Volumetric and Sedimentation Survey of WRIGHT PATMAN LAKE

March - June 2010 Survey

Texas Water Development Board

August 2012

Texas Water Development Board

Prepared for:

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

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Executive summary

In December 2009, the Texas Water Development Board entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, to perform a volumetric and sedimentation survey of Wright Patman Lake. The U.S. Army Corps of Engineers, Fort Worth District, provided 100% of the funding for this survey through their Texas Water Allocation Assessment Program. Surveying 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 in select locations and correlated with the multi-frequency depth sounder signal returns to estimate sediment accumulation thicknesses and sedimentation rates.

Wright Patman Dam and Wright Patman Lake are located on the Sulphur River in Bowie and Cass Counties, nine miles southwest of Texarkana, Texas. TWDB collected bathymetric data for Wright Patman Lake between March 26, 2010, and June 7, 2010. The daily average water surface elevations during that time ranged between 235.32 and 226.58 feet above mean sea level (NGVD29).

The 2010 TWDB volumetric survey indicates Wright Patman Lake has a total reservoir capacity of 97,927 acre-feet and encompasses 18,247 acres at conservation pool elevation (220.6 feet above mean sea level, NGVD29). Previous capacity estimates include the original design estimate of 158,000 acre-feet at the time of impoundment in 1956, and a re-analysis of the 1997 TWDB volumetric survey data using current processing procedures that resulted in an updated capacity estimate of 115,715 acre-feet.

Based on two methods for estimating sedimentation rates, the 2010 TWDB sedimentation survey estimates Wright Patman Lake loses between 730 and 1,362 acre-feet of capacity per year due to sedimentation below conservation pool elevation (220.6 feet above mean sea level, NGVD29). Sediment accumulation is found throughout the lake. Pockets of greater sediment accumulation are dispersed throughout the lake, but do not match any patterns or features such as submerged river channels or floodplains. TWDB recommends that a similar methodology be used to resurvey Wright Patman Lake in 10 years or after a major flood event.

Table of Contents

List of Tables

List of Figures

Appendices

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

Introduction

The Hydrographic Survey Program of the Texas Water Development Board (TWDB) was authorized by the 72^{nd} Texas 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 December 2009, TWDB entered into an agreement with U.S. Army Corps of Engineers, Fort Worth District, to perform a volumetric and sedimentation survey of Wright Patman Lake. The U.S. Army Corps of Engineers, Fort Worth District, provided 100% of the funding for this survey through their Texas Water Allocation Assessment Program (TWDB, 2009). This report describes the methods used to conduct the volumetric and sedimentation survey, including data collection and processing techniques. This report serves as the final contract deliverable from TWDB to the U.S. Army Corps of Engineers, Fort Worth District and contains as deliverables: (1) an elevation-area-capacity table of the lake acceptable to the Texas Commission on Environmental Quality [Appendix A, B], (2) a bottom contour map [Figure 5], (3) a shaded relief plot of the lake bottom [Figure 3], and (4) an estimate of sediment accumulation and location [Figure 11].

Wright Patman Lake general information

Wright Patman Dam and Wright Patman Lake are located on the Sulphur River in Bowie and Cass Counties, nine miles southwest of Texarkana (Figure 1). Wright Patman Dam and Lake are owned and operated by the U.S. Army Corps of Engineers, Fort Worth District. Wright Patman Lake was built primarily as a water supply reservoir for the City of Texarkana and as flood protection for the Sulphur and Red Rivers (USACE, 2012).

Construction on Wright Patman Dam began on August 20, 1948, and the dam was completed on May 19, 1954. Water began flowing through the control structures on July 2, 1953, and deliberate impoundment began June 27, 1956 (TWDB, 1974, USACE, 2007). Additional pertinent data about Wright Patman Dam and Wright Patman Lake can be found in Table 1.

Water rights for Wright Patman Lake have been appropriated to the City of Texarkana through Certificate of Adjudication 03-4836. The complete certificate is on file in the Information Resources Division of the Texas Commission on Environmental Quality.

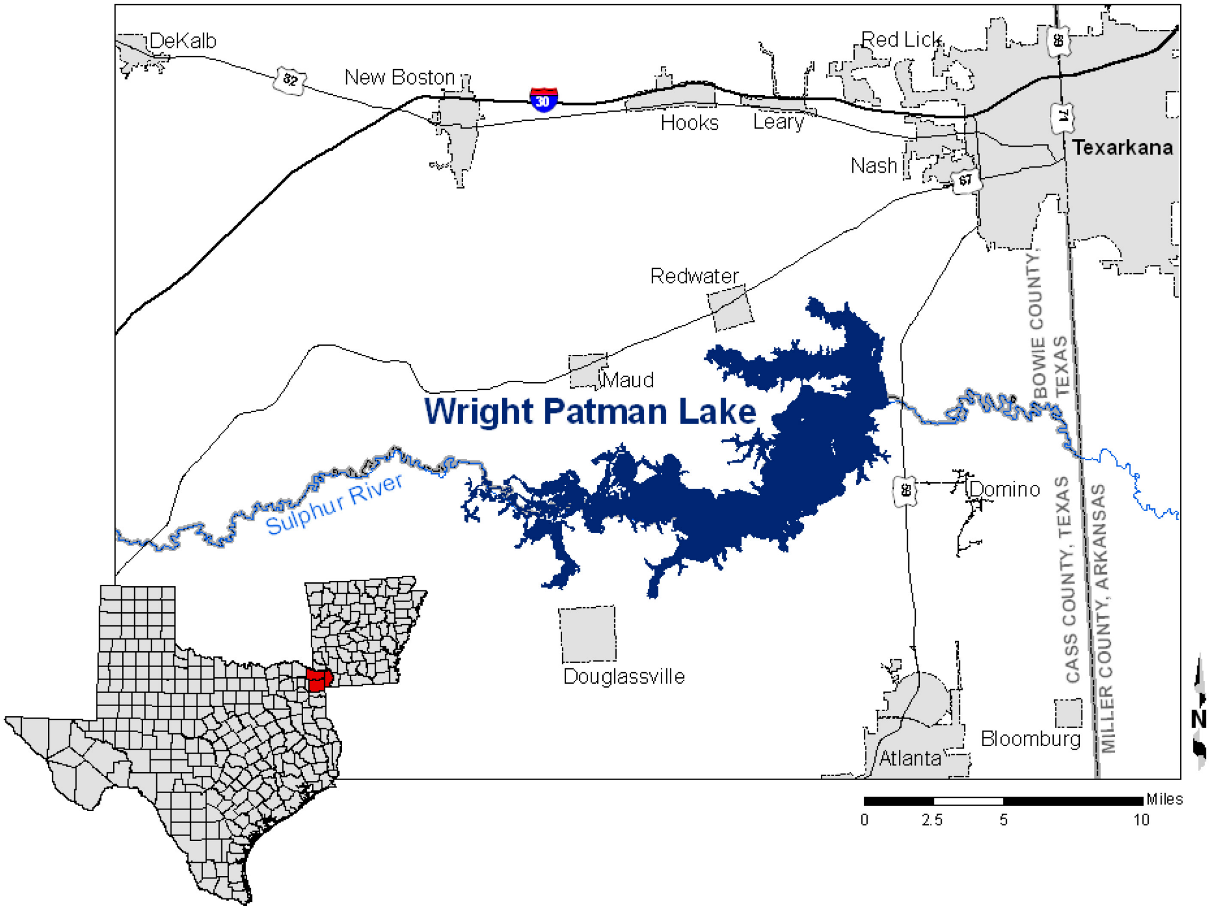


Figure 1. **Location map – Wright Patman Lake**

Table 1. Pertinent data for Wright Patman Dam and Wright Patman Lake

Owner			
U.S. Army Corps of Engineers, Fort Worth District			
Engineer (design)			
U.S. Army Corps of Engineers, New Orleans District			
Location of dam			
On the Sulphur River in Bowie and Cass Counties, 9 miles southwest of Texarkana			
Drainage area			
3,400 square miles			
Dam			
Type	Earthfill		
Length	18,500 feet		
Maximum height	106 feet		
Top width	30 feet		
Spillway			
Crest elevation	259.5 feet above mean sea level		
Length	200 feet		
Type	Concrete chute		
Outlet works			
Type	2 conduits, each 20-feet diameter		
Invert elevation	200 feet above mean sea level		
Control	4 gates, each 10 by 20 feet		
Reservoir data (based on 2010 TWDB survey)			
Feature	**Elevation (feet NGVD29[a])**	**Capacity (acre-feet)**	**Area (acres)**
Top of dam	286.0	N/A	N/A
Top of surcharge pool	278.9	N/A	N/A
Top of flood control pool	259.5	N/A	N/A
Reservoir operating levels:			
November 1 – March 31	220.6	97,927	18,247
April 1 – May 31	227.5	*	*
June 1 – October 4	225.0	195,398	24,705
October 5 – October 31	221.2	109,275	19,584
Invert of conduits	200.0	27	20
Streambed	180.0	0	0

Source: (TWDB, 1974, USACE, 2006, USACE, 2007)

* 2010 area and capacity estimates calculated only to elevation 226.3 feet due to survey conditions.

