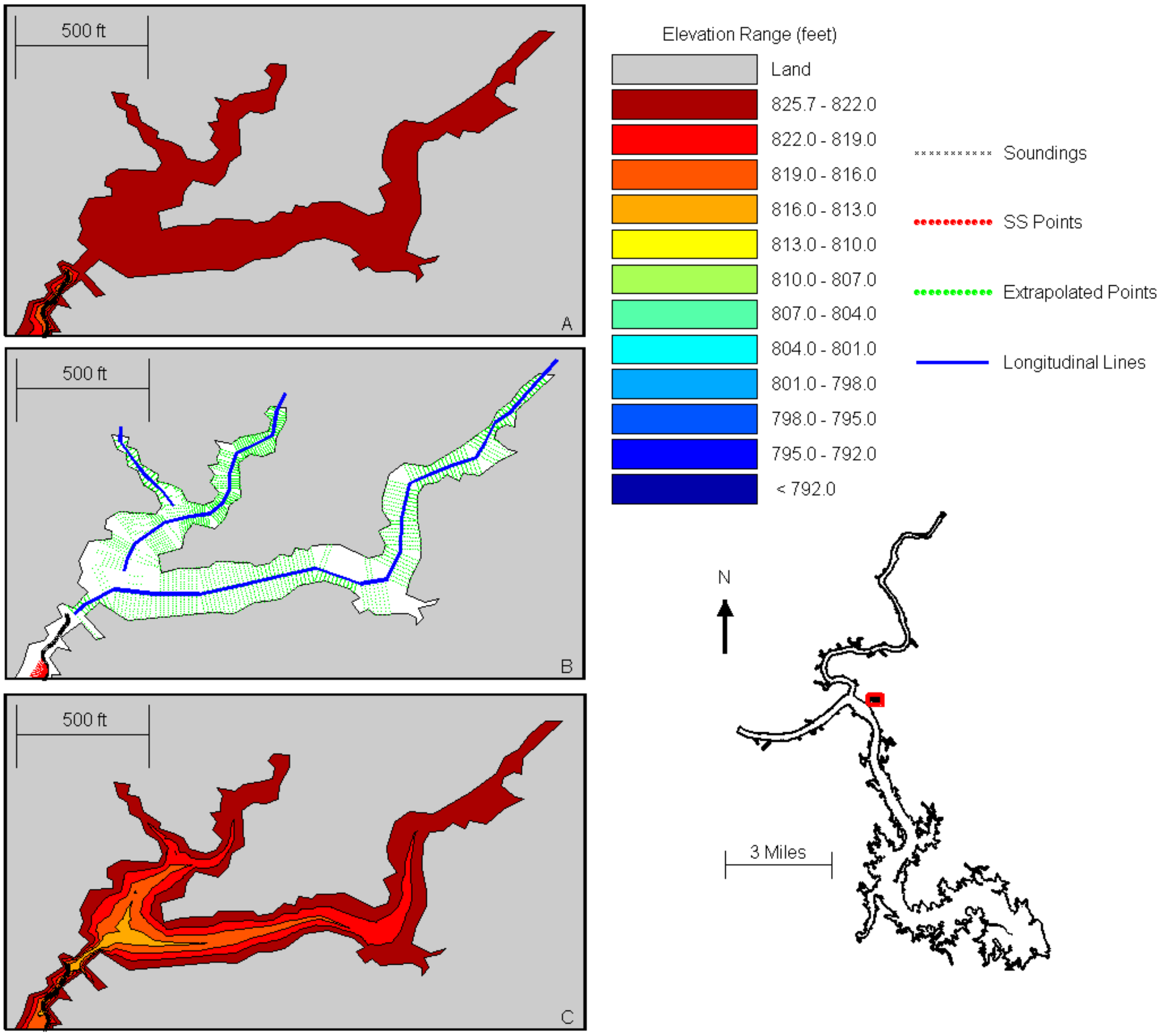

Figure 8 *- Application of the Line Extrapolation technique to Lake LBJ sounding data – A) bathymetric contours without extrapolated points, B) Sounding points (black) and extrapolated points (red) with the "longitudinal lines" (blue), reservoir boundary shown at elevation 825.68 feet (black), C) bathymetric contours with the extrapolated points. Note: In 8A 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 absent from portions of the reservoir. Inclusion of the extrapolated points (8C) corrects this and smoothes the bathymetric contours.*

The assumption inherent in the line extrapolation method 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 method are "more accurate" than those derived without line extrapolation. For the purpose of estimating the volume of water within Lake LBJ, the line extrapolation method is justified in that it produces a reasonable representation of reservoir bathymetry in the shallow areas accessible by TWDB survey vessels. 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 LBJ have 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 method is provided in the HydroEdit User's Manual.[12]

Survey Results

Volumetric Survey

The results of the TWDB 2007 Volumetric Survey indicate Lake LBJ has a total reservoir capacity of 133,090 acre-feet and encompasses 6,273 acres at conservation pool elevation (825.68 feet NAVD 88). Per data provided by LCRA[13,14], the capacity of Lake LBJ in 1951 was estimated at 138,460 acre-feet and in 1995 at 134,353 acre-feet. After applying the self-similar and line extrapolation techniques to the LCRA-collected survey data from 1995 and using 1995 aerial photos to define the lake boundary, TWDB revised the 1995 capacity estimate to 135,421 acre-feet. Table 2 provides a summary of these results.

Table 2 – Comparisons of Historical CPE Volumes of Lake LBJ

		Time Interval (years)		Capacity Loss (acre-ft)		Loss Rate (acre-ft/year)	
Year	Capacity (acre-ft)	Total*	Recent*	Total*	Recent*	Total*	Recent*
1951	138,460	--	--	--	--	--	--
1995 Revised	135,421	45	--	3,309	--	67.5	--
2007	133,090	57	13	5,370	2,331	94.2	179.3

* Total refers to changes from 1951 to the time of interest, Recent refers to changes from 1995 to 2007.

Analysis of the data presented in Table 2 suggests that the rate of capacity loss (due to sediment accumulation) has nearly tripled during the period from 1995 to 2007 when compared with the period from 1951 to 1995. This increase in sediment accumulation rates may be attributed to increased development within the Lake LBJ watershed, although verification of this hypothesis was not attempted within the scope of this project. Alternative explanations for the increase are that the lake capacities calculated in 1951, 1995, and/or 2007 include significant error, thus making comparisons unreliable.

Sedimentation Survey

The 200 kHz, 50 kHz, and 24 kHz frequency data were used to interpret the distribution and accumulation of sediment throughout Lake LBJ. Figure 9 shows the thickness of sediment throughout the reservoir. To assist in the interpretation of post-impoundment sediment accumulation, ancillary data was collected in the form of seven core samples. Sediment cores were collected between July 9th, 2007 and August 1st, 2007 by Professor John Dunbar of Baylor University (under contract with TWDB). Cores were collected using a Specialty Devices, Inc. VibraCore system and their content was analyzed by Baylor University staff.

