# Volumetric and Sedimentation Survey of LAKE CHEROKEE

## April 2015 Survey

Texas Water Development Board

January 2016

# Texas Water Development Board



Prepared for:

**City of Longview**

With Support Provided by:

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



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

Jason J. Kemp, Manager
Holly Holmquist
Khan Iqbal
Bianca D. Whitaker
Michael Vielleux, P.E.
Nathan Leber

Published and distributed by the

Texas Water Development Board

P.O. Box 13231, Austin, TX 78711-3231

## Executive summary

In January 2015, the Texas Water Development Board (TWDB) entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, to perform a volumetric and sedimentation survey of Lake Cherokee. The City of Longview provided 50% of the funding for this survey, while the U.S. Army Corps of Engineers, Fort Worth District, provided the remaining 50% of the funding through their Planning Assistance to States Program. Surveying was performed using a multi-frequency (208 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.

Cherokee Dam and Lake Cherokee are located on Cherokee Bayou, approximately 12 miles southeast of Longview, in southeastern Gregg and northeastern Rusk Counties, Texas. The conservation pool elevation of Lake Cherokee is 280.0 feet above mean sea level (NGVD29). TWDB collected bathymetric data for Lake Cherokee between March 31, 2015, and April 14, 2015. The daily average water surface elevations during the survey ranged between 279.80 and 280.38 feet above mean sea level (NGVD29).

**The 2015 TWDB volumetric survey indicates that Lake Cherokee has a total reservoir capacity of 44,475 acre-feet and encompasses 3,749 acres at conservation pool elevation (280.0 feet above mean sea level, NGVD29).** Previous capacity estimates include the original design estimate of 62,400 acre-feet by the Cherokee Water Company, a recalculated original design estimate by the U.S. Soil Conservation Service in 1960 of 49,295 acre-feet, a 1960 U.S. Soil Conservation Service survey estimate of 46,705 acre-feet, and volumes obtained from two TWDB surveys in 1996 and 2003. Both prior TWDB volumetric surveys were re-evaluated using current processing procedures resulting in updated capacity estimates of 42,314 acre-feet and 44,440 acre-feet, respectively.

**Based on two methods for estimating sedimentation rates, the 2015 TWDB sedimentation survey estimates Lake Cherokee to have an average loss of capacity between 41 and 72 acre-feet per year since impoundment due to sedimentation below conservation pool elevation (280.0 feet NGVD29).** Sediment accumulation varies throughout the reservoir and appears to be greater in natural depressions or low lying areas of the flood plain. TWDB recommends that a similar methodology be used to resurvey Lake Cherokee 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 72nd Texas State Legislature in 1991. Section 15.804 of 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 January 2015, the Texas Water Development Board (TWDB) entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, to perform a volumetric and sedimentation survey of Lake Cherokee. The City of Longview provided 50% of the funding for this survey, while the U.S. Army Corps of Engineers, Fort Worth District, provided the remaining 50% of the funding through their Planning Assistance to States Program (TWDB, 2015). 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 City of Longview and the U.S. Army Corps of Engineers, Fort Worth District, and contains as deliverables: (1) a shaded relief plot of the reservoir bottom [Figure 4], (2) a bottom contour map [Figure 6], (3) an estimate of sediment accumulation and location [Figure 10], and (4) an elevation-area-capacity table of the reservoir acceptable to the Texas Commission on Environmental Quality [Appendix A, B].

## Lake Cherokee general information

Cherokee Dam and Lake Cherokee are located on Cherokee Bayou (Sabine River Basin), approximately 12 miles southeast of Longview, in southeastern Gregg and northeastern Rusk Counties, Texas (Figure 1). Cherokee Dam and Lake Cherokee are owned and operated by the Cherokee Water Company, Longview, Texas. Construction on Cherokee Dam began on February 26, 1948, and deliberate impoundment began on October 1, 1948. Cherokee Dam was completed on November 19, 1948 (TWDB, 1974). Cherokee Dam and Lake Cherokee were built primarily for water supply storage for the City of Longview and for cooling at the Knox Lee Power plant operated by AEP Southwestern Electric Power Company (SWEPCO) (SCS, 1960, TWDB, 1974, SWEPCO, 2015). Additional pertinent data about Cherokee Dam and Lake Cherokee can be found in Table 1.

Water rights for Lake Cherokee have been appropriated to the City of Longview through Certificate of Adjudication No. 05-4642. The complete certificate is on file in the Information Resources Division of the Texas Commission on Environmental Quality.

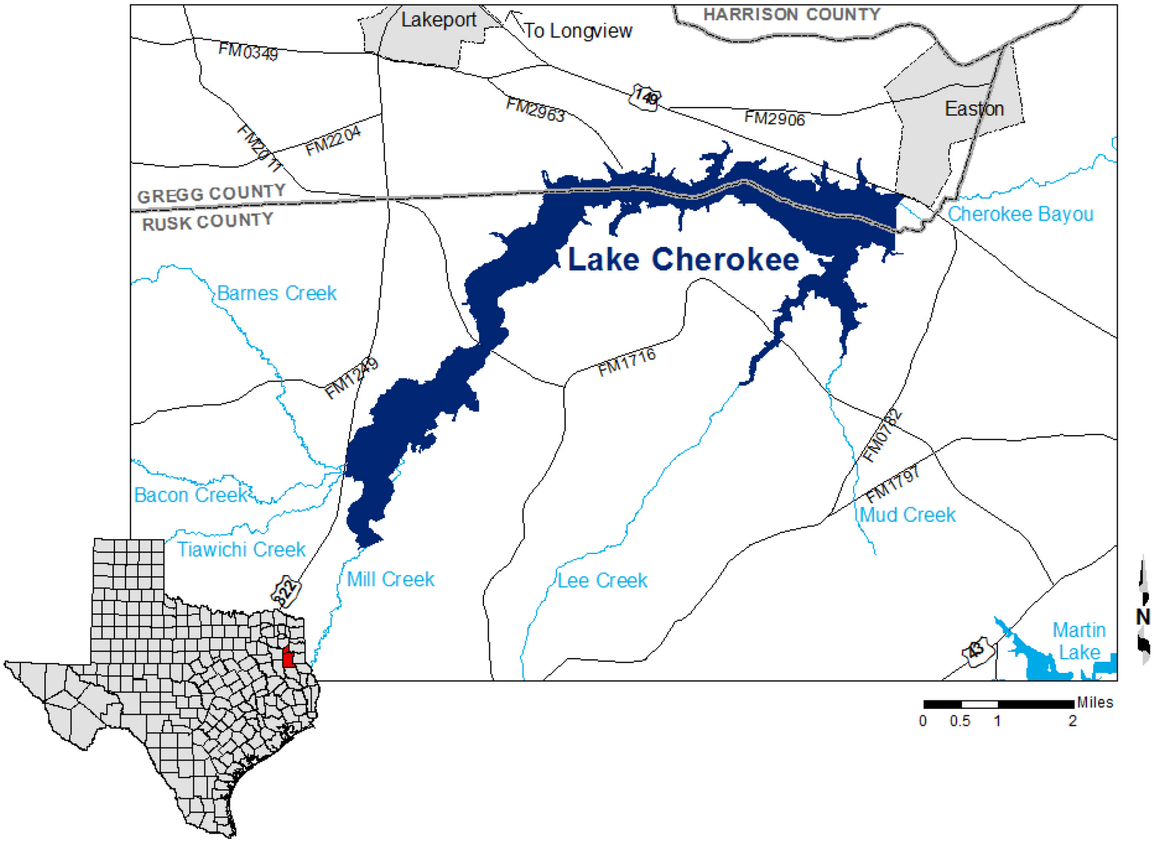



**Figure 1. Location of Lake Cherokee**

| **Table 1.** | **Pertinent data for Cherokee Dam and Lake Cherokee** | | |
|---|---|---|---|
| **Owner** | | | |
| Cherokee Water Company, Longview, Texas | | | |
| **Engineer (design)** | | | |
| Powell and Powell | | | |
| **Location of dam** | | | |
| On Cherokee Bayou approximately 8 miles upstream from its confluence with the Sabine River, in Gregg and Rusk Counties, 12 miles southeast of the city of Longview. | | | |
| **Drainage area** | | | |
| 158 square miles | | | |
| **Dam** | | | |
| Type | Earthfill | | |
| Length (including spillways) | 4,000 feet | | |
| Maximum height | 45 feet | | |
| Top width | 20 feet | | |
| Top elevation | 295.0 feet above mean sea level | | |
| **Spillway (emergency)** | | | |
| Type | Cut in natural ground | | |
| Crest elevation | 287.7 feet above mean sea level | | |
| Crest length | 160 feet | | |
| Location | Near right end of dam | | |
| **Spillway (service)** | | | |
| Type | Uncontrolled concrete structure | | |
| Crest elevation | 280.0 feet above mean sea level | | |
| Crest length | 828± feet | | |
| Location | Left end of dam | | |
| **Outlet works** | | | |
| Type | Concrete pipe, 18-inch diameter | | |
| Invert elevation | 260.0 feet above mean sea level | | |
| Control | Gate valve operated from a tower | | |
| **Reservoir data** (Based on 2015 TWDB survey) | | | |
| **Feature** | **Elevation (feet NGVD29[a])** | **Capacity (acre-feet)** | **Area (acres)** |
| Top of dam | 295.0 | N/A | N/A |
| Top of design flood pool | 291.0 | N/A | N/A |
| Crest of emergency spillway | 287.7 | N/A | N/A |
| Crest of service spillway | 280.0 | 44,475 | 3,749 |
| Invert of 18-inch outlet | 260.0 | 4,382 | 846 |

*Source:* (SCS, 1960, TWDB, 1974)

[a] NGVD29 = National Geodetic Vertical Datum 1929

# Volumetric and sedimentation survey of Lake Cherokee

## Datum

The vertical datum used during this survey is unknown. It is assumed to be equivalent to the National Geodetic Vertical Datum 1929 (NGVD29). Elevations herein are reported in feet above mean sea level relative to a reservoir gage maintained by the City of Longview and water levels provided from the SWEPCO Knox Lee Power Plant (V. Faulkner, personal communication, June 23, 2015). All pertinent water surface elevations were provided to TWDB by the Cherokee Water Company and volume and area calculations in this report are referenced to those water levels. 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 Lake Cherokee between March 31, 2015, and April 14, 2015. The daily average water surface elevations during the survey ranged between 279.80 and 280.38 feet above mean sea level (NGVD29) (V. Faulkner, personal communication, June 23, 2015). For data collection, TWDB used a Specialty Devices, Inc. (SDI), single-beam, multi-frequency (208 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder integrated with differential global positioning system (DGPS) equipment. Data was collected along pre-planned survey lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 500 feet apart. Many of the same survey lines were also used by TWDB during the 2003 and 1996 surveys. The depth sounder was calibrated daily using a velocity profiler to measure the speed of sound in the water column and a weighted tape or stadia rod for depth reading verification. Figure 2 shows where data collection occurred during the 2015 TWDB survey.