[a] NGVD29 = National Geodetic Vertical Datum 1929

Volumetric and sedimentation survey of Wright Patman Lake

Datum

The vertical datum used during this survey is the National Geodetic Vertical Datum 1929 (NGVD29). This datum is also utilized by the United States Geological Survey (USGS) for the reservoir elevation gage *USGS 07344200 Wright Patman Lk nr Texarkana, TX* (USGS, 2011). Elevations herein are reported in feet above mean sea level relative to the NGVD29 datum. Volume and area calculations in this report are referenced to water levels provided by the USGS gage. The horizontal datum used for this report is North American Datum 1983 (NAD83), and the horizontal coordinate system is State Plane Texas North Central Zone (feet).

TWDB bathymetric and sedimentation data collection

TWDB collected bathymetric data for Wright Patman Lake between March 26, 2010, and June 7, 2010. The daily average water surface elevations during that time ranged between 235.32 and 226.58 feet above mean sea level (NGVD29). Data was collected using a Specialty Devices, Inc., single-beam, 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 submerged river channels and spaced approximately 500 feet apart. Many of the survey lines were also surveyed by TWDB during the 1997 survey. The depth sounder was calibrated daily using a velocity profiler to measure the speed of sound in the water column and a weighted tape or stadia rod for depth reading verification. Figure 2 shows where data was collected during the 2010 TWDB survey.

All sounding data was collected and reviewed before sediment core sample sites were selected. Sediment core samples are collected at regularly spaced intervals within the lake, or at locations where interpretation of the acoustic display would be difficult without site-specific sediment core data. Following analysis of the sounding data, TWDB selected five locations where sounding data had been previously collected (Figure 2) to collect sediment core samples. The samples were collected on April 3, 2012, with a custom sediment coring boat and SDI VibraCore system.

Sediment cores are collected in 3-inch diameter aluminum tubes. Analysis of the acoustic data collected during the bathymetric survey assists in determining the depth of penetration to which the tube must be driven during sediment sampling. The goal is to collect a sediment core sample extending from the current lake bottom, through the accumulated sediment, and to the pre-impoundment surface. After retrieving the sample, a stadia rod is inserted into the top of the tube to assist in locating the top of the sediment in the tube. This identifies the location of the layer corresponding to the current reservoir surface. The aluminum tube is cut to this level, capped, and transported back to TWDB headquarters for further analysis. During this time, some settling of the upper layer can occur.

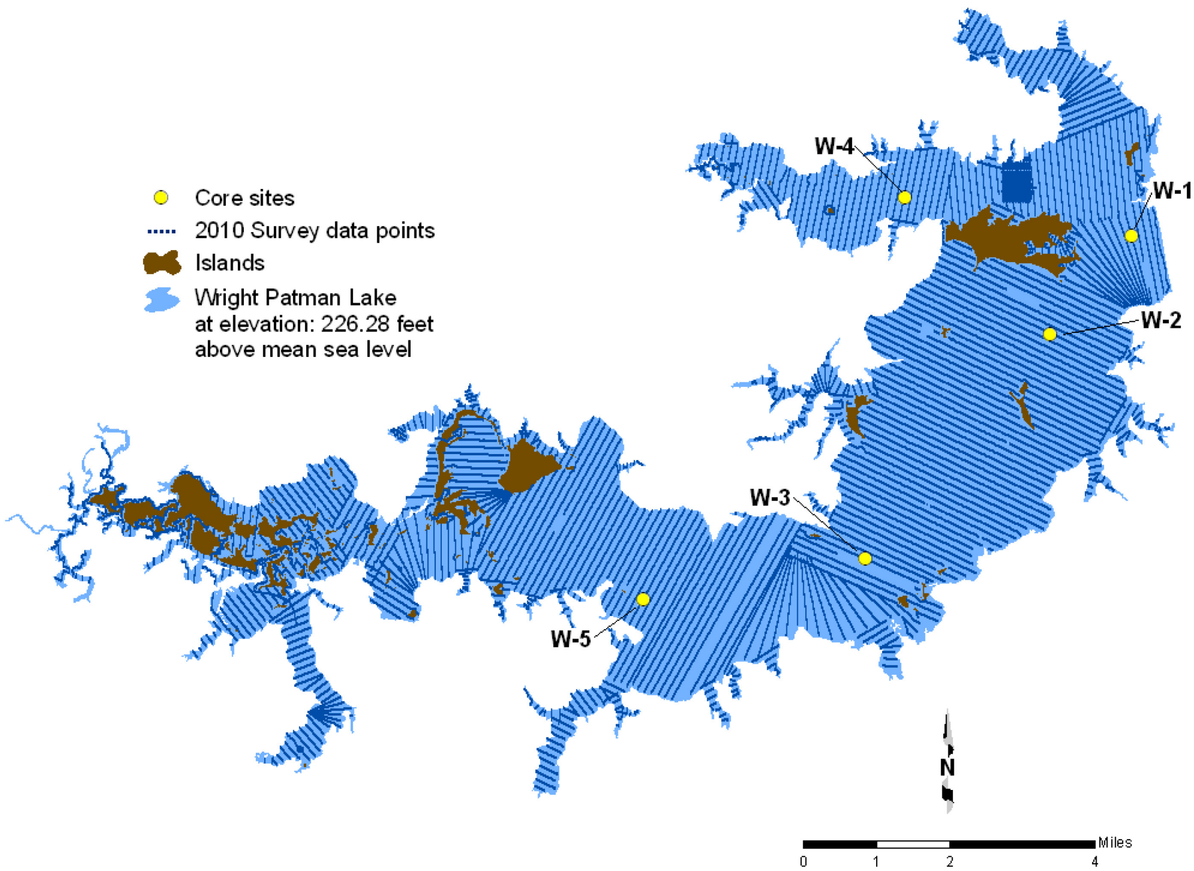


Figure 2. **Data collected during 2010 TWDB Wright Patman Lake survey**

Data processing

Model boundaries

The reservoir boundary was digitized from aerial photographs, also known as digital orthophoto quarter-quadrangle images (DOQQs), obtained from the Texas Natural Resources Information System (TNRIS, 2009) using Environmental Systems Research Institute's ArcGIS 9.3.1 software. The quarter-quadrangles that cover Wright Patman Lake are Wright Patman Lake (NW, NE, SW, SE), Maud (NE, SW, SE), Corley (SW, SE), Bryans Mill (NE), Douglassville (NW, NE), and Atlanta North (NW). The DOQQs were photographed on August 3, 2010, and August 13, 2010, while the daily average water surface elevation measured 226.48 and 226.08 feet above mean sea level, respectively. According to metadata associated with the 2010 DOQQS, the photographs have a resolution or ground sample distance of 1.0-meters and a horizontal accuracy within + / - 6 meters to true ground (USDA, 2011, TNRIS, 2010). For this analysis, the boundary was digitized at the land-water interface in the 2010 photographs and given an elevation of 226.28 feet above mean sea level, the average elevation of the lake at the time of the photographs.

Triangulated Irregular Network model

Following completion of data collection, the raw data files collected by TWDB were edited to remove data anomalies. The reservoirs current bottom surface is automatically determined by the data acquisition software. TWDB developed an algorithm to automatically determine the pre-impoundment surface, i.e. sediment thickness, based on the intensity of the acoustic returns. DepthPic is used to display, interpret, and edit the multi-frequency data by manually removing data anomalies in both the current bottom surface and pre-impoundment surface. An in-house software package, HydroTools, is used to identify the current reservoir–bottom surface, pre-impoundment surface and sediment thickness at each sounding location and output the data into a single file. The water surface elevation at the time of each sounding was used to convert each sounding depth to a corresponding reservoir-bottom elevation. For processing outside of DepthPic, the sounding coordinates were exported. Using the self-similar interpolation technique described below (Furnans, 2006), TWDB created additional interpolated bathymetric elevation data between surveyed cross sections. To approximate reservoir bathymetry in shallow, un-surveyed regions, TWDB used the line extrapolation technique described below (Furnans, 2006). The point files resulting from both the data interpolation and extrapolation were exported, and used in conjunction with the sounding and boundary files to create a Triangulated Irregular Network (TIN) model with the 3D Analyst Extension of ArcGIS. The 3D Analyst algorithm uses Delaunay's criteria for triangulation to create a grid composed of triangles from non-uniformly spaced points, including the boundary vertices (ESRI, 1995).

Area, volume, and contour calculations

Using ArcInfo software and the TIN models, volumes and areas were calculated for the entire reservoir at 0.1 feet intervals, from elevation 189.6 to 226.3 feet. The elevation-capacity table and elevation-area table, updated for 2010, are presented in Appendices A and B, respectively. The area-capacity curves are presented in Appendix C.

The volumetric TIN model was converted to a raster representation using a cell size of 2 feet by 2 feet. The raster data was then used to produce an elevation relief map (Figure 3), representing the topography of the reservoir bottom, a depth range map (Figure 4), showing shaded depth ranges for Wright Patman Lake, and a 2-foot contour map (Figure 5 - attached).