The results of the TWDB 2007 Sedimentation Survey indicate Lake LBJ has accumulated 5,654 acre-feet of sediment since impoundment began in 1951. Based on this measured sediment volume and assuming a constant sediment accumulation rate, Lake LBJ loses approximately 100 acre-feet of capacity per year. This estimated loss rate is consistent with that calculated from volume comparisons between the 2007 survey and 1951 capacity estimate (Table 2). The thickest sediment deposits are in the submerged river channel throughout the main lake body, and sediment was not present in the Llano River arm, Colorado River arm, or Sandy Creek arms of Lake LBJ. This sediment distribution suggests incoming sediment quickly travels downstream within Lake LBJ, where it settles to the bottom, upstream of Wirtz Dam. The maximum sediment thickness observed in Lake LBJ was 7.1 feet. A complete description of the sediment measurement methodology and sample results is presented in Appendix D.

The TWDB considers the 2007 survey to be significantly more accurate than previous surveys and recommends that a similar methodology be used to resurvey Lake LBJ in approximately 10 years, or after a major flood event. Results from such a survey would allow the sediment accumulation rate for Lake LBJ to be quantified with greater accuracy. Additional point estimates of sediment accumulation rates may also be obtained through assessment of the Cesium-137 content within sediment cores.[15]

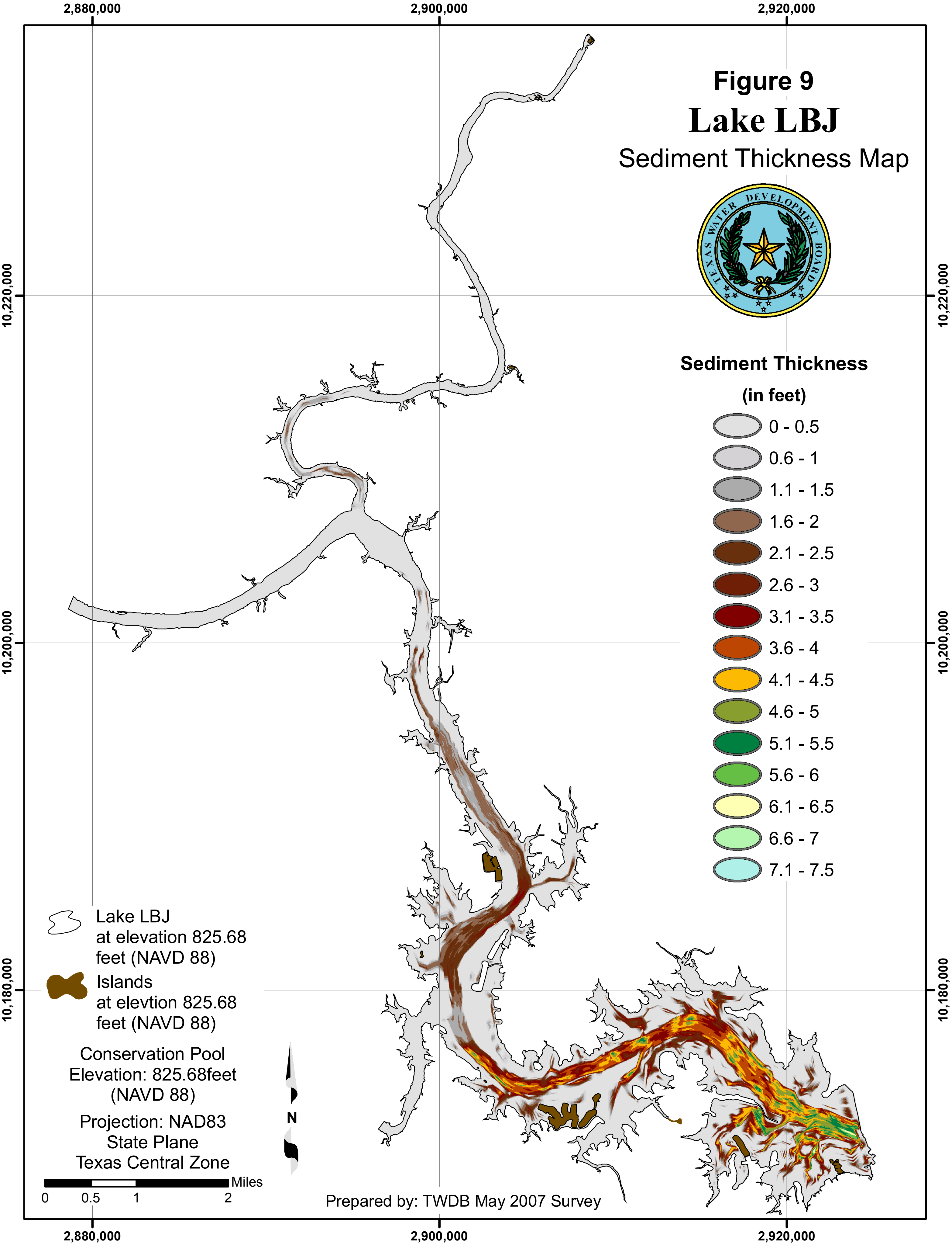
Figure 9
Lake LBJ
Sediment Thickness Map
TEXAS WATER DEVELOPMENT BOARD
Sediment Thickness
(in feet)
0 - 0.5
0.6 - 1
1.1 - 1.5
1.6 - 2
2.1 - 2.5
2.6 - 3
3.1 - 3.5
3.6 - 4
4.1 - 4.5
4.6 - 5
5.1 - 5.5
5.6 - 6
6.1 - 6.5
6.6 - 7
7.1 - 7.5
Lake LBJ
at elevation 825.68
feet (NAVD 88)
Islands
at elevtion 825.68
feet (NAVD 88)
Conservation Pool
Elevation: 825.68feet
(NAVD 88)
Projection: NAD83
State Plane
Texas Central Zone
N
0
0.5
1
2
Miles
Prepared by: TWDB May 2007 Survey
2,880,000
2,900,000
2,920,000
10,220,000
10,200,000
10,180,000

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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Or

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

References

1. Lower Colorado Regional Water Planning Group, Region K, 2006, LCWPG Water Plan, Chapter 3, http://www.twdb.state.tx.us/rwpg/2006_RWP/RegionK/Chapter%203.pdf