All sounding data was collected and reviewed before sediment core sampling sites were selected. Sediment core samples are collected at regularly spaced intervals within the reservoir, or at locations where interpretation of the acoustic display would be difficult without site-specific sediment core data. After analyzing the sounding data, TWDB selected eight locations to collect sediment core samples (Figure 2). The sediment core samples were collected on June 4, 2015, with a custom-coring boat and SDI VibeCore system. Several of the cores sites were the same as those cored during the 2003 survey.

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 the tube must be driven during sediment sampling. The goal is to collect a sediment core sample extending from the current reservoir-bottom surface, through the accumulated sediment, and to the pre-impoundment surface. After retrieving the sample, a stadia rod is inserted into the top of the aluminum tubes to assist in locating the top of the sediment in the tube. This identifies the location of the layer corresponding to the current reservoir-bottom 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.

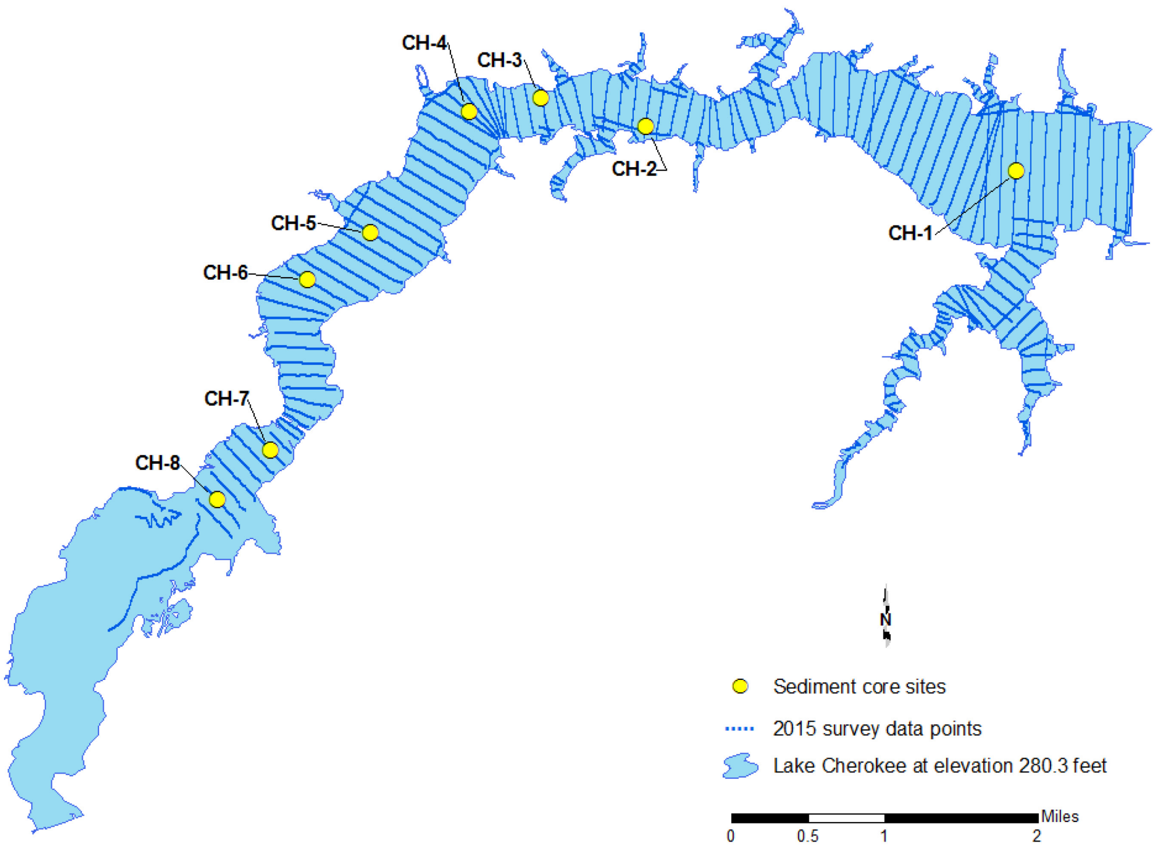



**Figure 2. Data collected during 2015 TWDB Lake Cherokee survey**

## 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, 2015a) using Environmental Systems Research Institute's ArcGIS software. The quarter-quadrangles that cover Lake Cherokee are Elderville (NW, NE, SW), Tatum (NW), and Lakeport (SE). The DOQQs were photographed on January 12, 2009, and January 15, 2009, while the daily average water surface elevation measured 280.3 feet above mean sea level and 280.4 feet above mean sea level, respectively (V. Faulkner, personal communication, August 12, 2015). According to metadata associated with the 2009 DOQQs, the photographs have a resolution or ground sample distance of 0.5 meter and a horizontal accuracy within 3-5 meters to true ground. For this analysis, the boundary was digitized at the land-water interface in the 2009 photographs and assigned an elevation of 280.3 feet. Several modifications were made to the boundary to account for shoreline development that has occurred since the 2009 photos by referencing aerial photographs taken on July 28, 2012, and September 22, 2014, while the daily average water surface elevation measured 278.5 feet above mean sea level and 277.7 feet above mean sea level, respectively (V. Faulkner, personal communication, June 23, 2015). According to metadata associated with the 2012 and 2014 DOQQs, the photographs have a resolution or ground sample distance of 1.0-meters and a horizontal accuracy within ±6 meters to true ground (TNRIS, 2015b, USDA, 2015).

### Triangulated Irregular Network model

Following completion of data collection, the raw data files collected by TWDB were edited to remove data anomalies. DepthPic©, software developed by SDI, Inc., was used to display, interpret, and edit the multi-frequency data by manually removing data anomalies in the current bottom surface and manually digitizing the reservoir-bottom surface at the time of initial impoundment (i.e. pre-impoundment surface). For processing outside of DepthPic©, an in-house software package, HydroTools, was used to identify the current reservoir-bottom surface, pre-impoundment surface, 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. This survey point dataset was then preconditioned by inserting a uniform grid of artificial survey points between the actual survey lines. Bathymetric elevations at these artificial points were determined using an anisotropic spatial interpolation algorithm described in the next section. This technique creates a high resolution, uniform grid of interpolated bathymetric elevation points throughout a majority of the reservoir (McEwen et al., 2014a). Finally, the point file resulting from spatial interpolation was used in conjunction with sounding and boundary data to create volumetric and sediment Triangulated Irregular Network (TIN) models utilizing the 3D Analyst Extension of ArcGIS. The 3D Analyst algorithm uses Delaunay's criteria for triangulation to create a grid composed of triangles from non-uniformly spaced points, including the boundary vertices (ESRI, 1995).

### Spatial interpolation of reservoir bathymetry

Isotropic spatial interpolation techniques such as the Delaunay triangulation used by the 3D Analyst extension of ArcGIS are, in many instances, unable to suitably interpolate bathymetries between survey lines common to reservoir surveys. Reservoirs and stream channels are anisotropic morphological features where bathymetry at any particular location is more similar to upstream and downstream locations than to transverse locations.

Interpolation schemes that do not consider this anisotropy lead to the creation of several types of artifacts in the final representation of the reservoir bottom surface and hence to errors in volume. These include: artificially-curved contour lines extending into the reservoir where the reservoir walls are steep or the reservoir is relatively narrow; intermittent representation of submerged stream channel connectivity; and oscillations of contour lines in between survey lines. These artifacts reduce the accuracy of the resulting volumetric and sediment TIN models in areas between actual survey data.

To improve the accuracy of bathymetric representation between survey lines, TWDB developed various anisotropic spatial interpolation techniques. Generally, the directionality of interpolation at different locations of a reservoir can be determined from external data sources. A basic assumption is that the reservoir profile in the vicinity of a particular location has upstream and downstream similarity. In addition, the sinuosity and directionality of submerged stream channels can be determined by directly examining the survey data, or more robustly by examining scanned USGS 7.5 minute quadrangle maps (known as digital raster graphics) and hypsography files (the vector format of USGS 7.5 minute quadrangle map contours), when available. Using the survey data, polygons are created to partition the reservoir into segments with centerlines defining directionality of interpolation within each segment. For surveys with similar spatial coverage, these interpolation definition files are in principle independent of the survey data and could be applied to past and future survey data of the same reservoir. In practice, however, minor revisions of the interpolation definition files may be needed to account for differences in spatial coverage and boundary conditions between surveys. Using the interpolation definition files and survey data, the current reservoir-bottom elevation, pre-impoundment elevation, and sediment thickness are calculated for each point in the high resolution uniform grid of artificial survey points. The reservoir boundary, artificial survey points grid, and survey data points are used to create volumetric and sediment TIN models representing the reservoir bathymetry and sediment accumulation throughout the reservoir. Specific details of this interpolation technique can be found in the HydroTools manual (McEwen et al., 2014a) and in McEwen et al., 2014b.