Self-similar interpolation

The 3D Analyst extension of ArcGIS utilizes the Delaunay method for triangulation. A limitation of the Delaunay method for triangulation when creating TIN models results in artificially-curved contour lines extending into the reservoir where the reservoir walls are steep and the reservoir is relatively narrow. These curved contours are likely a poor representation of the true reservoir bathymetry in these areas. Also, if the surveyed cross sections are not perpendicular to the centerline of the submerged river channel (the location of which is often unknown until after the survey), the TIN model is not likely to represent the true channel bathymetry well.To ameliorate these problems, a self-similar interpolation routine developed by TWDB was used to interpolate the bathymetry between many survey lines. The self-similar interpolation technique increases the density of points input into the TIN model, and directs the TIN interpolation to better represent the reservoir topography between cross sections (Furnans, 2006). In the case of Wright Patman Lake, application of self-similar interpolation improved representation of the lake morphology near the banks and submerged river channels (Figure 6). In areas where obvious geomorphic features

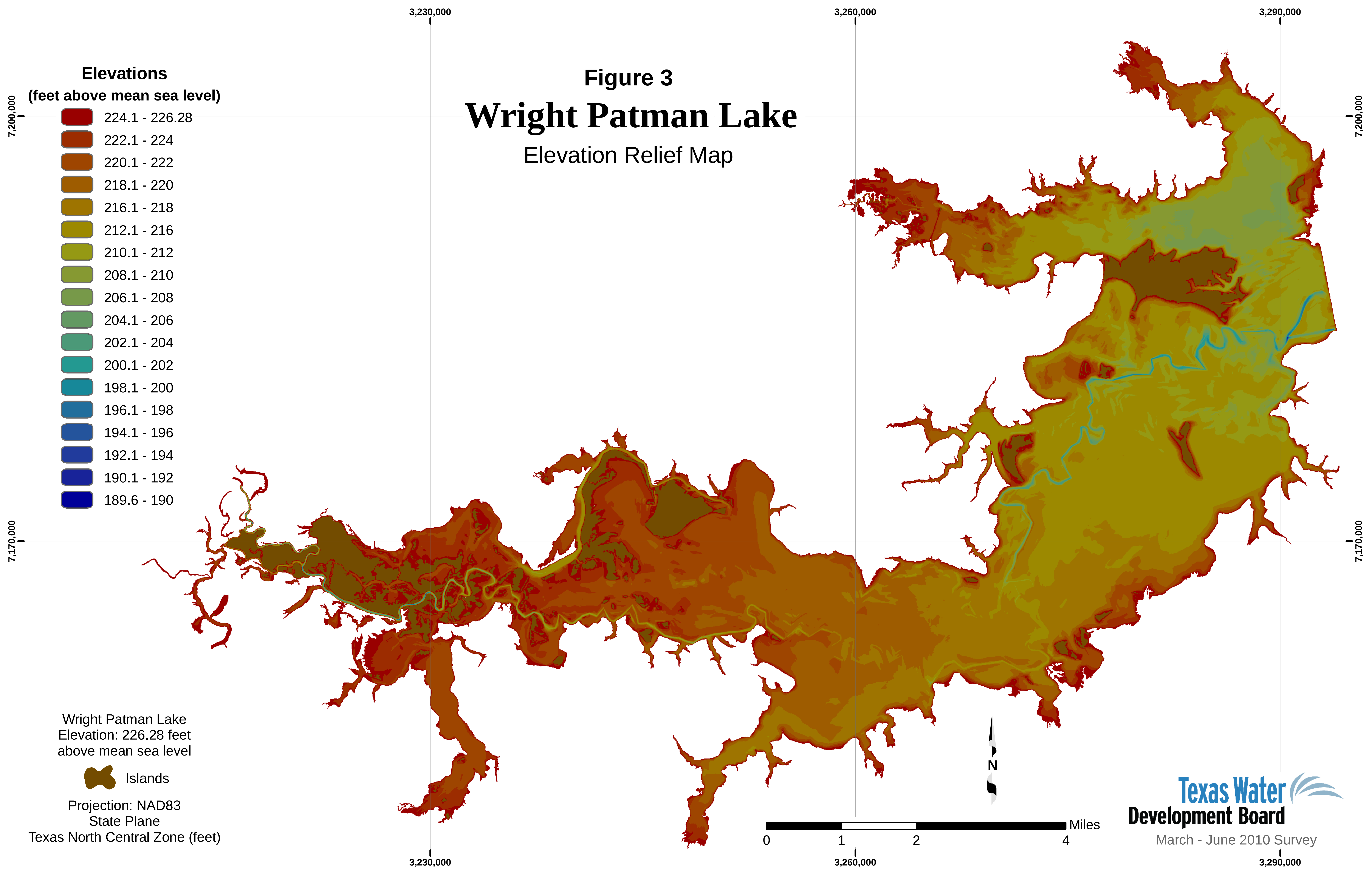
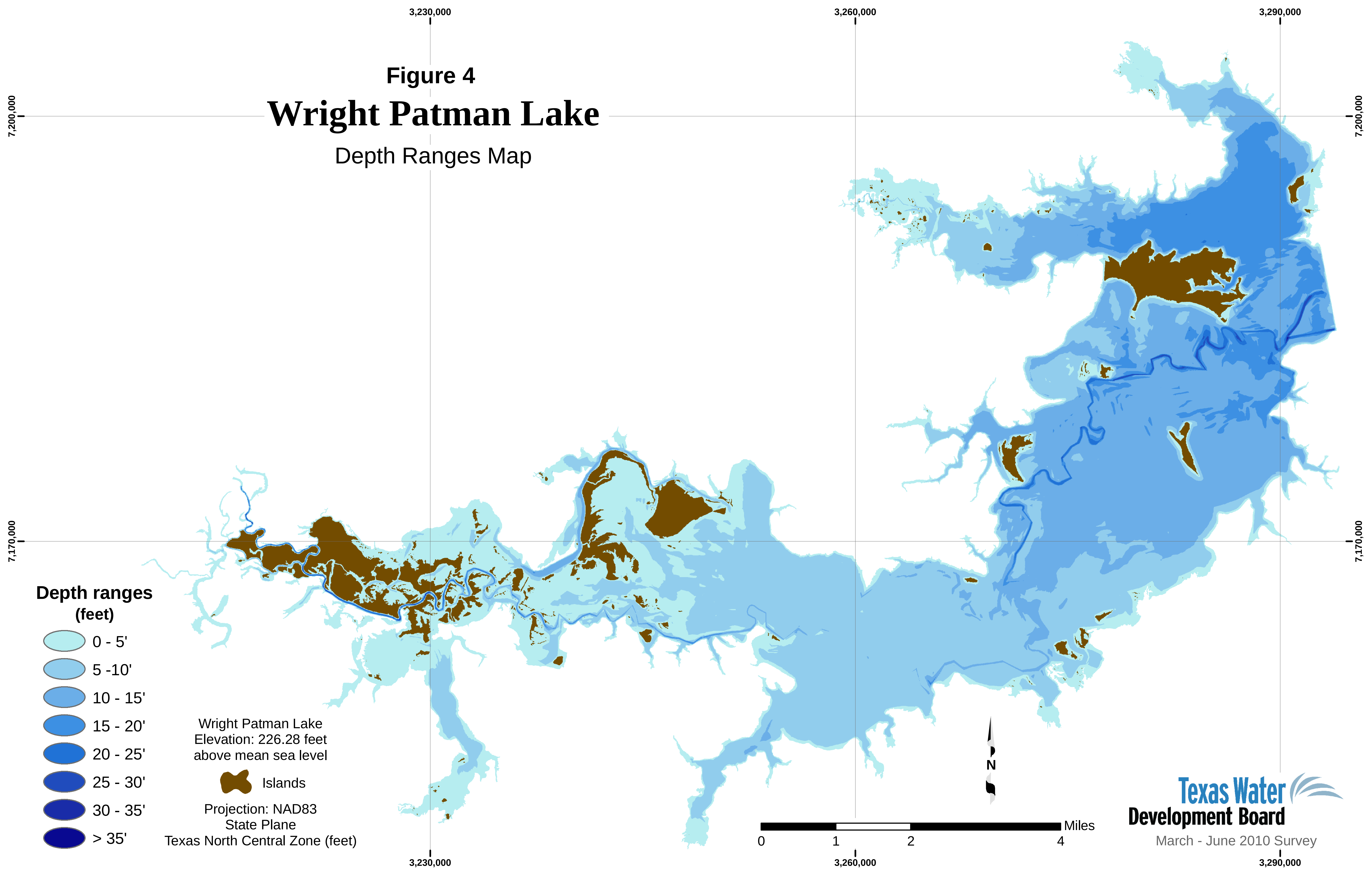