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Appendix A

Lake Lyndon Baines Johnson

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD
CAPACITY IN ACRE-FEET
ELEVATION INCREMENT IS ONE TENTH FOOT

May 2007 SURVEY
Conservation Pool Elevation 825.68 Feet NAVD88

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
751	0	0	0	0	0	0	0	0	0	0
752	0	0	0	0	0	0	0	0	0	0
753	0	0	0	0	0	1	1	1	2	2
754	3	4	4	5	6	8	9	11	12	14
755	16	18	20	23	25	28	31	34	37	40
756	44	47	51	55	59	63	67	71	76	81
757	86	92	97	103	109	115	121	128	134	141
758	147	154	161	169	176	183	191	199	207	215
759	223	231	240	249	257	266	275	285	294	304
760	313	323	333	343	353	364	374	385	396	406
761	417	429	440	451	463	475	487	499	511	524
762	536	549	562	575	588	602	615	629	643	657
763	671	685	700	715	730	745	760	776	792	808
764	824	840	856	873	889	906	923	940	958	975
765	993	1,010	1,028	1,046	1,064	1,082	1,101	1,120	1,138	1,157
766	1,176	1,196	1,215	1,235	1,254	1,275	1,295	1,315	1,336	1,357
767	1,378	1,399	1,420	1,442	1,464	1,486	1,509	1,531	1,554	1,577
768	1,601	1,624	1,648	1,672	1,696	1,720	1,745	1,770	1,795	1,820
769	1,846	1,873	1,899	1,926	1,954	1,981	2,009	2,038	2,066	2,095
770	2,124	2,153	2,182	2,211	2,241	2,271	2,301	2,331	2,362	2,393
771	2,424	2,455	2,486	2,518	2,550	2,582	2,615	2,647	2,680	2,713
772	2,747	2,780	2,814	2,848	2,883	2,917	2,952	2,987	3,023	3,058
773	3,094	3,130	3,167	3,204	3,241	3,279	3,318	3,357	3,396	3,436
774	3,476	3,516	3,556	3,597	3,638	3,679	3,721	3,762	3,804	3,846
775	3,889	3,931	3,974	4,017	4,061	4,104	4,148	4,192	4,237	4,282
776	4,327	4,372	4,418	4,464	4,510	4,557	4,604	4,651	4,698	4,746
777	4,794	4,842	4,890	4,939	4,987	5,036	5,085	5,135	5,185	5,235
778	5,285	5,335	5,386	5,437	5,489	5,540	5,592	5,644	5,697	5,749
779	5,802	5,856	5,909	5,963	6,018	6,072	6,127	6,183	6,239	6,295
780	6,353	6,410	6,469	6,527	6,586	6,646	6,706	6,767	6,828	6,889
781	6,951	7,014	7,078	7,142	7,206	7,272	7,337	7,404	7,470	7,538
782	7,605	7,673	7,742	7,811	7,881	7,951	8,022	8,093	8,164	8,236
783	8,309	8,382	8,455	8,529	8,603	8,678	8,753	8,828	8,905	8,981
784	9,058	9,136	9,214	9,292	9,371	9,451	9,531	9,611	9,693	9,774
785	9,857	9,940	10,024	10,109	10,194	10,281	10,368	10,456	10,546	10,636
786	10,727	10,818	10,910	11,003	11,096	11,190	11,285	11,381	11,477	11,574
787	11,671	11,769	11,868	11,968	12,068	12,169	12,271	12,373	12,476	12,579
788	12,684	12,789	12,894	13,001	13,108	13,216	13,324	13,433	13,543	13,654
789	13,765	13,876	13,989	14,102	14,216	14,331	14,446	14,562	14,678	14,795
790	14,913	15,032	15,151	15,271	15,391	15,512	15,634	15,757	15,880	16,004
791	16,129	16,254	16,381	16,508	16,636	16,764	16,893	17,023	17,154	17,286
792	17,418	17,551	17,685	17,820	17,956	18,092	18,229	18,368	18,506	18,646
793	18,787	18,928	19,071	19,214	19,358	19,503	19,649	19,796	19,944	20,092
794	20,242	20,392	20,543	20,695	20,848	21,002	21,157	21,312	21,469	21,627
795	21,785	21,945	22,105	22,267	22,429	22,593	22,757	22,923	23,090	23,258
796	23,427	23,597	23,768	23,940	24,114	24,288	24,464	24,642	24,820	25,000
797	25,181	25,363	25,547	25,732	25,918	26,105	26,294	26,483	26,674	26,867
798	27,060	27,255	27,451	27,648	27,847	28,047	28,249	28,452	28,657	28,862
799	29,070	29,278	29,488	29,699	29,912	30,125	30,340	30,557	30,774	30,993
800	31,213	31,434	31,657	31,880	32,105	32,331	32,558	32,786	33,015	33,245
801	33,476	33,709	33,942	34,177	34,413	34,650	34,888	35,127	35,367	35,609
802	35,852	36,095	36,340	36,586	36,833	37,081	37,330	37,580	37,832	38,084
803	38,338	38,592	38,848	39,105	39,363	39,622	39,882	40,143	40,406	40,669
804	40,934	41,199	41,466	41,734	42,003	42,274	42,545	42,818	43,091	43,367

Appendix A (continued)

Lake Lyndon Baines Johnson

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD
CAPACITY IN ACRE-FEET
ELEVATION INCREMENT IS ONE TENTH FOOT

May 2007 SURVEY
Conservation Pool Elevation 825.68 Feet NAVD88

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
805	43,643	43,920	44,199	44,479	44,760	45,042	45,325	45,610	45,896	46,183
806	46,471	46,760	47,051	47,343	47,636	47,930	48,226	48,522	48,821	49,120
807	49,421	49,722	50,026	50,330	50,636	50,943	51,251	51,561	51,872	52,184
808	52,497	52,812	53,128	53,446	53,764	54,084	54,405	54,728	55,052	55,377
809	55,703	56,030	56,359	56,689	57,021	57,354	57,688	58,023	58,360	58,698
810	59,038	59,378	59,720	60,063	60,408	60,753	61,100	61,449	61,798	62,149
811	62,501	62,855	63,210	63,566	63,924	64,284	64,644	65,006	65,370	65,735
812	66,101	66,469	66,838	67,208	67,580	67,954	68,329	68,706	69,084	69,464
813	69,845	70,227	70,612	70,997	71,385	71,774	72,164	72,556	72,950	73,346
814	73,743	74,141	74,542	74,944	75,348	75,753	76,160	76,569	76,980	77,393
815	77,807	78,224	78,642	79,062	79,485	79,909	80,335	80,763	81,193	81,626
816	82,060	82,497	82,935	83,376	83,819	84,263	84,709	85,158	85,608	86,060
817	86,515	86,971	87,430	87,890	88,353	88,817	89,283	89,752	90,221	90,693
818	91,167	91,642	92,119	92,598	93,079	93,562	94,046	94,533	95,021	95,512
819	96,004	96,498	96,994	97,492	97,992	98,494	98,998	99,504	100,012	100,522
820	101,034	101,547	102,063	102,581	103,101	103,622	104,146	104,672	105,199	105,728
821	106,260	106,792	107,328	107,864	108,403	108,943	109,484	110,028	110,573	111,120
822	111,669	112,219	112,772	113,326	113,882	114,440	114,999	115,561	116,124	116,688
823	117,255	117,823	118,392	118,964	119,537	120,111	120,687	121,265	121,844	122,426
824	123,008	123,593	124,179	124,767	125,357	125,949	126,542	127,138	127,735	128,335
825	128,936	129,539	130,146	130,754	131,365	131,979	132,595	133,216	133,844	134,474
826	135,105	135,738	136,374	137,014	137,657	138,302	138,951	139,602	140,255	140,911
827	141,569	142,230	142,893	143,559	144,228	144,899	145,572	146,250	146,929	147,612
828	148,297	148,985	149,676	150,370	151,067	151,766	152,469	153,174	153,882	154,593
829	155,306	156,022	156,742	157,464	158,189	158,917	159,647	160,381	161,118	161,857
830	162,600	163,345	164,094	164,845	165,599	166,356	167,116	167,879	168,645	169,414
831	170,186	170,960	171,738	172,518	173,301	174,087	174,875	175,667	176,461	177,258
832	178,057	178,859	179,664	180,472	181,282	182,095	182,911	183,730	184,551	185,376
833	186,203	187,033	187,866	188,702	189,541	190,383	191,227	192,075	192,926	193,780
834	194,636	195,495	196,358	197,223	198,091	198,962	199,835	200,712	201,591	202,474
835	203,359	204,247	205,138	206,031	206,928	207,827	208,729	209,634	210,542	211,453
836	212,367	213,283	214,202	215,124	216,049	216,977	217,907	218,841	219,777	220,716
837	221,658	222,602	223,550	224,500	225,453	226,408	227,367	228,329	229,293	230,260
838	231,230	232,203	233,179	234,157	235,139	236,124	237,111	238,101	239,094	240,090
839	241,089	242,091	243,096	244,103	245,114	246,127	247,143	248,163	249,186	250,211
840	251,240	252,271	253,306	254,343	255,384	256,428	257,474	258,524	259,577	260,634
841	261,693	262,755	263,821	264,890	265,962	267,036	268,114	269,196	270,280	271,368
842	272,458	273,551	274,649	275,749	276,853	277,959	279,068	280,182	281,297	282,417
843	283,540	284,665	285,795	286,927	288,063	289,201	290,343	291,489	292,637	293,789
844	294,944	296,102	297,264	298,429	299,597	300,768	301,943	303,121	304,302	305,488
845	306,675									