In areas inaccessible to survey data collection, such as small coves and shallow upstream areas of the reservoir, linear interpolation is used for volumetric and sediment accumulation estimations. The linear interpolation follows a linear definition file linking the survey points file to the lake boundary file (McEwen et al., 2014a). Without linearly interpolated data, the TIN model builds flat triangles. A flat triangle is defined as a triangle where all three vertices are equal in elevation, generally the elevation of the reservoir boundary. Reducing flat triangles by applying linear interpolation improves the elevation-capacity and elevation-area calculations. It is not always possible to remove all flat triangles, and linear interpolation is only applied where adding bathymetry is deemed reasonable.

Figure 3 illustrates typical results from application of the anisotropic interpolation and linear interpolation techniques to Lake Cherokee. In Figure 3A, deeper channels indicated by surveyed cross sections are not continuously represented in areas between survey cross sections. This is an artifact of the TIN generation routine rather than an accurate representation of the physical bathymetric surface. Inclusion of interpolation points in creation of the volumetric TIN model, represented in Figure 3B, directs Delaunay triangulation to better represent the reservoir bathymetry between survey cross-sections. The bathymetry shown in Figure 3C was used in computing reservoir capacity and area tables (Appendix A, B).

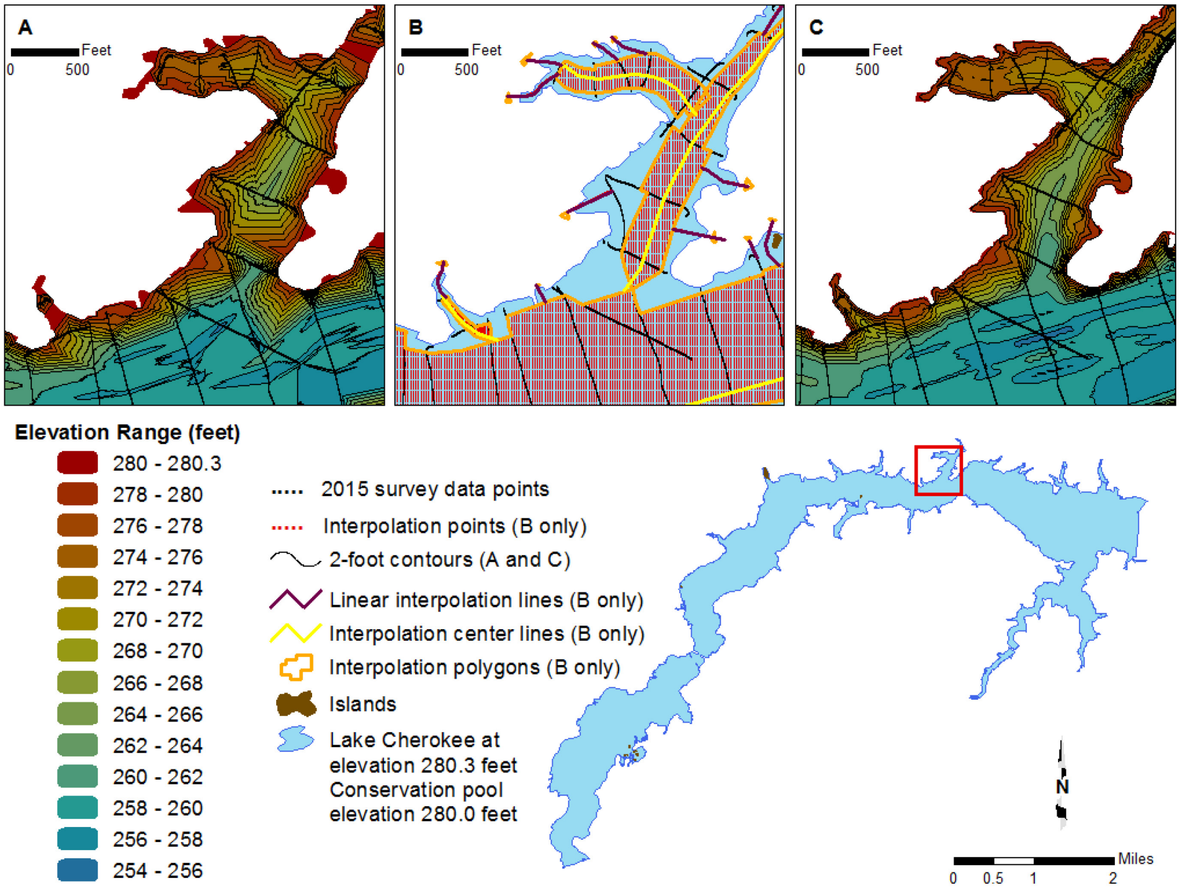



**Figure 3. Anisotropic spatial interpolation and linear interpolation of Lake Cherokee sounding data - A) bathymetric contours without interpolated points, B) sounding points (black) and interpolated points (red), C) bathymetric contours with the interpolated points**

## Area, volume, and contour calculation

Using ArcInfo software and the volumetric TIN model, volumes and areas were calculated for the entire reservoir at 0.1-foot intervals, from 246.7 to 280.3 feet. While linear interpolation was used to estimate the topography in areas that were inaccessible by boat or too shallow for the instruments to work properly, development of anomalous "flat triangles", that is triangles whose three vertices all have the same elevation, in the TIN model are unavoidable. The flat triangles in turn lead to anomalous calculations of surface area and volume at the boundary elevation 280.3 feet. To eliminate the effects of the flat triangles on area and volume calculations, areas between elevations 279.5 feet and 280.3 feet were linearly interpolated between the computed values, and volumes above elevation 279.5 feet were calculated based on the corrected areas. The elevation-capacity table and elevation-area table, updated for 2015, are presented in Appendices A and B, respectively. The capacity curve is presented in Appendix C, and the area curve is presented in Appendix

D. However, due to the inaccessibility of the upper reaches, and the increasing uncertainty in the elevation-area-capacity relationship as the elevation approaches 280.3 feet, the tables and curves are only provided up to conservation pool elevation, 280.0 feet.

The volumetric TIN model was converted to a raster representation using a cell size of 1 foot by 1 foot. The raster data was then used to produce: an elevation relief map (Figure 4), representing the topography of the reservoir bottom; a depth range map (Figure 5), showing shaded depth ranges for Lake Cherokee; and a 2-foot contour map (Figure 6 - attached).