Figure 3
Wright Patman Lake
Elevation Relief Map
Elevations
(feet above mean sea level)
224.1 - 226.28
222.1 - 224
220.1 - 222
218.1 - 220
216.1 - 218
212.1 - 216
210.1 - 212
208.1 - 210
206.1 - 208
204.1 - 206
202.1 - 204
200.1 - 202
198.1 - 200
196.1 - 198
194.1 - 196
192.1 - 194
190.1 - 192
189.6 - 190
Wright Patman Lake
Elevation: 226.28 feet
above mean sea level
Islands
Projection: NAD83
State Plane
Texas North Central Zone (feet)
3,230,000
3,260,000
3,290,000
7,200,000
7,170,000
N
Miles
0
1
2
4
Texas Water
Development Board
March - June 2010 Survey


3,230,000
3,260,000
3,290,000
7,200,000
7,170,000
Figure 4
Wright Patman Lake
Depth Ranges Map
Depth ranges
(feet)
0 - 5'
5 -10'
10 - 15'
15 - 20'
20 - 25'
25 - 30'
30 - 35'
> 35'
Wright Patman Lake
Elevation: 226.28 feet
above mean sea level
Islands
Projection: NAD83
State Plane
Texas North Central Zone (feet)
N
Miles
0
1
2
4
Texas Water
Development Board
March - June 2010 Survey

indicate a high-probability of cross-sectional shape changes (e.g. incoming tributaries, significant widening/narrowing of channel, etc.), the assumptions used in applying self-similar interpolation are not likely to be valid. Therefore, interpolation was not used in areas of Wright Patman Lake where a high probability of change between cross-sections exists. Interpolation points are added, and channels delineated, based on scanned USGS 7.5 minute quadrangle maps known as Digital Raster Graphics, and hypsography, the vector format of USGS 7.5 minute quadrangle map contours, when available (USGS, 2007). Figure 6 illustrates typical results from the self-similar interpolation routine for Wright Patman Lake. The bathymetry shown in Figure 6C was used in computing reservoir capacity and area tables (Appendix A, B).

In Figure 6A the deeper channels indicated by the surveyed cross sections are not continuously represented in the areas between survey cross sections. This is an artifact of the TIN generation routine, rather than an accurate representation of the physical bathymetric surface. Inclusion of interpolation points, represented in Figure 6B, in creation of the TIN model directs the Delaunay method for triangulation to better represent the lake bathymetry between survey cross-sections.

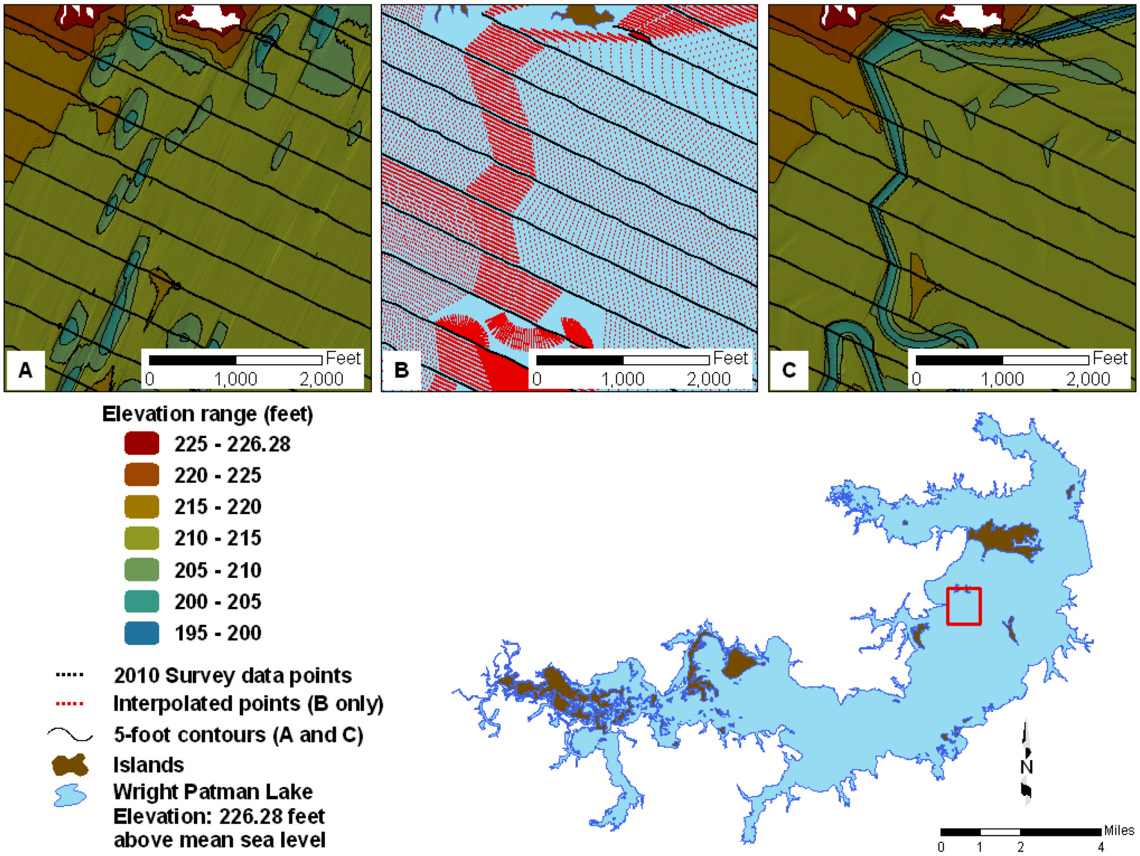


Figure 6. **Application of the self-similar interpolation technique to Wright Patman Lake sounding data – A) bathymetric contours without interpolated points, B) sounding points (black) and interpolated points (red), C) bathymetric contours with the interpolated points**

Line extrapolation

In order to estimate the bathymetry within the small coves and other un-surveyed portions of Wright Patman Lake, TWDB applied a line extrapolation technique similar to the interpolation discussed above. TWDB uses line extrapolation to project bathymetries in small coves or where water depths are too shallow to allow boat passage. Line extrapolation requires the user to define (1) a center line approximately bisecting the small cove, (2) the elevation at the beginning of the center line, (3) the number of cross sections along the center line, and (4) the number of points between the center line and the cove boundary. The starting elevation of the center line is estimated based on the nearest surveyed depth.

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

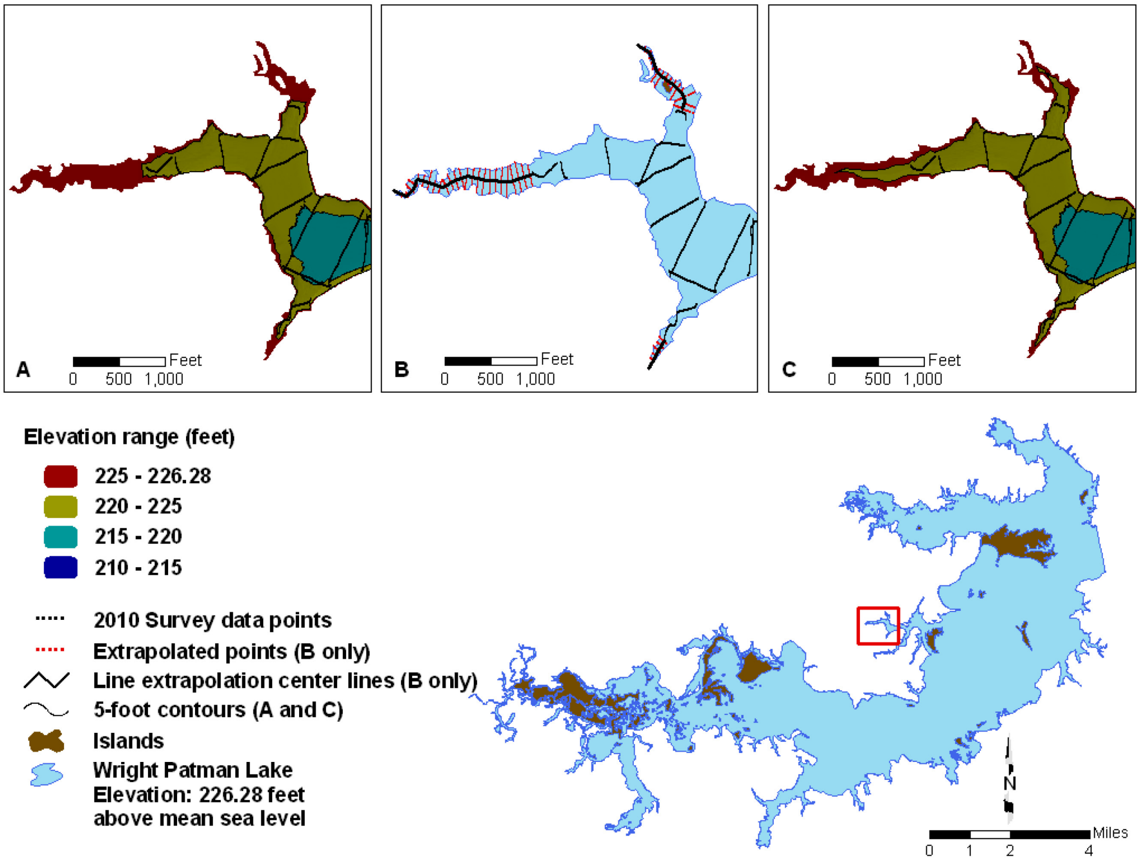


Figure 7. **Application of the line extrapolation technique to Wright Patman Lake sounding data – A) bathymetric contours without extrapolated points, B) Sounding points (black), extrapolated points (red), with reservoir boundary shown at elevation 226.28 feet, and C) bathymetric contours with extrapolated points**

As shown in Figure 7A, the bathymetric contours do not extend into the un-surveyed area and flat triangles are formed connecting the nodes of the reservoir boundary. This is an artifact of the TIN model generation routine when data points are too far apart or are absent from portions of the reservoir.