Appendix B

Lake Lyndon Baines Johnson

RESERVOIR AREA TABLE

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

May 2007 SURVEY
Conservation Pool Elevation 825.68 Feet NAVD88

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
751	0	0	0	0	0	0	0	0	0	0
752	0	0	0	0	0	0	0	0	0	0
753	0	1	1	2	2	3	3	4	5	5
754	6	7	9	10	12	13	15	16	18	19
755	21	22	23	25	26	28	29	31	32	33
756	35	36	37	38	40	41	44	46	48	50
757	52	54	57	59	60	62	63	64	66	67
758	68	70	71	73	74	76	77	78	80	81
759	83	85	86	87	89	90	92	93	94	96
760	97	98	100	102	103	104	106	107	108	110
761	111	113	114	115	117	119	120	122	123	125
762	127	128	130	132	133	135	137	138	139	141
763	143	145	147	149	151	153	155	157	159	160
764	162	163	165	166	168	169	170	172	173	175
765	176	178	179	181	182	184	185	187	189	190
766	192	194	195	197	199	201	203	205	207	209
767	212	214	216	219	221	223	225	227	229	231
768	234	236	238	240	242	245	247	251	254	257
769	261	265	268	272	275	278	280	283	286	288
770	290	292	294	296	298	300	302	304	306	308
771	311	314	316	319	321	323	326	328	330	332
772	335	337	340	342	345	347	350	352	355	358
773	361	364	368	372	378	384	388	392	395	397
774	400	403	405	408	410	413	415	418	420	423
775	425	427	430	432	435	437	440	443	446	449
776	452	456	459	462	465	468	470	473	475	477
777	479	482	484	486	489	491	493	496	498	501
778	504	506	509	512	515	517	520	523	526	529
779	532	535	538	542	545	548	552	556	561	569
780	576	580	585	589	593	598	602	608	613	619
781	626	632	638	644	649	654	659	664	670	675
782	680	685	690	694	699	704	708	713	717	722
783	726	731	736	740	745	749	754	759	764	769
784	773	778	782	787	791	797	803	810	816	822
785	829	836	843	850	859	868	879	889	897	904
786	911	917	924	931	938	945	951	958	965	972
787	979	986	992	999	1,006	1,012	1,019	1,026	1,032	1,039
788	1,046	1,053	1,061	1,068	1,075	1,082	1,088	1,095	1,101	1,108
789	1,114	1,121	1,128	1,135	1,142	1,149	1,156	1,162	1,169	1,175
790	1,182	1,188	1,195	1,202	1,208	1,215	1,222	1,229	1,237	1,244
791	1,252	1,259	1,267	1,274	1,281	1,289	1,296	1,304	1,312	1,320
792	1,328	1,336	1,344	1,352	1,360	1,369	1,377	1,385	1,393	1,402
793	1,410	1,419	1,429	1,438	1,446	1,455	1,464	1,472	1,481	1,490
794	1,499	1,507	1,516	1,525	1,534	1,543	1,552	1,561	1,571	1,580
795	1,590	1,600	1,610	1,620	1,631	1,641	1,652	1,662	1,673	1,683
796	1,694	1,705	1,718	1,729	1,741	1,753	1,766	1,779	1,791	1,804
797	1,817	1,830	1,842	1,855	1,867	1,879	1,891	1,904	1,916	1,929
798	1,942	1,954	1,968	1,981	1,995	2,009	2,023	2,038	2,052	2,065
799	2,079	2,092	2,105	2,118	2,131	2,144	2,156	2,169	2,182	2,195
800	2,207	2,219	2,230	2,241	2,252	2,263	2,275	2,286	2,297	2,308
801	2,319	2,330	2,341	2,352	2,364	2,375	2,387	2,398	2,410	2,421
802	2,432	2,443	2,453	2,464	2,475	2,486	2,497	2,508	2,519	2,530
803	2,541	2,552	2,563	2,574	2,585	2,596	2,607	2,618	2,629	2,640
804	2,651	2,662	2,674	2,685	2,697	2,708	2,720	2,732	2,744	2,756

Appendix B (continued)