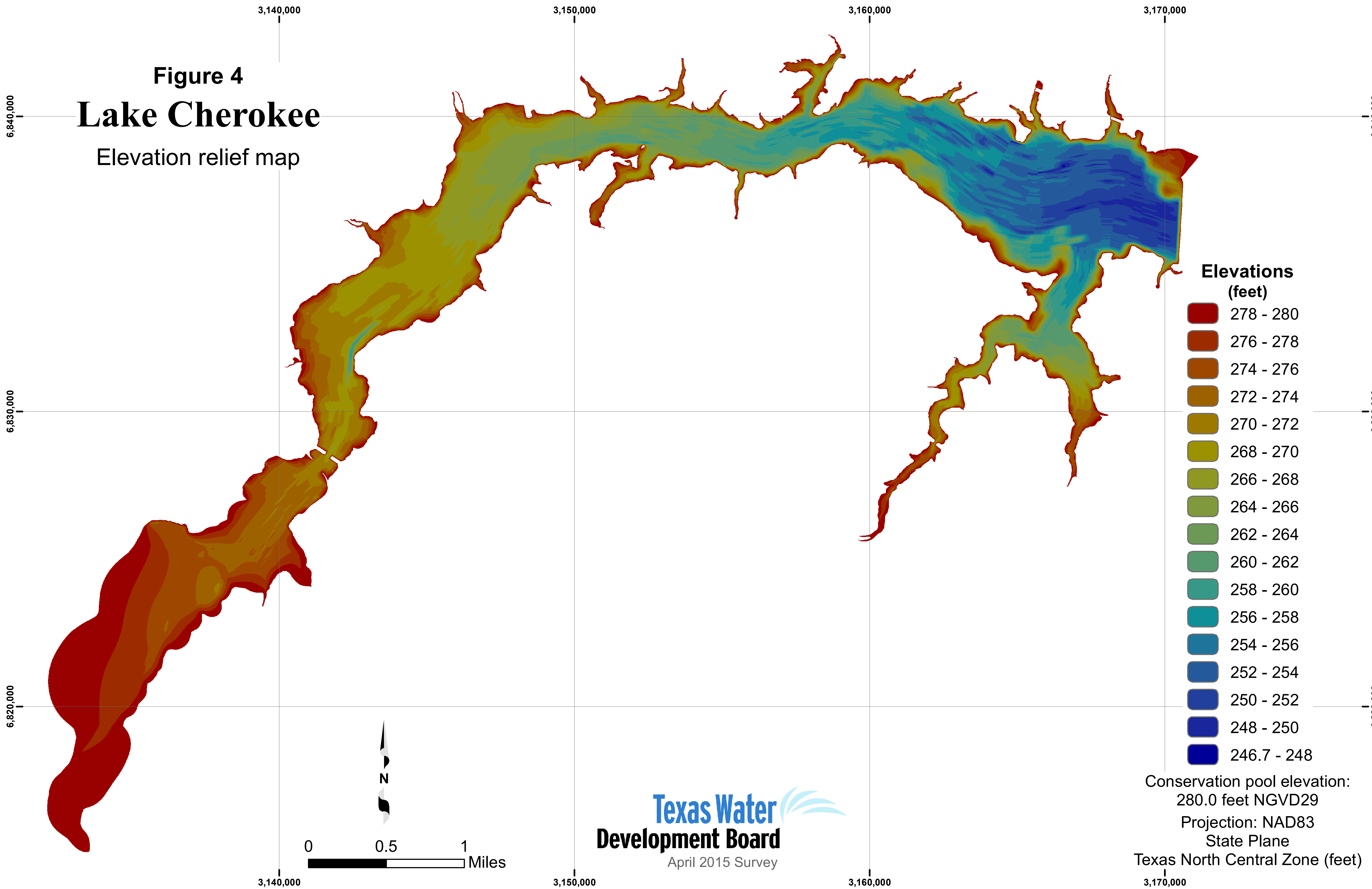



**Figure 4**
# Lake Cherokee
Elevation relief map

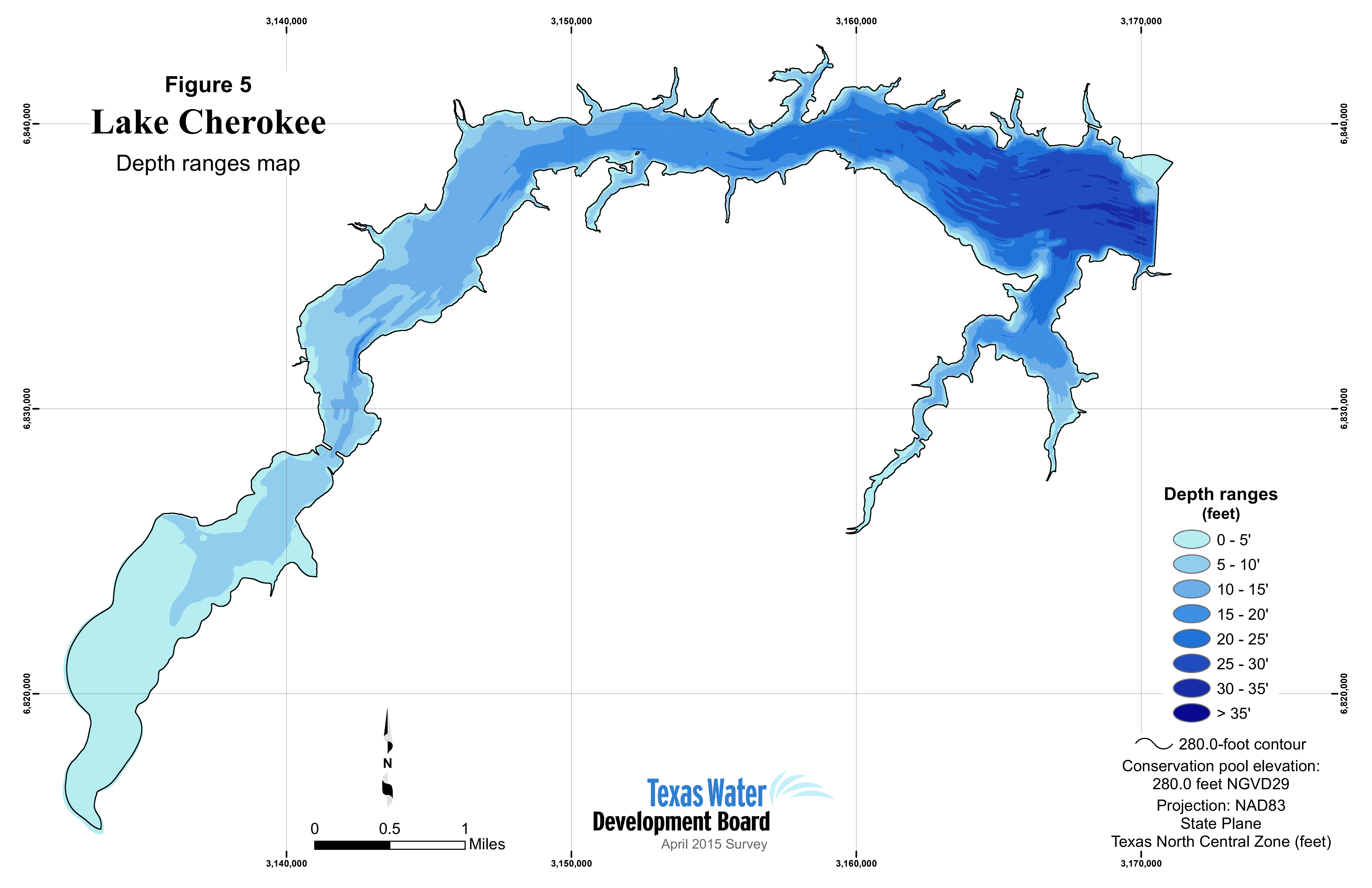


Figure 5
Lake Cherokee
Depth ranges map
3,140,000
3,150,000
3,160,000
3,170,000
6,840,000
6,830,000
6,820,000
Depth ranges
(feet)
0 - 5'
5 - 10'
10 - 15'
15 - 20'
20 - 25'
25 - 30'
30 - 35'
> 35'
280.0-foot contour
Conservation pool elevation:
280.0 feet NGVD29
Projection: NAD83
State Plane
Texas North Central Zone (feet)
N
0
0.5
1
Miles
Texas Water
Development Board
April 2015 Survey

**Analysis of sediment data from Lake Cherokee**

Sedimentation in Lake Cherokee was determined by analyzing the acoustic signal returns of all three depth sounder frequencies in the DepthPic© software. The 208 kHz signal was analyzed to determine the current bathymetric surface of the reservoir, while all three frequencies, 208 kHz, 50 kHz, and 24 kHz, were analyzed to determine the reservoir bathymetric surface at the time of initial impoundment (i.e. pre-impoundment surface). Sediment core samples collected in the reservoir 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 or more of the following methods: (1) a visual examination of the sediment core for 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 Munsell soil color, texture, relative water content, and presence of organic materials, were also recorded (Table 2).

**Table 2. Sediment core sampling analysis data - Lake Cherokee**

| Core | Easting[a] (ft) | Northing[a] (ft) | Total core sample/ post-impoundment sediment | Sediment core description | Munsell soil color |
|---|---|---|---|---|---|
| CH-1 | 3166550.97 | 6837228.64 | 37.5"/ 8.5" | 0-5.5" high water content, loam | GLEY1 2.5/10Y |
| | | | | 5.5-8.5" high water content, high organic matter content (full leaves, twigs), loam | 5Y 2.5/1 |
| | | | | 8.5-28.5" highly dense, organic matter present, sandy loam with small clay pockets | 5Y 4/2 |
| | | | | 28.5-37.5" very dense, small organic matter present, sandy clay with small clay pockets | 5Y 4/1 |
| CH-2 | 3153780.87 | 6838726.86 | 52.5"/7.0" | 0-7.0" high water content, sandy loam | 5Y 2.5/2 |
| | | | | 7.0-21.5" dense, small organic matter present (twigs), sandy loam | 2.5Y 4/2 |
| | | | | 21.5-30.0" very dense, silty clay loam | 2.5Y 4/1 |
| | | | | 30.0-50.5" high water content, dense, silty clay loam | 2.5Y 5/1 |
| | | | | 50.5-52.5" dense, small dry clay pockets, silty clay | 5Y 4/2 |
| CH-3 | 3150172.91 | 6839705.25 | 49.0"/19.5" | 0-4" water and fluff | N/A |
| | | | | 4-19.5" high water content, silty loam | 5Y 4/1 |
| | | | | 19.5-49.0" dense, top 1" wet fine sand, sandy clay | 2.5Y 4/1 |
| CH-4 | 3147721.62 | 6839230.79 | 60"/4.5" | 0-2" water and fluff | N/A |
| | | | | 2-4.5" high water content, small organic matter, silty loam | 5Y 2.5/2 |
| | | | | 4.5-35.0" high water content, dense, small organic matter, sandy loam | 2.5Y 4/1 |
| | | | | 35.0-49.5" low water content, very dense, 10% mottled color, sandy clay loam | 5Y 4/2 |
| | | | | 49.5-60.0" very dense, large pockets of clay, 50% mottled color, sandy clay loam | 5Y 4/1 & 5YR 4/6 |
| CH-5 | 3144294.29 | 6835091.31 | 59.75"/8" | 0-2.5" water and fluff | N/A |
| | | | | 2.5-8.0" high water content, silty loam | 5Y 2.5/2 |
| | | | | 8.0-15.0" organic matter top 1.5", high water content, small organic matter, silty loam | 2.5Y 3/1 |
| | | | | 15.0-35.0" high water content, dense, sandy loam | 5Y 5/2 |
| | | | | 35.0-48.5" low water content, very dense, 30% mottled color, sandy loam | 5Y 5/3 |
| | | | | 48.5-59.75" very dense, 40% mottled color, sandy loam | 5Y 5/2 & 2.5Y 5/6 |

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

Table 2 (continued). **Sediment core sampling analysis data - Lake Cherokee**

| Core | Easting[a] (ft) | Northing[a] (ft) | Total core sample/ post-impoundment sediment | Sediment core description | Munsell soil color |
|---|---|---|---|---|---|
| CH-6 | 3142122.24 | 6833456.59 | 28”/12” | 0-4.0” water and fluff | N/A |
| | | | | 4.0-12.0” high water content, silty loam | 5Y 2.5/2 |
| | | | | 12.0-28.0” very dense, some organic matter present, sandy clay loam | 5Y 4/1 |
| CH-7 | 3140864.23 | 6827602.04 | 48”/16.5” | 0-6.0” water and fluff | N/A |
| | | | | 6.0-16.5” high water content, silty loam | 5Y 2.5/2 |
| | | | | 16.5-26.5” dense, organic matter present top 4”, silty clay loam | 5Y 4/1 |
| | | | | 26.5-48.0” very dense, 30% mottled color, clay | 5Y 4/2 |
| CH-8 | 3139017.75 | 6825869.59 | 20.5”/8.5” | 0-2.0” water and fluff | N/A |
| | | | | 2.0-4.5” high water content, small organics present, silty loam | 5Y 2.5/2 |
| | | | | 4.5-8.5” high water content, heavy/ coarse organic matter, sandy loam | 5Y 3/1 |
| | | | | 8.5-20.5” very dense, coarse organic matter in lower 3” (roots, twigs), medium clay pockets, clay loam | 5Y 4/1 |

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

A photograph of sediment core sample CH-3 is shown in Figure 7 and is representative of the sediment cores sampled from Lake Cherokee. The base of the sample is denoted by the blue line. The pre-impoundment boundary (yellow line) was evident within this sediment core sample at 19.5 inches and identified by the change in color, texture, moisture, porosity, and structure. Identification of the pre-impoundment surface for the remaining sediment cores followed a similar procedure.