The inherent assumption of line extrapolation is that a V-shaped cross section is a reasonable approximation of the actual unknown cross-section within the extrapolated area. 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 Wright Patman Lake had shapes more similar to U-profiles than to V-profiles. The V-profiles are thus conservative due to a greater implied volume of water for a U-profile when compared to a V-profile. Further information on line extrapolation is provided in the HydroEdit User's Manual (Furnans, 2006).

Analysis of sediment data from Wright Patman Lake

Sedimentation in Wright Patman Lake was determined by analyzing all three depth sounder frequencies in the DepthPic software. The 200 kHz signal was used to determine the current bathymetric surface of the lake, while all three frequencies, 200 kHz, 50 kHz and 24 kHz, were used to determine the reservoir bathymetric surface at the time of initial impoundment (i.e. pre-impoundment surface). Sediment core samples collected in the lake were used to assist in identifying the location of the pre-impoundment surface in the acoustic signals. The difference between the current surface and the pre-impoundment surface yields a sediment thickness value at each sounding location.

Analysis of the sediment core samples was conducted at TWDB headquarters in Austin. Each sample was split longitudinally and analyzed to identify the location of the pre-impoundment surface. The pre-impoundment surface is identified within the sediment core sample by one of the following methods: (1) a visual examination of the sediment 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 (Van Metre et al, 2004). The total sample length, sediment thickness and the pre-impoundment thickness were recorded. Physical characteristics of the sediment core, including color, texture, relative water content, and presence of organic materials, were also recorded (Table 2).

Table 2: Sediment core sampling analysis data – Wright Patman Lake

Core	Easting[a] (feet)	Northing[a] (feet)	Total core sample/post-impoundment sediment	Sediment core description	Munsell soil color
W-1	3291158.90	7188928.77	23.75"/21"	0-12" thin water logged sediment	5y 2.5/2
				12-18" gelatinous, clay loam	5y 3/2
				18-21" gelatinous, somewhat denser than above layer, clay loam	5y 4/2
				21-23.75" dense clay soil with organics present	10yr 4/1
W-2	3285255.55	7181811.69	16"/12"	0-9" high water content, no structure, clay loam	5y 2.5/1
				9-12" lower water content, clay loam, peds and roots present	10yr 3/1
				12-16" clay loam, peds and roots present	7.5yr 3/1
W-3	3271809.48	7165516.37	60"/N/A"	0-28" high water content, clay loam	10yr 3/1
				28-60" high water content, clay loam, pre-impoundment surface possibly not reached	7.5yr 3/2
W-4	3274701.73	7191688.00	48"/21"	0-12" highly water logged, silty clay	5y 2.5/2
				12-21" lower water content, clay loam	5y 3/2
				21-48" dense clay soil, organics present	7.5yr 5/1
W-5	3255769.72	7162569.34	21"/16"	0-13" high water content, clay loam	5yr 4/1
				13-16" high water content, peds present	2.5y 3/1
				16-21" soil peds present, organics present below 14", dense clay soil at bottom	10yr 4/1

[a] Coordinates are based on NAD83 State Plane Texas North Central System (feet)

A photograph of sediment core W-4 is shown in Figure 8 and is representative of the sediment cores sampled from Wright Patman Lake. The 200 kHz frequency measures the top layer as the current bottom surface of the reservoir.

Figure 8. Sediment core W-4 from Wright Patman Lake

Sediment core sample W-4 consisted of 48 inches of total sediment corresponding to the length of the aluminum sampling tube (tape measure is shown for scale). The upper sediment layer (horizon), 0 – 12 inches, consisted of highly water logged, silty clay sediment, and measured 5y 2.5/2 on the Munsell soil color chart. The second horizon, beginning at 12 inches and extending to 21 inches below the surface, consisted of a clay loam with a lower water content and a 5y 3/2 Munsell soil color. The third horizon consisted of very dense clay soil with organics and a 7.5yr 5/1 Munsell soil color.

The pre-impoundment boundary (red line in Figure 8) was evident within this sediment core sample at 21 inches and is identified by the change in soil color, texture, moisture, porosity, and structure. Identification of the pre-impoundment surface for the remaining sediment cores followed a similar procedure.

Figures 9 and 10 illustrate how the sediment thickness identified from a sediment core sample is used with the sounding data to help identify the post-impoundment sediment interface in the acoustic signal. Within DepthPic, the current surface is automatically determined based on the signal returns from the 200 kHz transducer and verified by TWDB staff, while the pre-impoundment surface must be determined visually.

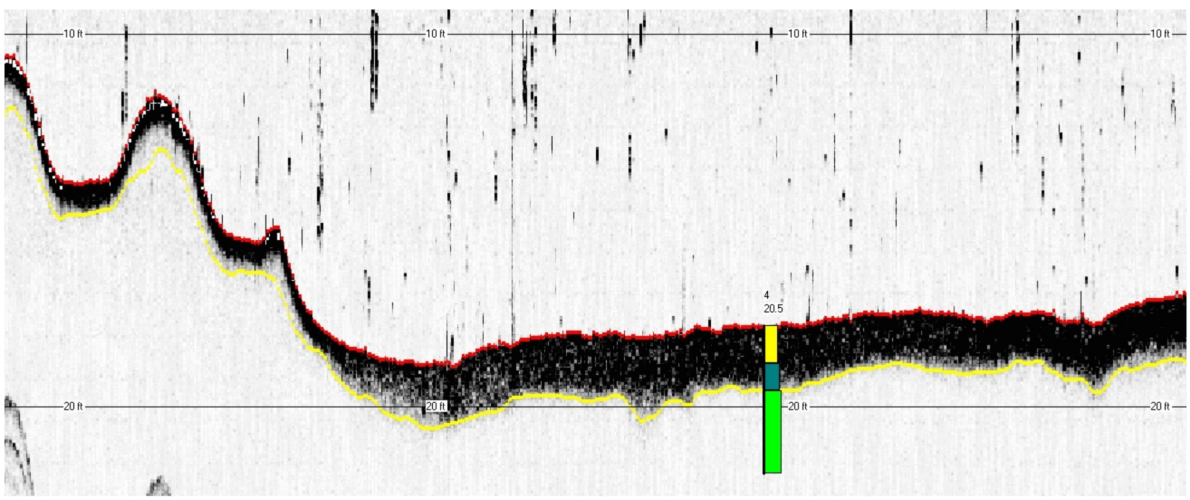


Figure 9. **Cross-section of data collected during 2010 survey, displayed in DepthPic (200 kHz frequency), correlated with sediment core sample W-4 and showing the current surface in red and pre-impoundment surface in yellow**