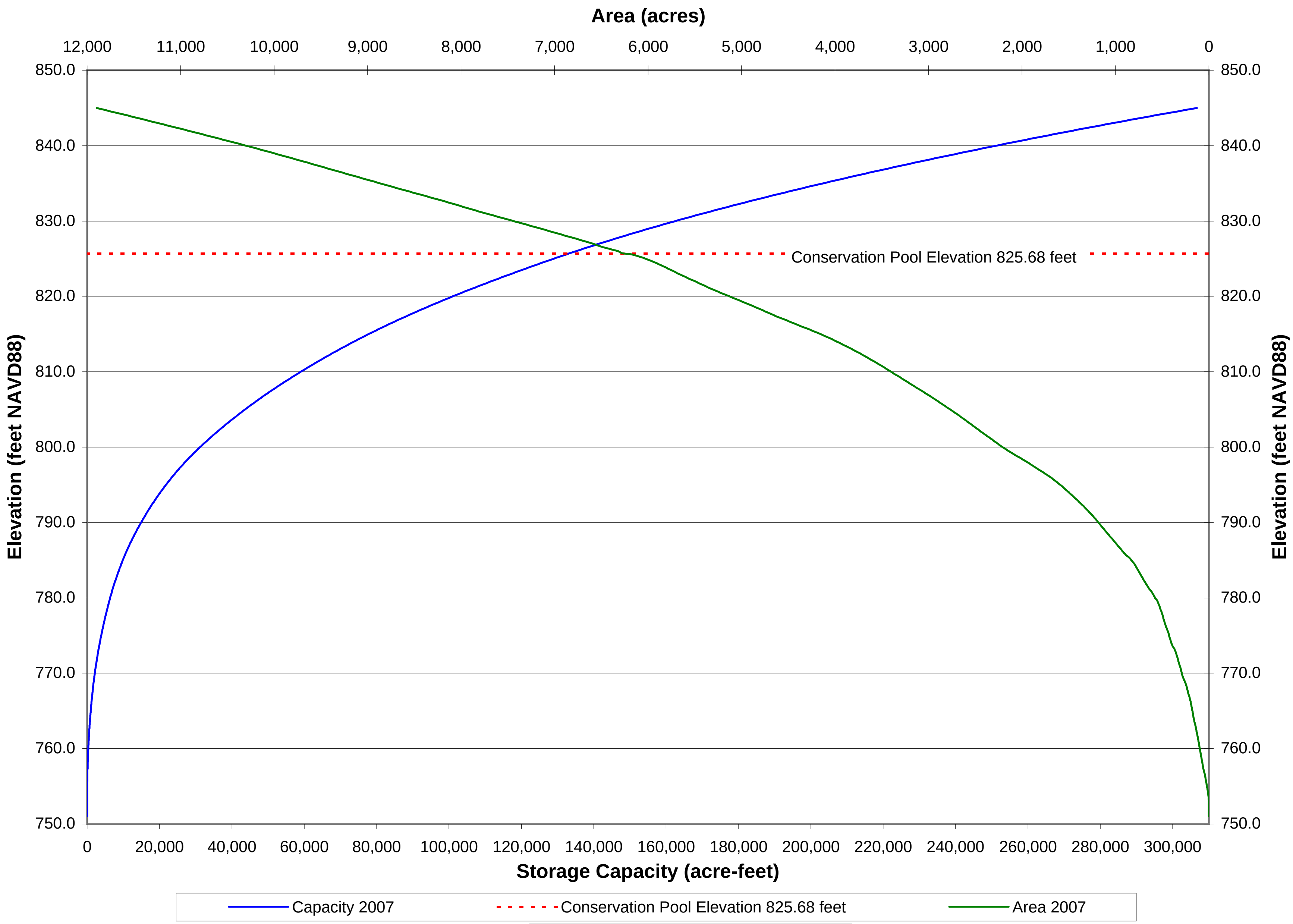
Lake Lyndon Baines Johnson

RESERVOIR AREA TABLE

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

May 2007 SURVEY
Conservation Pool Elevation 825.68 Feet NAVD88

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
805	2,768	2,780	2,792	2,804	2,816	2,828	2,840	2,852	2,864	2,876
806	2,888	2,900	2,912	2,924	2,937	2,949	2,962	2,975	2,988	3,000
807	3,013	3,026	3,038	3,051	3,064	3,076	3,089	3,102	3,115	3,128
808	3,141	3,154	3,167	3,180	3,193	3,206	3,218	3,231	3,244	3,257
809	3,270	3,282	3,295	3,308	3,321	3,335	3,348	3,361	3,374	3,387
810	3,400	3,412	3,425	3,438	3,450	3,463	3,476	3,489	3,502	3,515
811	3,530	3,544	3,558	3,571	3,585	3,599	3,614	3,628	3,642	3,656
812	3,670	3,684	3,698	3,712	3,727	3,743	3,759	3,774	3,789	3,804
813	3,819	3,835	3,850	3,866	3,881	3,897	3,913	3,930	3,946	3,963
814	3,979	3,996	4,012	4,029	4,046	4,064	4,081	4,099	4,118	4,137
815	4,156	4,174	4,193	4,212	4,231	4,251	4,272	4,292	4,312	4,333
816	4,355	4,376	4,397	4,416	4,435	4,454	4,474	4,493	4,513	4,533
817	4,553	4,574	4,596	4,616	4,635	4,654	4,672	4,690	4,708	4,726
818	4,744	4,763	4,781	4,799	4,817	4,836	4,856	4,874	4,893	4,913
819	4,932	4,952	4,971	4,990	5,010	5,029	5,049	5,069	5,088	5,109
820	5,129	5,149	5,168	5,187	5,207	5,227	5,246	5,265	5,284	5,303
821	5,322	5,340	5,357	5,375	5,392	5,409	5,427	5,444	5,461	5,479
822	5,497	5,515	5,533	5,551	5,569	5,587	5,604	5,621	5,638	5,655
823	5,672	5,689	5,705	5,721	5,737	5,753	5,770	5,786	5,803	5,820
824	5,837	5,854	5,872	5,890	5,908	5,926	5,945	5,964	5,984	6,004
825	6,024	6,047	6,073	6,097	6,123	6,149	6,178	6,275	6,290	6,304
826	6,318	6,347	6,379	6,413	6,444	6,472	6,498	6,522	6,546	6,570
827	6,594	6,619	6,645	6,671	6,698	6,726	6,754	6,782	6,811	6,840
828	6,868	6,897	6,925	6,953	6,981	7,009	7,037	7,065	7,093	7,121
829	7,150	7,178	7,207	7,236	7,265	7,294	7,323	7,352	7,381	7,410
830	7,439	7,469	7,498	7,528	7,557	7,586	7,615	7,644	7,674	7,703
831	7,732	7,761	7,789	7,817	7,845	7,872	7,900	7,927	7,954	7,981
832	8,008	8,035	8,062	8,089	8,117	8,144	8,173	8,201	8,230	8,259
833	8,288	8,316	8,345	8,374	8,403	8,432	8,462	8,491	8,521	8,550
834	8,579	8,608	8,638	8,666	8,695	8,724	8,752	8,781	8,809	8,837
835	8,865	8,893	8,922	8,950	8,979	9,008	9,036	9,065	9,093	9,122
836	9,150	9,178	9,206	9,235	9,263	9,291	9,319	9,348	9,376	9,404
837	9,432	9,460	9,488	9,516	9,544	9,572	9,601	9,629	9,658	9,686
838	9,715	9,743	9,772	9,801	9,830	9,859	9,888	9,917	9,946	9,974
839	10,003	10,032	10,061	10,091	10,120	10,150	10,180	10,210	10,240	10,270
840	10,300	10,330	10,360	10,391	10,421	10,452	10,484	10,515	10,547	10,578
841	10,609	10,640	10,671	10,702	10,733	10,764	10,796	10,827	10,859	10,891
842	10,922	10,954	10,986	11,018	11,049	11,081	11,113	11,145	11,178	11,210
843	11,243	11,275	11,308	11,340	11,372	11,404	11,436	11,469	11,501	11,534
844	11,566	11,599	11,632	11,665	11,698	11,731	11,764	11,797	11,831	11,865
845	11,899									