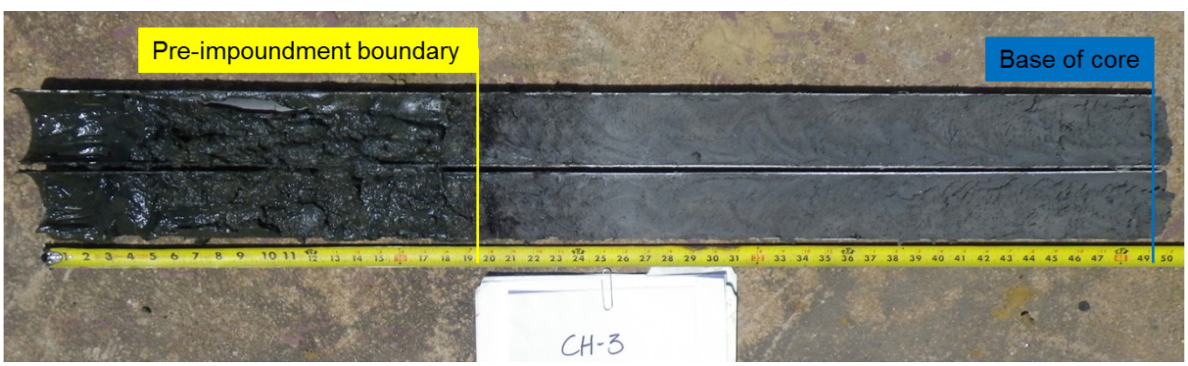



**Figure 7. Sediment core sample CH-3 from Lake Cherokee**

Figures 8 and 9 illustrate how measurements from sediment core samples are used with sonar data to help identify the interface between the post- and pre-impoundment layers in the acoustic signal. Within DepthPic©, the current surface is automatically determined based on signal returns from the 208 kHz transducer and verified by TWDB staff, while the pre-impoundment surface must be determined visually. The pre-impoundment surface is first identified along cross-sections for which sediment core samples have been collected.

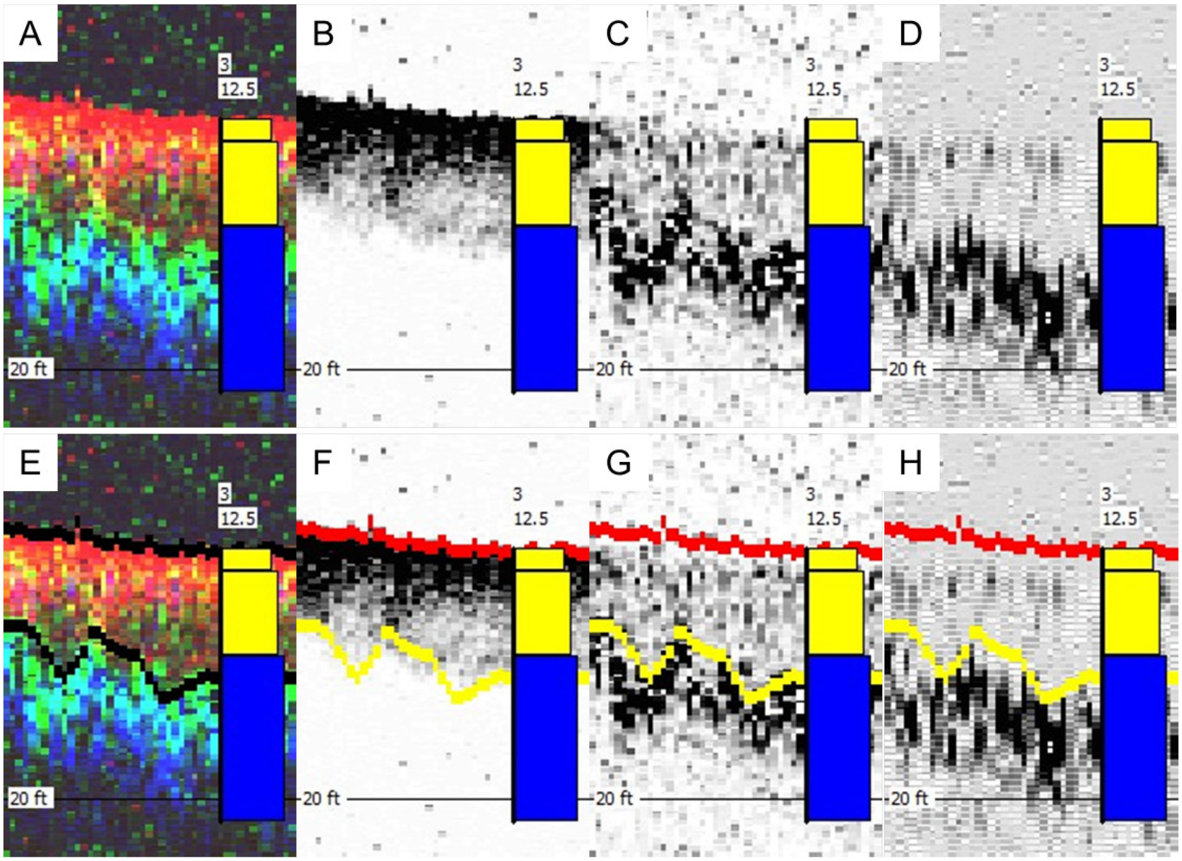



**Figure 8. Comparison of sediment core sample CH-3 with acoustic signal returns: A,E) combined acoustic signal returns, B,F) 208 kHz frequency, C,G) 50 kHz frequency, D,H) 24 kHz frequency**

Figure 8 compares sediment core sample CH-3 with the acoustic signals for all frequencies combined (A, E), 208 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 boxes represent post-impoundment sediment, and the blue box represents the pre-impoundment sediment. In Figures 8A-D, the bathymetric surfaces are not shown. In Figure 8E, the current bathymetric surface is represented as the top black line and in Figures 8F-H as the top red line. The pre-impoundment surface is identified by comparing boundaries observed in the 208 kHz, 50 kHz and 24 kHz signals to the location of the pre-impoundment surface of the sediment core sample. Each sediment core sample was compared to all three frequencies and the boundary in the 50 kHz signal most closely matched the pre-impoundment interface of the sediment core samples; therefore, the 50 kHz signal was used to locate the pre-impoundment layer. The pre-impoundment surface was manually drawn and is represented by the bottom black line in Figure 8E, and by the yellow line in Figures

8F-H. Figure 9 shows sediment core sample CH-3 correlated with the 50 kHz frequency of the nearest surveyed cross-section. 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.

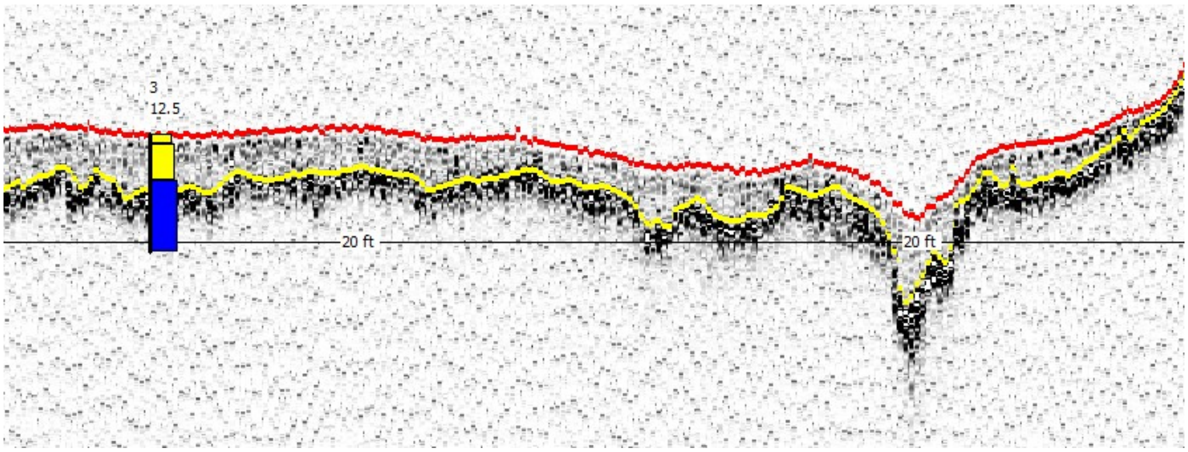



**Figure 9. Cross-section of data collected during survey, displayed in DepthPic© (50 kHz frequency), correlated with sediment core sample CH-3 and showing the current surface in red and pre-impoundment surface in yellow**

After the pre-impoundment surface from all cross-sections is identified, a sediment thickness TIN model is created following standard GIS techniques (Furnans, 2007). Sediment thicknesses were interpolated between surveyed cross-sections using HydroTools with the same interpolation definition file used for bathymetric interpolation. For the purposes of the TIN model creation, TWDB assumed sediment thickness at the reservoir boundary was zero feet (defined as the 280.3 foot NGVD29 elevation contour). The sediment thickness TIN model was converted to a raster representation using a cell size of 1 foot by 1 foot and used to produce a sediment thickness map of Lake Cherokee (Figure 10).