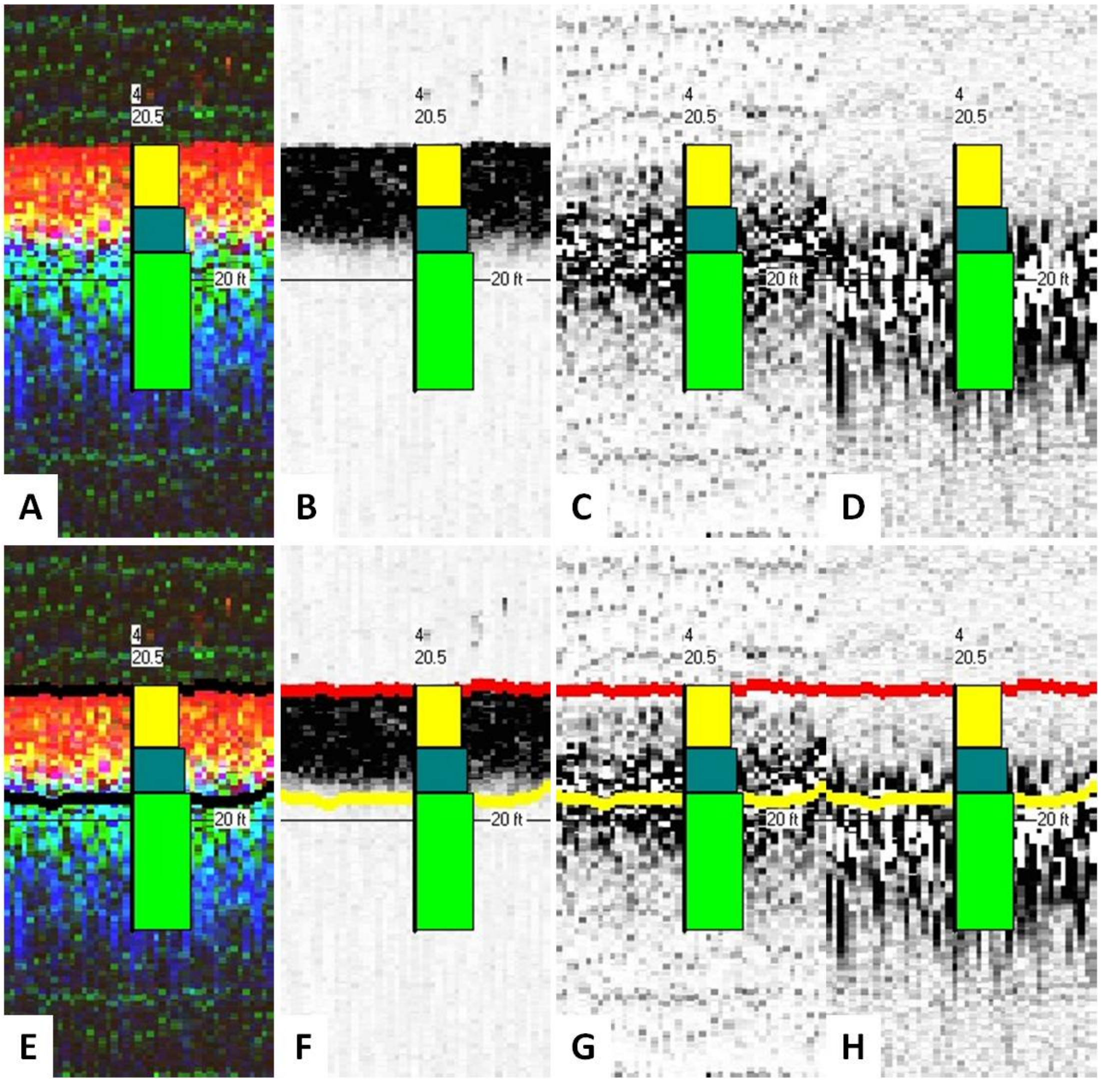


Figure 10. **Comparison of sediment core W-4 with acoustic signal returns A,E) combined acoustic signal returns, B,F) 200 kHz frequency, C,G) 50 kHz frequency, D,H) 24 kHz frequency**

Figure 10 shows the acoustic signals for all frequencies combined (A, E), 200 kHz (B, F), 50 kHz (C, G), and 24 kHz (D, H). The sediment core sample is represented in each figure as colored boxes. The yellow and blue boxes represent post-impoundment sediment based on analysis of sample W-4 (Figure 8, Table 2). The yellow box is the first layer, 12 inches of highly water logged silty clay, while the blue box represents clay loam sediment of lower water content. The green box represents the pre-impoundment sediment consisting of a dense clay soil with organics. In figure 10A-D, the bathymetric surfaces are not shown. In figure 10E, the current bathymetric surface is represented as the top black line and in Figures 10F-H as the top red line. The pre-impoundment surface is visually identified by comparing boundaries observed in the 200 kHz, 50 kHz, and 24 kHz signals to the location of the pre-impoundment surface based on the core sample (designated by the location of the interface between the blue and green boxes). In this example, the change in the 200 kHz signal most closely matched the pre-impoundment interface based on the sediment core sample; therefore, the 200 kHz signal was used to locate the pre-impoundment layer. TWDB used an algorithm based on the intensity of the acoustic returns of the 200 kHz frequency to select the pre-impoundment surface. Using the cumulative distribution of the signal intensity for each acoustic sounding, the location of the pre-impoundment surface was selected as the location in the cumulative distribution above which 98 percent of the reflected intensity was found. Each profile was visually inspected to verify the surface was selected as expected. DepthPic was used to manually edit the surface where this technique was unable to accurately locate the surface, for example, in shallow vegetated areas, and steep slopes such as those found in river channels. The pre-impoundment surface is represented by the bottom black line in Figure 10E, and by the yellow line in Figures 10F-H. The pre-impoundment surface identified along cross-sections where sediment core samples were collected is used as a guide for identifying the pre-impoundment surface along cross-sections where sediment core samples were not collected.

After the pre-impoundment surface from all cross-sections was identified, a sediment thickness TIN model is created following standard GIS techniques (Furnans, 2007). Sediment thicknesses were interpolated between surveyed cross-sections using the TWDB self-similar interpolation technique (Furnans, 2006). For the purposes of the TIN model creation, TWDB assumed sediment thickness at the model boundary was zero feet (defined as the 226.28 foot NGVD29 elevation contour). This TIN model was converted to a raster representation using a cell size of 5 feet by 5 feet and used to produce a sediment thickness map (Figure 11) representing sediment accumulation throughout Wright Patman Lake.

Survey results

Volumetric survey

The results of the 2010 TWDB volumetric survey indicate Wright Patman Lake has a total reservoir capacity of 97,927 acre-feet and encompasses 18,247 acres at conservation pool elevation (220.6 feet above mean sea level, NGVD29). The U.S. Army Corps of Engineers, Fort Worth District estimated the original design capacity of

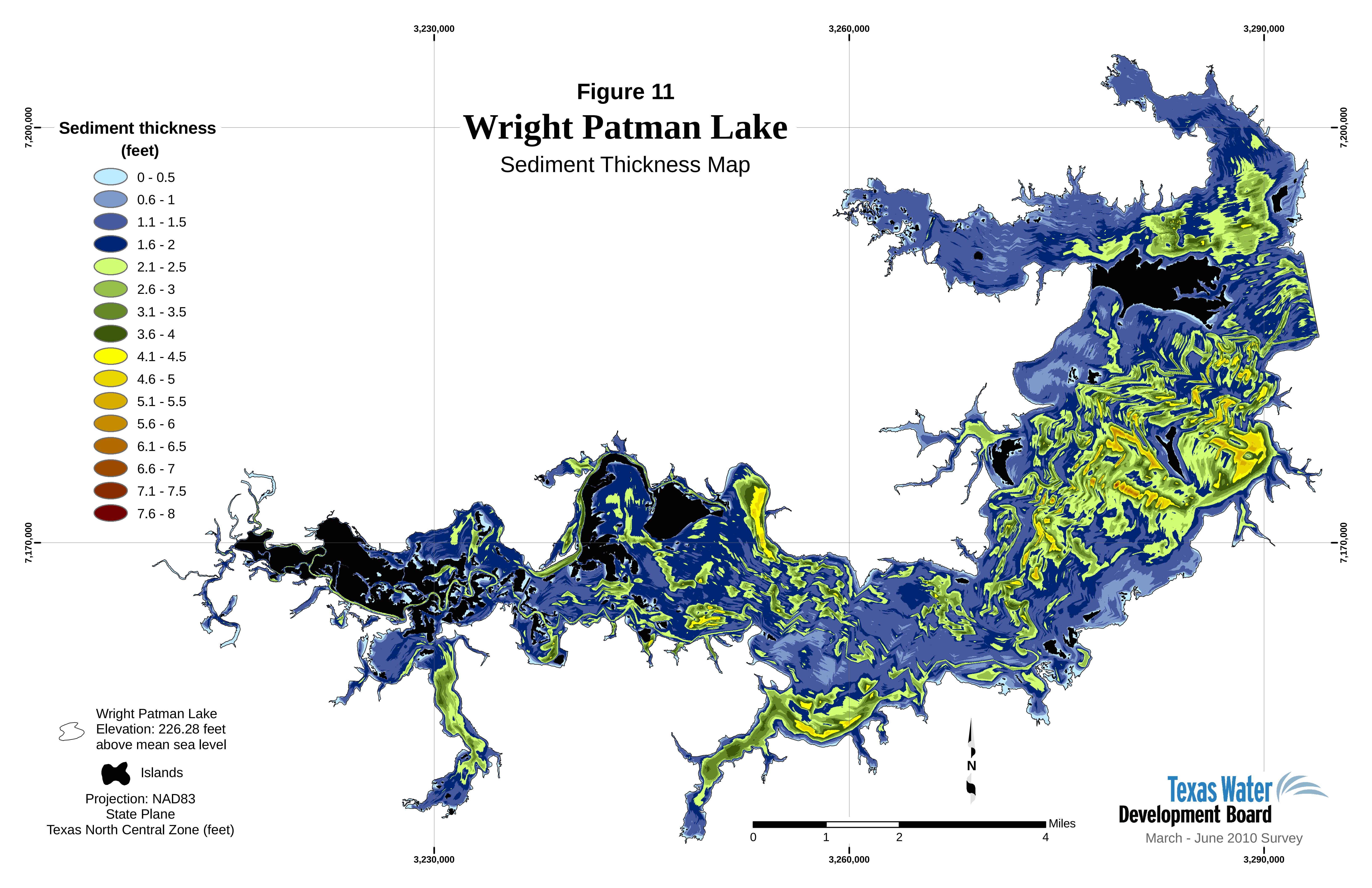


Figure 11
Wright Patman Lake
Sediment Thickness Map
Sediment thickness (feet)
0 - 0.5
0.6 - 1
1.1 - 1.5
1.6 - 2
2.1 - 2.5
2.6 - 3
3.1 - 3.5
3.6 - 4
4.1 - 4.5
4.6 - 5
5.1 - 5.5
5.6 - 6
6.1 - 6.5
6.6 - 7
7.1 - 7.5
7.6 - 8
Wright Patman Lake Elevation: 226.28 feet above mean sea level
Islands
Projection: NAD83 State Plane Texas North Central Zone (feet)
3,230,000
3,260,000
3,290,000
7,200,000
7,170,000
N
Miles
0
1
2
4
Texas Water Development Board
March - June 2010 Survey

Wright Patman Lake to be 158,000 acre-feet encompassing 20,300 acres at elevation 220.6 feet (USACE, 2011a). Differences in past and present survey methodologies make direct comparison of volumetric surveys difficult and potentially unreliable.