Lake Lyndon Baines Johnson
May 2007 Survey
Prepared by: TWDB

Appendix C: Area and Capacity Curves

Appendix D

Analysis of Sediment Accumulation Data from Lake LBJ

Executive Summary

The results of the TWDB 2007 Sedimentation Survey indicate Lake LBJ has accumulated 5,654 acre-feet of sediment since impoundment began in 1951. Based on this measured sediment volume and assuming a constant sediment accumulation rate, Lake LBJ loses approximately 100 acre-feet of capacity per year. This estimated loss rate is consistent with that calculated from volume comparisons between the 2007 survey and 1951 capacity estimate. The thickest sediment deposits are in the submerged river channel throughout the main lake body, and sediment was not present in the Llano River arm, Colorado River arm, or Sandy Creek arms of Lake LBJ. This sediment distribution suggests incoming sediment quickly travels downstream within Lake LBJ, where it settles to the bottom, upstream of Wirtz Dam. The maximum sediment thickness observed in Lake LBJ was 7.1 feet.

Introduction

This appendix includes the results of the sedimentation investigation using a multi-frequency depth sounder performed by the Texas Water Development Board (TWDB) and sediment core data collected by Baylor University professor John Dunbar (under contract to TWDB). 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 LBJ.

Data Collection & Processing Methodology

TWDB conducted the initial Lake LBJ survey on May 4th, 7th-10th, and 14th-16th of 2007 with additional data collected on August 3rd and October 9th of 2007. During the survey, Lake LBJ water surface elevations ranged between 825.25 and 825.53 feet (NAVD 88). For 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. 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. 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 2007 survey, team members collected approximately 149,000 data points over cross-sections totaling nearly 146 miles in length. Figure D1 shows where data points were collected during the TWDB 2007 survey.

To assist in the interpretation of post-impoundment sediment accumulation, ancillary data was collected in the form of seven core samples (Figure D1). Sediment cores were collected between July 9th, 2007 and August 1st, 2007 by Professor John Dunbar of Baylor University (under contract with TWDB). Cores were collected using a Specialty Devices, Inc. VibraCore system and their content was analyzed by Baylor University staff.[1] The coordinates and extent of each core sample are provided in Table D1. Figure D2 shows the cross-section of sediment core 11. At this location, 22 inches of clay-rich muddy sediment were collected, with the upper 2-inch sediment layer (Figure D2) having a high water content. The pre-impoundment boundary was evident from this core at a distance of 4 inches above the core base. Below this location, the sediment soil structure was well developed, organic material was present, and the soil consisted mostly of compacted sand. Above this location, the soil is a clay-rich mud and the moisture content generally increases (Figure D2).

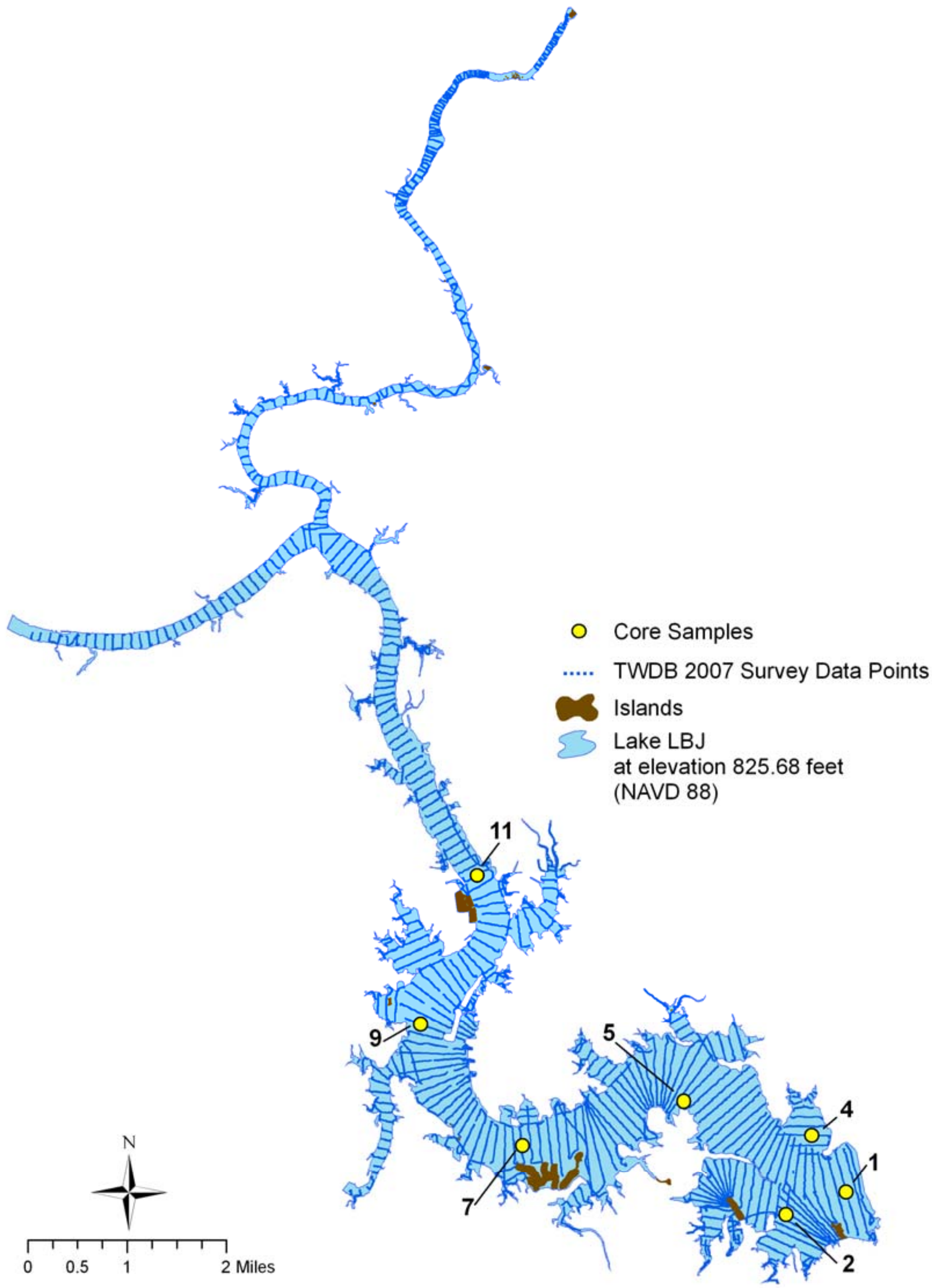


Figure D1 – TWDB 2007 survey data points for Lake LBJ. Sounding data used in assessing sediment content are shown in blue.