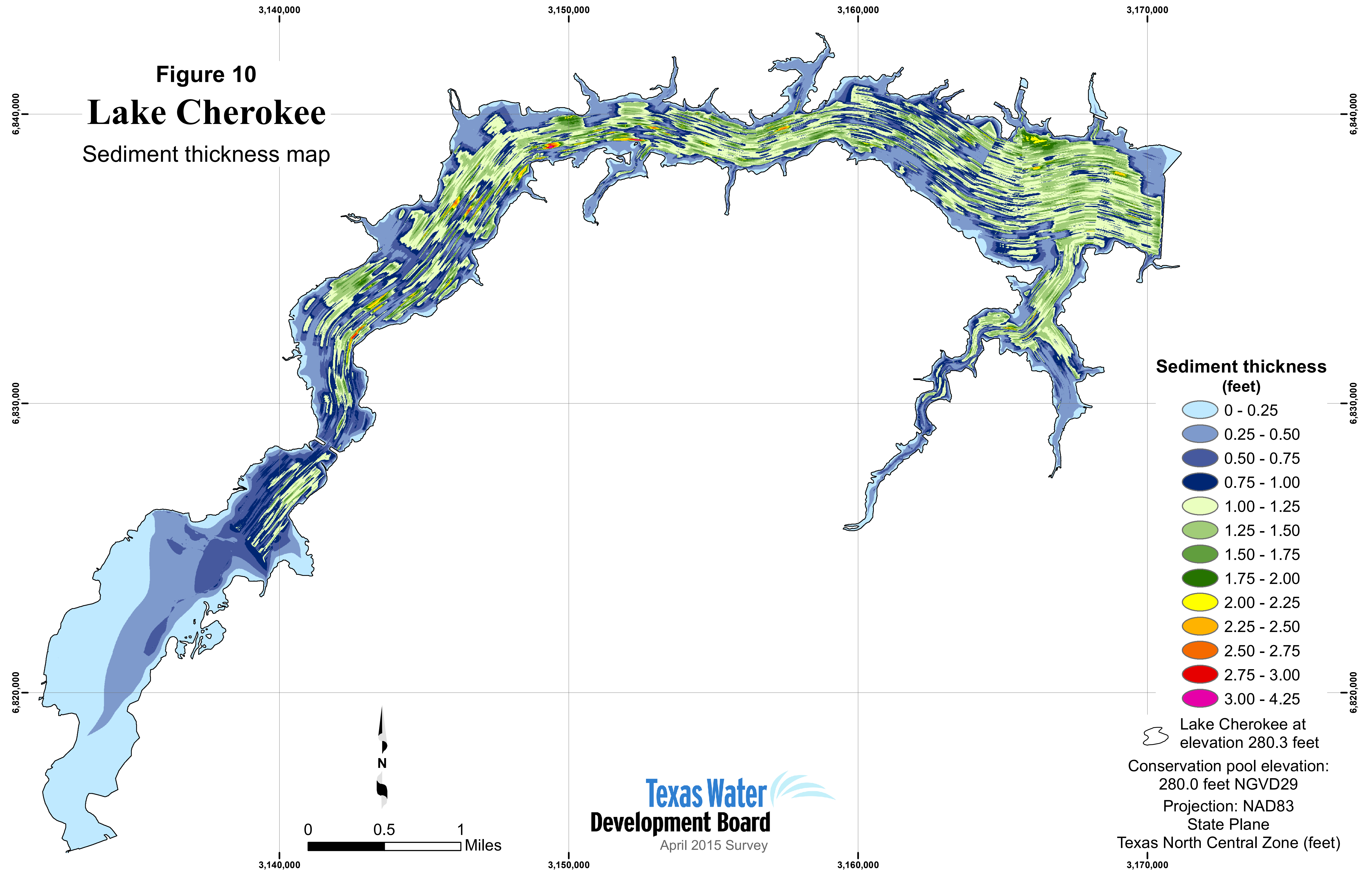


Figure 10
Lake Cherokee
Sediment thickness map
3,140,000
3,150,000
3,160,000
3,170,000
6,840,000
6,830,000
6,820,000
Sediment thickness (feet)
0 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.25
1.25 - 1.50
1.50 - 1.75
1.75 - 2.00
2.00 - 2.25
2.25 - 2.50
2.50 - 2.75
2.75 - 3.00
3.00 - 4.25
Lake Cherokee at elevation 280.3 feet
Conservation pool elevation: 280.0 feet NGVD29
Projection: NAD83 State Plane Texas North Central Zone (feet)
N
0 0.5 1 Miles
Texas Water Development Board
April 2015 Survey

## Survey results

### Volumetric survey

**The results of the 2015 TWDB volumetric survey indicate Lake Cherokee has a total reservoir capacity of 44,475 acre-feet and encompasses 3,749 acres at conservation pool elevation (280.0 feet above mean sea level, NGVD29).** A sedimentation survey conducted by the U.S. Soil Conservation Service (SCS) in 1960 determined the original area and capacity per the Cherokee Water company of 62,400 acre-feet encompassing 3,479 acres to be inaccurate. Based on the 1960 survey, the SCS estimated the original area and capacity to be 49,295 acre-feet encompassing 3,987 acres. The then current 1960 area and capacity were estimated to be 46,705 acre-feet encompassing 3,987 acres (SCS, 1960). Because of differences in past and present survey methodologies, direct comparison of volumetric surveys to estimate loss of capacity is difficult and can be unreliable.

To properly compare results from TWDB surveys of Lake Cherokee, TWDB applied the 2015 data processing techniques to the survey data collected in 1996 and 2003. Specifically, TWDB applied anisotropic spatial interpolation to the survey data collected in 1996 and 2003 using the same interpolation definition file as was used for the 2015 survey, with minor edits to account for differences in data coverage and boundary conditions. The 1996 survey boundary was digitized from USGS 7.5 minute quadrangle maps titled ELDERVILLE, TX. (Provisional 1983), LAKEPORT, TX. (Provisional 1983), and TATUM, TX. (Provisional 1983). While linear interpolation was used to estimate the topography in areas without data, flat triangles led to anomalous area and volume calculations at the boundary elevation of 280.0 feet. Therefore, areas between 276.5 feet and 280.0 feet were linearly interpolated between the computed values, and volumes above 276.5 feet were calculated based on the corrected areas. The 2003 survey boundary was digitized from aerial photographs taken on March 9, 1995, while the water surface elevation of the reservoir measured 280.6 feet above mean sea level. According to the associated metadata, the 1995-1996 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. To ameliorate the effect of the flat triangles, areas between 279.5 feet and 280.6 feet were linearly interpolated between the computed values, and volumes above 279.5 feet were calculated based on the corrected areas. Re-evaluation of the 1996 and 2003 surveys resulted in a 1.9 percent and 1.6 percent increase, respectively, in total capacity estimates at conservation pool elevation 280.0 feet (Table 3). Re-evaluation of the 2003 sedimentation survey resulted in a total pre-impoundment capacity estimate of 45,760 acre-feet, a 1.6 percent increase in capacity.

**Table 3. Current and previous survey capacity and surface area data**

| Survey | Surface area (acres) | Total capacity (acre-feet) |
|---|---|---|
| Original design [a] | 3,479 | 62,400 |
| Original design recalculated by SCS 1960 [a] | 3,987 | 49,295 |
| SCS 1960[a] | 3,987 | 46,705 |
| TWDB 1996[b] | 3,083 | 41,506 |
| TWDB 1996 (re-calculated) | 3,083 | 42,314 |
| TWDB 2003[c] | 3,467 | 43,737 |
| TWDB 2003 (re-calculated) | 3,493 | 44,440 |
| TWDB 2015 | 3,749 | 44,475 |

[a] Source: (SCS, 1960)
[b] Source: (TWDB, 2003)
[c] Source: (TWDB, 2004)

## Sedimentation survey

**Based on two methods for estimating sedimentation rates, the 2015 TWDB sedimentation survey estimates Lake Cherokee to have an average loss of capacity between 41 and 72 acre-feet per year since impoundment due to sedimentation below conservation pool elevation (280.0 feet NGVD29**). The sedimentation survey indicates sediment accumulation varies throughout the reservoir. Sediment accumulation appears to be greatest in the natural depressions or low lying areas of the flood plain. Comparison of capacity estimates of Lake Cherokee derived using differing methodologies are provided in Table 4 for sedimentation rate calculation.

**Table 4. Capacity loss comparisons for Lake Cherokee**

| Survey | Volume comparisons at conservation pool elevation (acre-feet) | | | | Pre-impoundment (acre-feet) |
|---|---|---|---|---|---|
| Original design recalculated by SCS 1960[a] | 49,295 | <> | <> | <> | <> |
| SCS 1960[a] | <> | 46,705 | <> | <> | <> |
| TWDB 1996 (re-calculated) | <> | <> | 42,314 | <> | |
| TWDB 2003 (re-calculated) | <> | <> | <> | 44,440 | <> |
| TWDB pre-impoundment estimate based on 2015 survey | <> | <> | <> | <> | 47,208[b] |
| 2015 volumetric survey | 44,475 | 44,475 | 44,475 | 44,475 | 44,475 |
| Volume difference (acre-feet) | 4,820 (9.8%) | 2,230 (4.8%) | -2,161 (-5.1%) | -35 (0.08%) | 2,733 (5.8%) |
| Number of years | 67 | 55 | 19 | 12 | 67 |
| Capacity loss rate (acre-feet/year) | 72 | 41 | -114 | -3 | 41 |

[a] Source: (SCS, 1960), note: Deliberate impoundment began on October 1, 1948, and Cherokee Dam was completed on November 19, 1948.
[b] 2015 TWDB surveyed capacity of 44,475 acre-feet plus 2015 TWDB surveyed sediment volume of 2,733 acre-feet

## Recommendations

To improve estimates of sediment accumulation rates, TWDB recommends resurveying Lake Cherokee 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 Lake Cherokee.

## TWDB contact information

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

Jason J. Kemp
Manager, TWDB Hydrographic Survey Program
Phone: (512) 463-2456
Email: Jason.Kemp@twdb.texas.gov

## References

ESRI (Environmental Systems Research Institute), 1995, ARC/INFO Surface Modeling and Display, TIN Users Guide, ESRI, 380 New York Street, Redlands, CA 92373.

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

McEwen, T., Brock, N., Kemp, J., Pothina, D. & Weyant, H., 2014a, HydroTools User's Manual, Texas Water Development Board.