To properly compare results from TWDB surveys of Wright Patman Lake, TWDB applied the 2010 data processing techniques to the survey data collected in 1997. Specifically, TWDB applied the self-similar interpolation and line extrapolation techniques to the 1997 survey dataset (Furnans, 2006). The original 1997 survey boundary was created from the 230.0 feet contour from 7.5 minute USGS quadrangle maps, with a stated accuracy of ± 1/2 the contour interval (USBB, 1947). To better define the reservoir's elevation-area-volume relationship, the original boundary was replaced with a new boundary created by digitizing the land water interface in DOQQs from 1995, which were not available at the time of the 1997 survey. The 1995 aerial photographs were taken on February 5, March 8, and March 9, 1995, while the water surface elevation of the lake measured 225.73, 223.16, and 223.17 feet, respectively (USACE, 2011b). According to the associated metadata, the 1995 DOQQs have a resolution of 1-meter, with a horizontal positional accuracy that meets the National Map Accuracy Standards (NMAS) for 1:12,000-scale products. The majority of the lake was photographed at the higher water surface elevation of 225.73 feet. For the areas of the lake near the dam and in the upper reaches that were photographed at the lower water surface elevations, the boundary was digitized at the tree line. The digitized boundary was validated against the 1997 TWDB survey data points where possible. The resulting boundary was given an elevation of 225.73 feet for use in the TIN model. The revised results are presented in Table 3.

Table 3. Capacity and area comparisons for Wright Patman Lake

Elevation (feet)	USACE [a]		TWDB 1997		TWDB 1997 revised		TWDB 2010	
	Capacity (acre-feet)	Area (acres)	Capacity (acre-feet)	Area (acres)	Capacity (acre-feet)	Area (acres)	Capacity (acre-feet)	Area (acres)
220.6	158,000	20,300	122,640	20,143	115,638	18,828	97,927	18,247
221.2	N/A	N/A	135,120	21,467	127,257	19,906	109,275	19,584
225.0	N/A	N/A	231,540	28,297	211,830	23,949	195,398	24,705
227.5	N/A	N/A	308,020	31,589	*	*	*	*

[a] Source: (USACE, 2011a)

* 2010 area and capacity estimates calculated only to elevation 226.3 feet and revised 1997 area and capacity estimates calculated only to elevation 225.7 feet due to survey conditions.

Sedimentation survey

Based on two methods for estimating sedimentation rates, the 2010 TWDB sedimentation survey estimates Wright Patman Lake loses between 730 and 1,362 acre-feet of capacity per year due to sedimentation (Table 4) below conservation pool elevation (220.6 feet above mean sea level, NGVD29). Sediment accumulation is found throughout the lake. Pockets of greater sediment accumulation are dispersed throughout the lake, but do not match any patterns or features such as submerged river channels or floodplains.

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

Sedimentation rates were calculated based on the difference between the current volumetric survey and the original design estimate; the current capacity estimation and the 2010 pre-impoundment capacity estimation; as well as the current volumetric capacity estimation and the revised 1997 volumetric capacity estimation (Table 4). Based on the 2010 estimated sediment volume, Wright Patman Lake lost an average of approximately 730 acre-feet of capacity per year from 1956 to 2010. Comparison of the current volumetric survey to the 1997 revised volumetric survey at elevation 220.6 feet suggests the current rate of sedimentation in Wright Patman Lake is approximately 1,368 acre-feet per year. Comparison of capacity estimates of Wright Patman Lake derived using differing methodologies are provided in Table 4 for sedimentation rate calculation.

Table 4. **Capacity loss comparisons for Wright Patman Lake**

Survey	Comparisons @ 220.6		
	Volume (acre-ft)		Pre-impoundment (acre-ft)
	Comparison #1	Comparison #2	Comparison #3
Original design estimate[a]	158,000	<>	<>
TWDB pre-impoundment estimate based on 2010 survey	<>	<>	137,336[b]
1997 TWDB volumetric survey (revised)	<>	115,638	<>
2010 volumetric survey	97,927	97,927	97,927
Volume difference (acre-feet)	60,073 (38%)	17,711 (15.3%)	39,409 (28.7%)
Number of years	54	13	54
Capacity loss rate (acre-feet/year)	1,112	1,362	730

[a] Source: (TWDB, 1974), note: Wright Patman Dam was completed on May 19, 1954, and deliberate impoundment began on June 27, 1956.
[b] 2010 TWDB surveyed capacity of 97,927 acre-feet plus 2010 TWDB surveyed sediment volume of 39,409 acre-feet.

Recommendations

To improve estimates of sediment accumulation rates, TWDB recommends resurveying Wright Patman Lake in approximately 10 years or after a major flood event. To further improve estimates of sediment accumulation, TWDB recommends another sedimentation survey. A re-survey would allow a more accurate quantification of the average sediment accumulation rate for Wright Patman Lake.

TWDB contact information

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

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Appendix A

WRIGHT PATMAN LAKE

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD
March - June 2010 Survey
CAPACITY IN ACRE-FEET
ELEVATION INCREMENT IS ONE TENTH FOOT

Seasonal pool elevations:

Nov 1 - Mar 31	220.6 feet
Apr 1 - May 31	227.5 feet
Jun 1 - Oct 4	225.0 feet
Oct 5 - Oct 31	221.2 feet

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
189	0	0	0	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	0	0	0
191	0	0	0	0	0	0	0	0	0	0
192	0	0	0	0	0	0	0	0	0	0
193	0	0	0	0	0	0	0	0	1	1
194	1	1	1	1	1	1	1	1	1	1
195	1	1	1	1	1	1	1	2	2	2
196	2	2	2	2	2	2	3	3	3	3
197	3	3	3	4	4	4	4	5	5	5
198	6	6	7	7	8	9	9	10	11	12
199	13	14	15	16	17	19	20	22	24	25
200	27	29	32	34	37	39	42	46	49	52
201	56	60	64	69	73	78	84	89	95	101
202	107	114	121	128	136	144	152	161	170	179
203	189	199	209	220	231	242	254	266	279	292
204	305	319	333	348	363	378	394	410	427	444
205	462	480	498	517	536	555	575	596	616	637
206	659	681	704	727	751	775	799	825	851	878
207	906	935	966	997	1,030	1,066	1,103	1,144	1,189	1,240
208	1,296	1,359	1,428	1,502	1,583	1,669	1,761	1,859	1,963	2,075
209	2,192	2,316	2,447	2,585	2,728	2,878	3,033	3,193	3,359	3,530
210	3,705	3,886	4,073	4,266	4,465	4,670	4,882	5,101	5,328	5,562
211	5,804	6,054	6,314	6,583	6,862	7,151	7,452	7,764	8,088	8,426
212	8,775	9,138	9,514	9,904	10,306	10,722	11,151	11,592	12,047	12,514
213	12,996	13,491	13,999	14,519	15,051	15,597	16,156	16,728	17,314	17,914
214	18,531	19,163	19,810	20,474	21,153	21,848	22,558	23,280	24,015	24,761
215	25,522	26,298	27,088	27,895	28,719	29,562	30,426	31,310	32,214	33,137
216	34,079	35,036	36,008	36,996	37,998	39,017	40,052	41,102	42,171	43,259
217	44,368	45,496	46,642	47,808	48,992	50,198	51,424	52,670	53,940	55,234
218	56,551	57,891	59,255	60,643	62,052	63,479	64,926	66,394	67,885	69,395
219	70,925	72,474	74,043	75,633	77,245	78,877	80,528	82,196	83,882	85,583
220	87,300	89,031	90,777	92,539	94,316	96,112	97,927	99,762	101,620	103,500
221	105,403	107,328	109,275	111,244	113,234	115,245	117,277	119,330	121,404	123,497
222	125,611	127,744	129,895	132,063	134,249	136,451	138,669	140,902	143,149	145,409
223	147,682	149,968	152,265	154,576	156,899	159,233	161,579	163,936	166,304	168,681
224	171,069	173,466	175,871	178,285	180,707	183,137	185,574	188,019	190,472	192,931
225	195,398	197,873	200,354	202,842	205,338	207,841	210,351	212,868	215,393	217,925
226	220,465	223,013	225,567	228,140						