Table D1 – Core Sampling Analysis Data – Lake LBJ

Core	Easting** (ft)	Northing** (ft)	Description
1	2923288.80	10171917.10	22" of muddy, silty-loam sediment, lacking soil structure
2	2920085.04	10170725.07	63" of muddy, clay-rich sediment
4	2921459.82	10174947.36	25" of muddy, clay-rich sediment
5	2914655.26	10176757.95	30" of layered sediment, including clay, sand, and silt.
7	2906007.82	10174368.30	24" of muddy silty-loam sediment, lacking soil structure
9	2900607.03	10180854.88	31" of sediment
11	2903639.21	10188778.31	22" of muddy, clay-rich sediment

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

Figure D2 – Sediment Core 11 from Lake LBJ, showing the pre-impoundment boundary 4 inches (10 cm) above the base of the core (left). The pre-impoundment boundary is marked by the change in soil structure below and above the area 4 inches up from the core base. Above 4 inches from the core base, the sediment is muddy with high clay content. Below 4 inches from the core base, the sediment is compacted sand with prevalent plant roots. This core contained 22 inches (55 cm) of post-impoundment sediment.

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 11 is shown with its corresponding sounding data. The 22 inches of sediment in core sample 11 are represented by the yellow box in the core sample shown in Figure D3. The yellow box shows the extent of the clay-rich mud shown in Figure D2. The green box represents pre-impoundment sediment. 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.

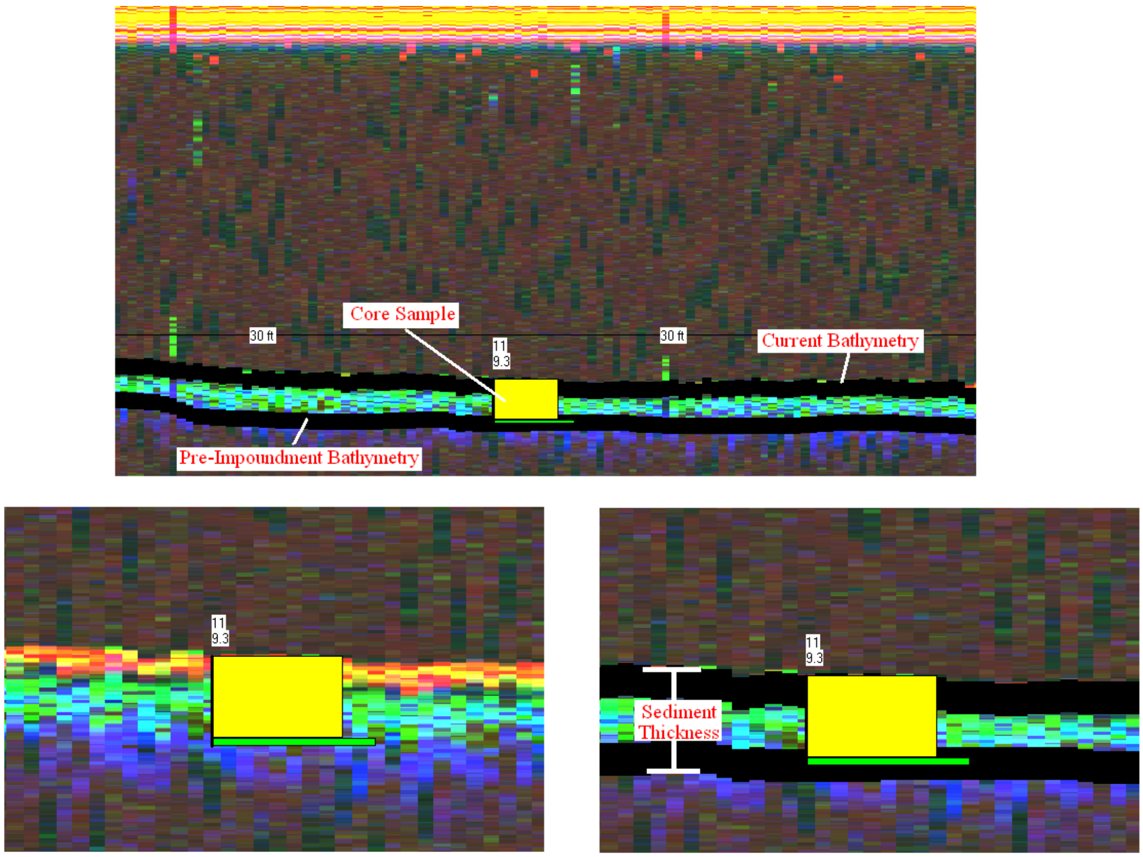


Figure D3 – DepthPic and core sample use in identifying the pre-impoundment bathymetry.

Within DepthPic, the current surface is automatically determined based on the signal returns from the 200 kHz transducer. The pre-impoundment surface must be determined visually based on the pixel color display and any available core sample data. Based on core sample 11, it is clear that the upper-most layer of sediment (with high water content) is denoted by the band of bright yellow-orange pixels. The underlying clay-rich muddy sediment with slightly less water content is denoted by the blue-green pixels in the DepthMap display (Figure D3). The pre-impoundment bathymetric surface for this cross-section is therefore identified as the base of the blue-green pixel band, where the pixels in the DepthPic display transition to dark blue. The current bathymetric surface is located at the top of the bright band of yellow-orange pixels. (Figure D3). For Lake LBJ, a large portion of the bathymetry is devoid of sediment. Such areas are evident in the DepthPic display as the pixels denoting the current bathymetric surface are often bright white or yellow (Figure D4). Additionally, there is often an acoustic reflection below the current bathymetry, with a topology identical to the current bathymetry (Figure D4).

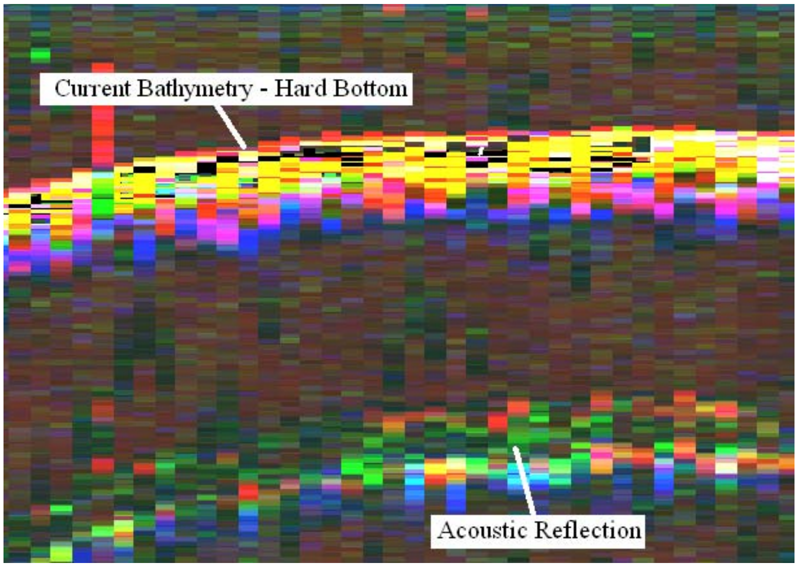


Figure D4 – Common DepthPic displays for areas of Lake LBJ in which sediment has not accumulated.