McEwen, T., Pothina, D. & Negusse, S., 2014b, Improving efficiency and repeatability of lake volume estimates using Python, submitted, Proceedings of the 10th Python for Scientific Computing Conference (SciPy 2014).

SCS (U.S. Soil Conservation Service), 1960, Report on Sedimentation of Lake Cherokee, Gregg and Rusk Counties, Texas, April 4 – May 13, 1060.

SWEPCO (Southwestern Electric Power Company), 2015, History, https://www.swepco.com/info/facts/History.aspx, accessed August 2015.

TNRIS (Texas Natural Resources Information System), 2015a, http://www.tnris.org/, accessed March 2015.

TNRIS (Texas Natural Resources Information System), 2015b, http://tnris.org/news/2015-01-09/naip-2014-statewide-aerial-available/, accessed August 2015.

TWDB (Texas Water Development Board), 1974, *Cherokee Dam and Lake Cherokee*, Report 126, Engineering Data on Dams and Reservoirs in Texas, Part I.

TWDB (Texas Water Development Board), 2003, Volumetric and Sediment Survey of Lake Cherokee, http://www.twdb.texas.gov/hydro_survey/Cherokee/1996-10/Cherokee1996_FinalReport.pdf.

TWDB (Texas Water Development Board), 2004, Volumetric Survey Report of Lake Cherokee, http://www.twdb.texas.gov/hydro_survey/Cherokee/2003-11/Cherokee2003_FinalReport.pdf.

TWDB (Texas Water Development Board), 2015, *Contract No. R1548011795* with U.S. Army Corps of Engineers, Fort Worth District.

USDA (US Department of Agriculture), 2011, *National Agricultural Imagery Program (NAIP) Information Sheet*, February 2015, http://www.fsa.usda.gov/Internet/FSA_File/naip_info_sheet_2015.pdf, accessed August 2015.

Van Metre, P.C., Wilson, J.T., Fuller, C.C., Callender, Edward, and Mahler, B.J., 2004, Collection, analysis, and age-dating of sediment cores from 56 U.S. lakes and reservoirs sampled by the U.S. Geological Survey, 1992-2001: U.S. Geological Survey Scientific Investigations Report 2004-5184, United States Geological Survey, 180p.

Appendix A

# Lake Cherokee

## RESERVOIR CAPACITY TABLE

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

April 2015 Survey
Conservation Pool Elevation 280.0 feet NGVD29

| ELEVATION in Feet | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 246 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 247 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 248 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 |
| 249 | 3 | 4 | 5 | 6 | 7 | 8 | 10 | 12 | 14 | 16 |
| 250 | 19 | 23 | 27 | 32 | 37 | 43 | 50 | 57 | 65 | 74 |
| 251 | 83 | 93 | 103 | 114 | 126 | 138 | 151 | 165 | 179 | 194 |
| 252 | 210 | 227 | 244 | 263 | 282 | 302 | 323 | 346 | 369 | 393 |
| 253 | 419 | 445 | 472 | 501 | 530 | 561 | 593 | 625 | 659 | 693 |
| 254 | 729 | 765 | 802 | 840 | 879 | 920 | 961 | 1,003 | 1,046 | 1,089 |
| 255 | 1,134 | 1,179 | 1,226 | 1,273 | 1,321 | 1,369 | 1,418 | 1,468 | 1,519 | 1,571 |
| 256 | 1,623 | 1,675 | 1,729 | 1,783 | 1,838 | 1,894 | 1,951 | 2,009 | 2,067 | 2,126 |
| 257 | 2,187 | 2,248 | 2,310 | 2,372 | 2,436 | 2,501 | 2,566 | 2,632 | 2,699 | 2,767 |
| 258 | 2,835 | 2,905 | 2,975 | 3,046 | 3,118 | 3,191 | 3,265 | 3,340 | 3,416 | 3,492 |
| 259 | 3,569 | 3,647 | 3,726 | 3,805 | 3,886 | 3,967 | 4,048 | 4,131 | 4,214 | 4,297 |
| 260 | 4,382 | 4,466 | 4,552 | 4,638 | 4,725 | 4,812 | 4,900 | 4,989 | 5,078 | 5,169 |
| 261 | 5,260 | 5,352 | 5,445 | 5,538 | 5,633 | 5,728 | 5,824 | 5,921 | 6,019 | 6,118 |
| 262 | 6,218 | 6,319 | 6,421 | 6,523 | 6,627 | 6,732 | 6,838 | 6,944 | 7,051 | 7,160 |
| 263 | 7,269 | 7,378 | 7,489 | 7,601 | 7,713 | 7,827 | 7,941 | 8,057 | 8,173 | 8,291 |
| 264 | 8,410 | 8,530 | 8,650 | 8,772 | 8,895 | 9,019 | 9,143 | 9,269 | 9,395 | 9,522 |
| 265 | 9,650 | 9,779 | 9,909 | 10,039 | 10,171 | 10,304 | 10,439 | 10,574 | 10,711 | 10,848 |
| 266 | 10,987 | 11,126 | 11,267 | 11,408 | 11,551 | 11,695 | 11,839 | 11,985 | 12,132 | 12,280 |
| 267 | 12,429 | 12,579 | 12,731 | 12,883 | 13,037 | 13,191 | 13,347 | 13,504 | 13,662 | 13,822 |
| 268 | 13,982 | 14,143 | 14,306 | 14,470 | 14,635 | 14,801 | 14,969 | 15,138 | 15,309 | 15,482 |
| 269 | 15,656 | 15,831 | 16,008 | 16,186 | 16,367 | 16,549 | 16,733 | 16,919 | 17,106 | 17,296 |
| 270 | 17,487 | 17,681 | 17,876 | 18,072 | 18,271 | 18,471 | 18,673 | 18,877 | 19,082 | 19,289 |
| 271 | 19,497 | 19,706 | 19,917 | 20,129 | 20,342 | 20,556 | 20,772 | 20,989 | 21,207 | 21,426 |
| 272 | 21,646 | 21,868 | 22,091 | 22,316 | 22,541 | 22,769 | 22,997 | 23,228 | 23,459 | 23,693 |
| 273 | 23,927 | 24,163 | 24,401 | 24,640 | 24,880 | 25,122 | 25,366 | 25,611 | 25,858 | 26,106 |
| 274 | 26,356 | 26,608 | 26,861 | 27,115 | 27,371 | 27,629 | 27,889 | 28,151 | 28,414 | 28,679 |
| 275 | 28,946 | 29,216 | 29,487 | 29,759 | 30,033 | 30,309 | 30,585 | 30,863 | 31,143 | 31,423 |
| 276 | 31,706 | 31,989 | 32,274 | 32,561 | 32,848 | 33,138 | 33,428 | 33,721 | 34,014 | 34,310 |
| 277 | 34,607 | 34,905 | 35,206 | 35,507 | 35,811 | 36,116 | 36,424 | 36,733 | 37,043 | 37,356 |
| 278 | 37,671 | 37,988 | 38,306 | 38,627 | 38,950 | 39,275 | 39,603 | 39,932 | 40,264 | 40,598 |
| 279 | 40,935 | 41,275 | 41,617 | 41,961 | 42,309 | 42,659 | 43,013 | 43,371 | 43,735 | 44,103 |
| 280 | 44,475 | | | | | | | | | |