Appendix B

WRIGHT PATMAN LAKE

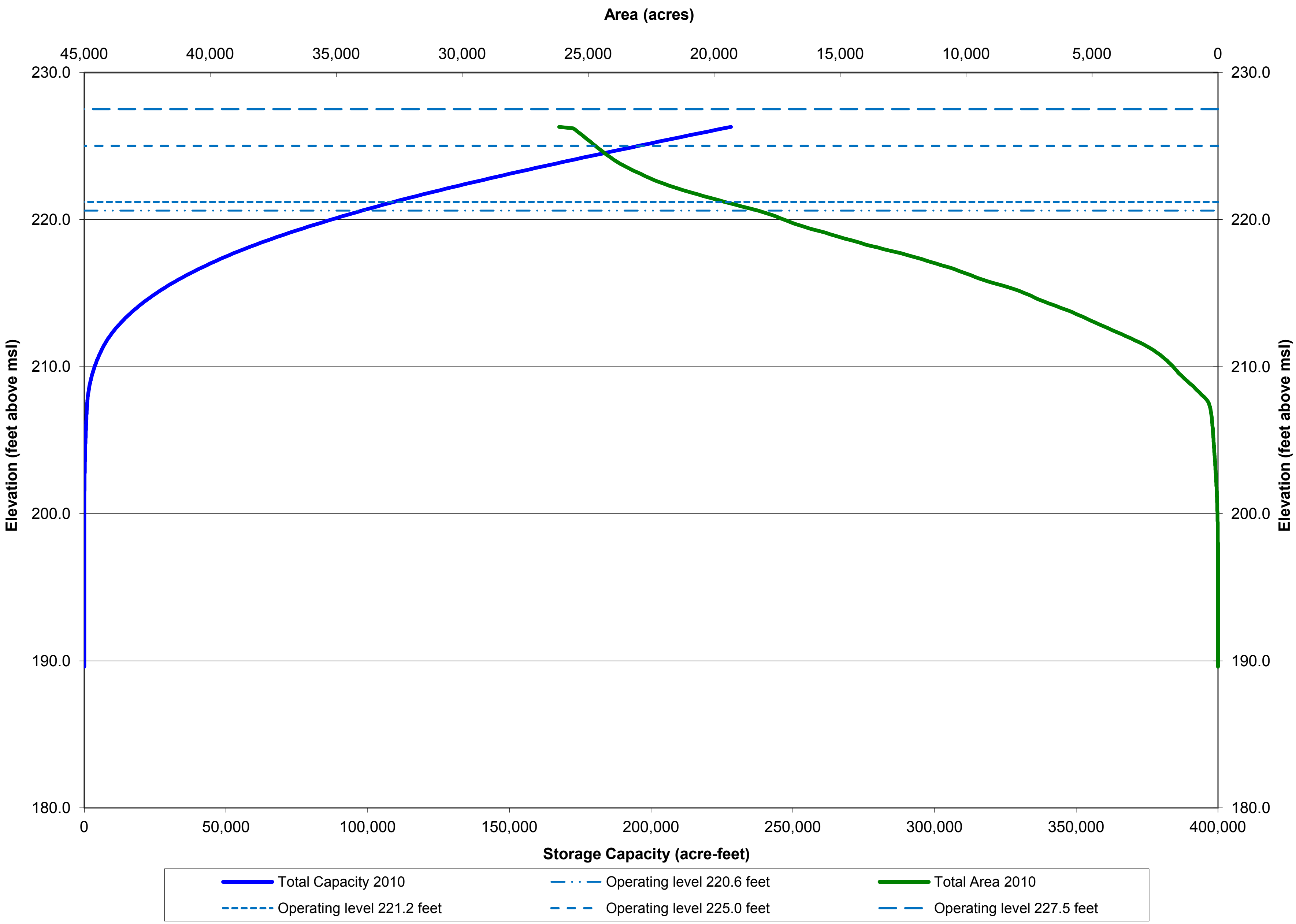
RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD
March - June 2010 Survey
AREA IN ACRES
ELEVATION INCREMENT IS ONE TENTH FOOT

Seasonal pool elevations:

Nov 1 - Mar 31	220.6 feet
Apr 1 - May 31	227.5 feet
Jun 1 - Oct 4	225.0 feet
Oct 5 - Oct 31	221.2 feet

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
189	0	0	0	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	0	0	0
191	0	0	0	0	0	0	0	0	0	0
192	0	0	0	0	0	0	0	0	0	0
193	0	0	0	0	0	0	0	0	0	0
194	0	0	0	0	0	0	0	1	1	1
195	1	1	1	1	1	1	1	1	1	1
196	1	1	1	1	1	1	1	1	1	1
197	2	2	2	2	2	2	3	3	3	4
198	4	5	5	6	7	7	8	8	9	9
199	10	11	12	12	13	14	15	16	18	19
200	20	22	23	25	27	28	30	32	34	36
201	39	41	43	46	48	51	53	56	59	62
202	65	68	71	75	78	82	85	88	91	95
203	98	101	105	108	112	116	120	124	128	132
204	136	140	145	149	153	157	161	165	169	173
205	177	181	185	189	193	197	201	205	209	214
206	219	224	229	234	239	244	250	257	267	276
207	286	297	309	323	341	361	391	429	477	532
208	597	659	718	777	835	891	948	1,009	1,079	1,144
209	1,210	1,276	1,342	1,405	1,465	1,525	1,579	1,630	1,681	1,730
210	1,780	1,838	1,896	1,959	2,023	2,088	2,156	2,227	2,302	2,380
211	2,462	2,549	2,643	2,738	2,841	2,946	3,061	3,185	3,310	3,434
212	3,562	3,696	3,826	3,959	4,092	4,220	4,351	4,481	4,610	4,749
213	4,886	5,013	5,138	5,261	5,389	5,524	5,657	5,788	5,928	6,084
214	6,243	6,399	6,553	6,712	6,879	7,023	7,160	7,285	7,406	7,533
215	7,681	7,831	7,984	8,152	8,328	8,535	8,740	8,947	9,134	9,330
216	9,493	9,649	9,797	9,950	10,110	10,265	10,427	10,588	10,784	10,985
217	11,185	11,375	11,559	11,746	11,952	12,159	12,357	12,577	12,817	13,057
218	13,291	13,510	13,763	13,991	14,180	14,371	14,566	14,800	15,009	15,198
219	15,397	15,585	15,791	16,018	16,222	16,415	16,595	16,777	16,935	17,092
220	17,240	17,384	17,535	17,696	17,867	18,049	18,247	18,464	18,686	18,913
221	19,142	19,361	19,584	19,794	19,999	20,217	20,429	20,635	20,836	21,035
222	21,231	21,419	21,602	21,774	21,941	22,103	22,256	22,399	22,535	22,667
223	22,793	22,916	23,042	23,168	23,287	23,401	23,514	23,622	23,729	23,829
224	23,924	24,012	24,097	24,179	24,258	24,337	24,413	24,487	24,561	24,633
225	24,705	24,777	24,849	24,921	24,993	25,065	25,138	25,212	25,285	25,360
226	25,435	25,511	25,590	26,148						



Wright Patman Lake
March - June 2010 Survey
Prepared by: TWDB

Appendix C: Area and Capacity Curves

Figure 5

CONTOURS
(feet above mean sea level)

226
224
222
220
218
216
214
212
210
208
206
204
202
200
198
196
194
192
190

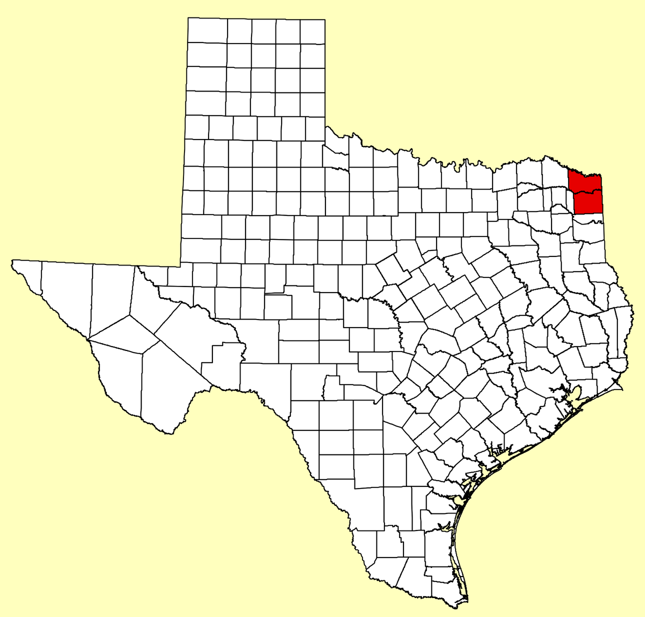
OPERATING LEVELS
(feet above mean sea level)

225.0
221.2
220.6

Islands at elevation 226.28 feet

Wright Patman Lake
Elevation 226.28 feet

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



Bowie and Cass 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 Wright Patman Lake. The Texas Water Development Board makes no representations nor assumes any liability.