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. For shallow areas of the lake within which sounding data were not collected, sediment thicknesses are assumed negligible. This assumption may lead to the calculated sediment volume underestimating the physical sediment volume present within the lake.

After manually digitizing the pre-impoundment surface from all cross-sections, both the pre-impoundment and current bathymetric surfaces are exported as X-,Y-,Z-coordinates from DepthPic 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 LBJ 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 as determined with the DepthPic software. Sediment thicknesses were interpolated for locations between surveyed cross-sections using the TWDB self-similar interpolation technique[3]. For the purposes of the TIN model creation, TWDB assumed 0-feet sediment thicknesses at the model boundaries (defined as the 825.68 foot NAVD 88 elevation contour).

Results

The results of the TWDB 2007 Sedimentation Survey indicate Lake LBJ has accumulated 5,654 acre-feet of sediment since impoundment began in 1951. The thickest sediment deposits are in the submerged river channel throughout the main lake body, and sediment was not present in the Llano River arm, Colorado River arm, or Sandy Creek arm of Lake LBJ. This sediment distribution suggests incoming sediment quickly travels downstream within Lake LBJ, where it settles to the bottom, upstream of Wirtz Dam. The maximum sediment thickness observed in Lake LBJ was 7.1 feet. Figure D5 depicts the sediment thickness in Lake LBJ.

Based on the measured sediment volume in Lake LBJ and assuming a constant rate of sediment accumulation over the 56 years since impoundment, Lake LBJ loses approximately 100 acre-feet of capacity per year. This estimated loss rate is consistent with that calculated from volume comparisons between the 2007 survey and 1951 capacity estimate (Table 2 – Main Survey Report). To improve the sediment accumulation rate estimates, TWDB recommends Lake LBJ be re-surveyed using similar methods in approximately 10 years or after a major flood event. Additional point estimates of sediment accumulation rates may also be obtained through assessment of the Cesium-137 content within sediment cores.[1]

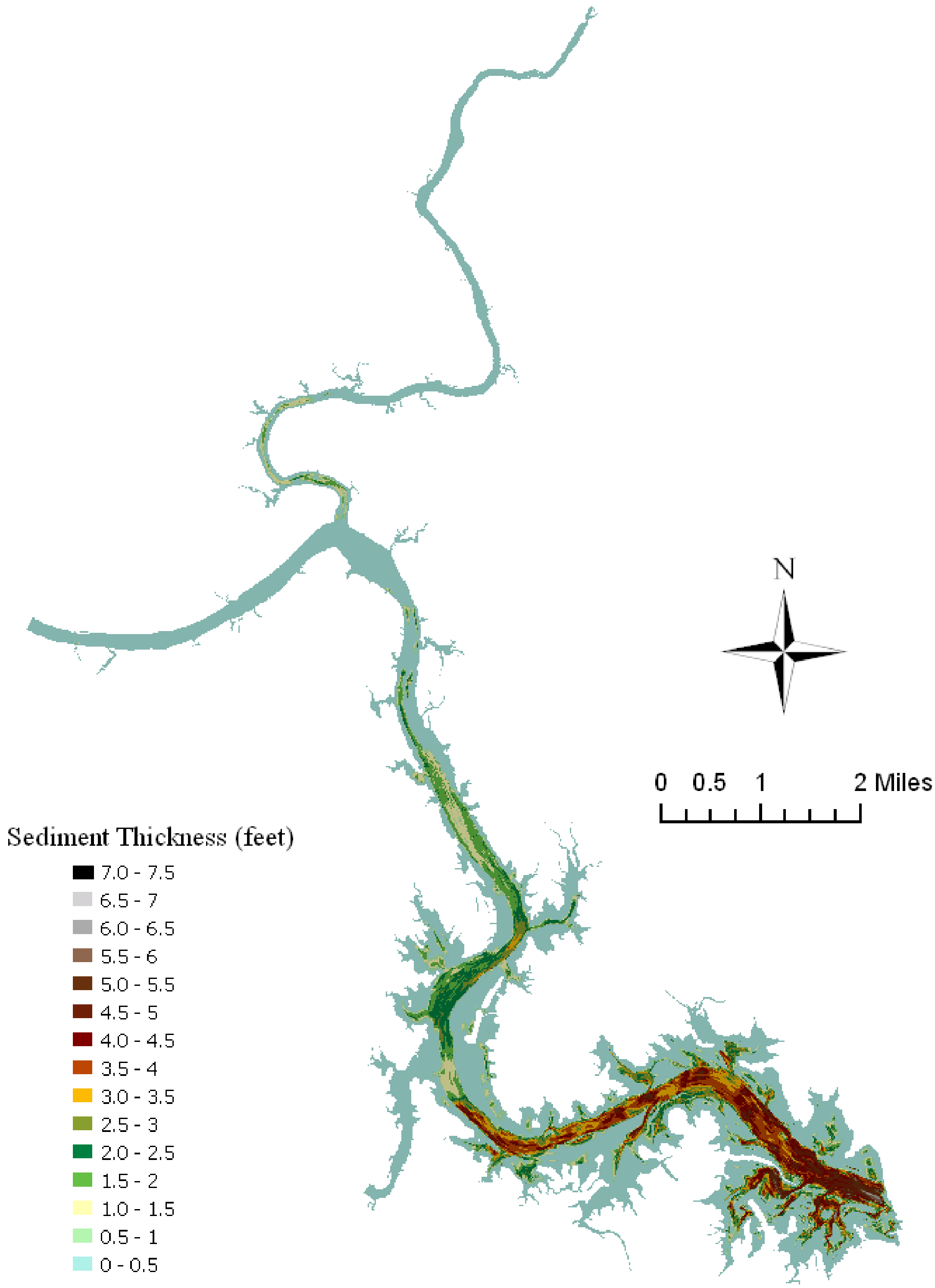


Figure D5 - Sediment thicknesses in Lake LBJ derived from multi-frequency sounding data.

References

1. Dunbar, John and Estep, Heidi. "Hydrographic Survey Program Assessment – Contract No. 0704800734 Final Report". Submitted to TWDB on 12/5/2008 from Baylor University
2. Furnans, J., Austin, B., Hydrographic survey methods for determining reservoir volume, Environmental Modelling & Software (2007), doi: 10.1016/j.envsoft.2007.05.011
3. Furnans, Jordan. Texas Water Development Board. 2006. "HydroEdit User's Manual."


Figure 6
TEXAS WATER DEVELOPMENT BOARD
CONTOURS
(in feet NAVD 88)
820
810
800
790
780
770
760
Islands
Lake LBJ
Conservation Pool Elevation:
825.68 feet (NAVD 88)
Projection: NAD83
State Plane
Texas Central Zone
Burnet and Llano 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 LBJ. The Texas Water Development Board makes no representation or assumes any liability.
Lake LBJ
10' - Contour Map
2,900,000
2,920,000
10,220,000
10,200,000
10,180,000
N
Miles
0
0.5
1
2
Prepared by: TEXAS WATER DEVELOPMENT BOARD May 2007 Survey