Note: Capacities above elevation 279.5 feet calculated from interpolated areas

Appendix B

# Lake Cherokee

## RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD

AREA IN ACRES

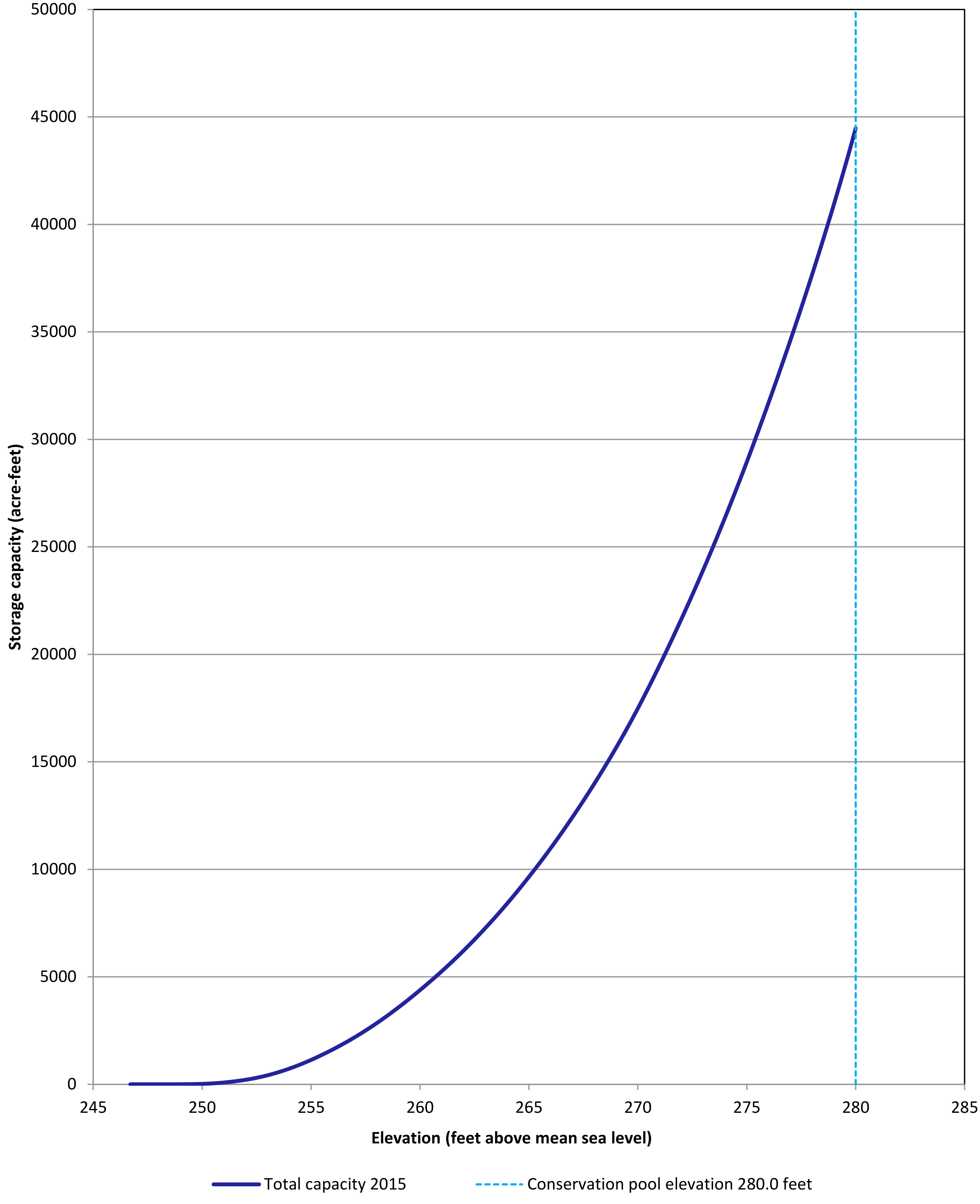
ELEVATION INCREMENT IS ONE TENTH FOOT

April 2015 Survey

Conservation Pool Elevation 280.0 feet NGVD29

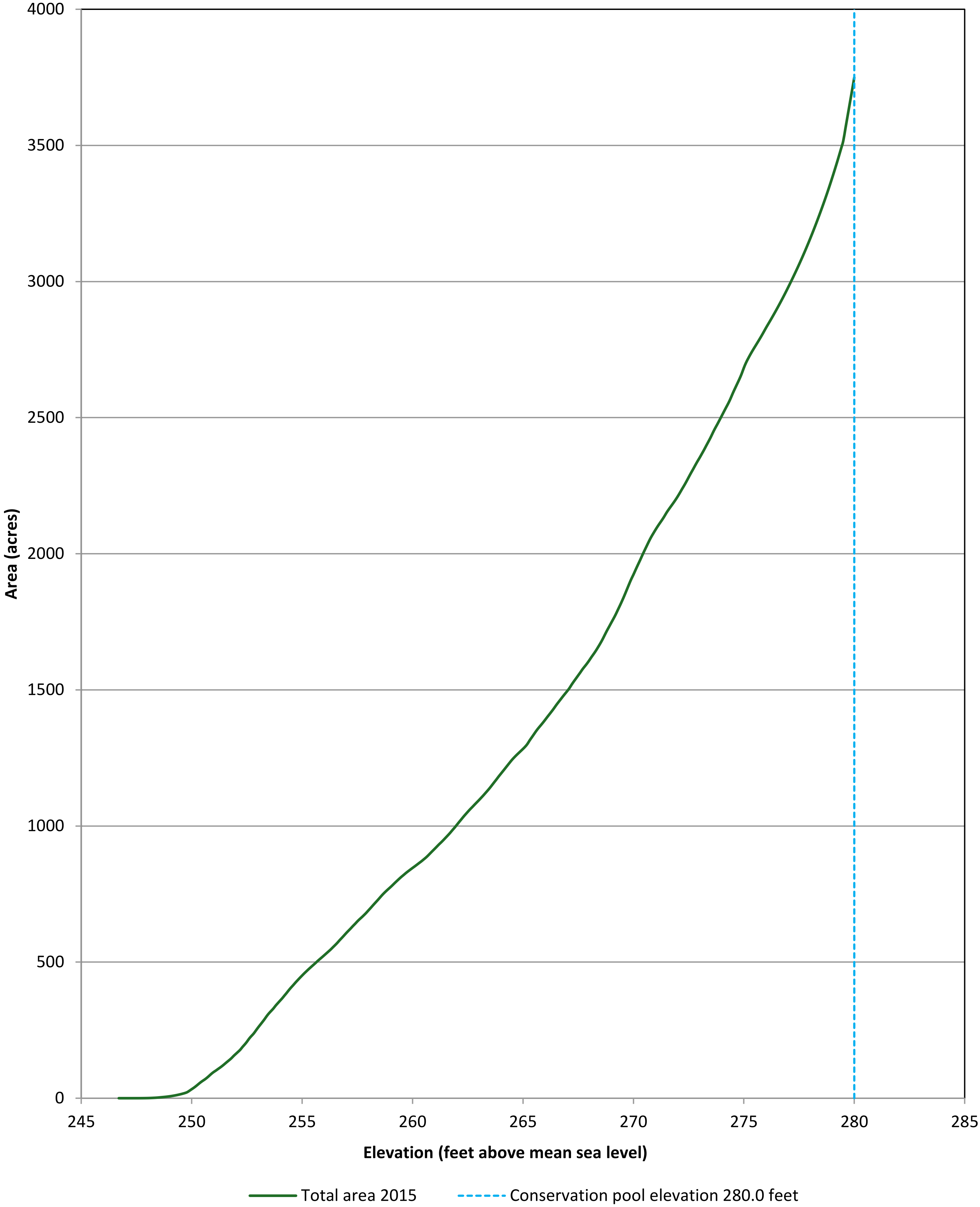
| ELEVATION in Feet | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 246 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 247 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 248 | 0 | 1 | 1 | 1 | 2 | 3 | 3 | 4 | 5 | 6 |
| 249 | 7 | 8 | 9 | 11 | 13 | 15 | 17 | 19 | 22 | 27 |
| 250 | 33 | 38 | 45 | 51 | 58 | 64 | 69 | 76 | 83 | 90 |
| 251 | 96 | 102 | 108 | 113 | 120 | 126 | 133 | 140 | 147 | 155 |
| 252 | 163 | 170 | 178 | 188 | 197 | 207 | 219 | 228 | 237 | 248 |
| 253 | 259 | 269 | 280 | 290 | 302 | 312 | 321 | 329 | 340 | 349 |
| 254 | 358 | 367 | 377 | 387 | 397 | 407 | 415 | 425 | 434 | 442 |
| 255 | 451 | 459 | 467 | 474 | 482 | 489 | 496 | 504 | 511 | 518 |
| 256 | 525 | 532 | 539 | 547 | 555 | 563 | 571 | 580 | 589 | 598 |
| 257 | 607 | 615 | 624 | 632 | 641 | 649 | 657 | 665 | 672 | 681 |
| 258 | 690 | 699 | 708 | 717 | 726 | 735 | 744 | 753 | 761 | 768 |
| 259 | 775 | 783 | 791 | 799 | 806 | 813 | 820 | 827 | 834 | 840 |
| 260 | 846 | 852 | 858 | 864 | 870 | 877 | 884 | 891 | 900 | 908 |
| 261 | 916 | 924 | 933 | 940 | 948 | 957 | 966 | 975 | 984 | 993 |
| 262 | 1,004 | 1,014 | 1,023 | 1,033 | 1,043 | 1,052 | 1,061 | 1,069 | 1,078 | 1,086 |
| 263 | 1,094 | 1,103 | 1,112 | 1,121 | 1,130 | 1,140 | 1,150 | 1,161 | 1,171 | 1,182 |
| 264 | 1,192 | 1,202 | 1,212 | 1,223 | 1,233 | 1,243 | 1,252 | 1,260 | 1,268 | 1,275 |
| 265 | 1,283 | 1,291 | 1,301 | 1,314 | 1,326 | 1,337 | 1,349 | 1,360 | 1,369 | 1,379 |
| 266 | 1,389 | 1,400 | 1,411 | 1,421 | 1,432 | 1,443 | 1,454 | 1,465 | 1,475 | 1,485 |
| 267 | 1,495 | 1,506 | 1,519 | 1,531 | 1,542 | 1,553 | 1,564 | 1,576 | 1,586 | 1,597 |
| 268 | 1,608 | 1,620 | 1,632 | 1,644 | 1,657 | 1,670 | 1,685 | 1,701 | 1,717 | 1,732 |
| 269 | 1,747 | 1,762 | 1,777 | 1,795 | 1,812 | 1,829 | 1,848 | 1,868 | 1,887 | 1,906 |
| 270 | 1,923 | 1,941 | 1,959 | 1,976 | 1,994 | 2,011 | 2,028 | 2,045 | 2,061 | 2,075 |
| 271 | 2,088 | 2,101 | 2,113 | 2,125 | 2,137 | 2,151 | 2,163 | 2,174 | 2,186 | 2,197 |
| 272 | 2,210 | 2,223 | 2,237 | 2,251 | 2,265 | 2,281 | 2,296 | 2,310 | 2,325 | 2,339 |
| 273 | 2,353 | 2,367 | 2,382 | 2,397 | 2,412 | 2,428 | 2,445 | 2,461 | 2,476 | 2,491 |
| 274 | 2,507 | 2,522 | 2,538 | 2,553 | 2,570 | 2,590 | 2,607 | 2,624 | 2,642 | 2,661 |
| 275 | 2,683 | 2,702 | 2,718 | 2,733 | 2,747 | 2,760 | 2,773 | 2,787 | 2,800 | 2,815 |
| 276 | 2,829 | 2,843 | 2,857 | 2,871 | 2,885 | 2,900 | 2,915 | 2,930 | 2,946 | 2,961 |
| 277 | 2,978 | 2,994 | 3,011 | 3,028 | 3,045 | 3,063 | 3,081 | 3,099 | 3,118 | 3,137 |
| 278 | 3,157 | 3,177 | 3,198 | 3,219 | 3,240 | 3,262 | 3,285 | 3,308 | 3,332 | 3,356 |
| 279 | 3,381 | 3,407 | 3,433 | 3,460 | 3,488 | 3,516 | 3,563 | 3,609 | 3,656 | 3,702 |
| 280 | 3,749 | | | | | | | | | |

Note: Areas between elevation 279.5 feet and model boundary elevation 280.3 feet linearly interpolated




**Lake Cherokee**
April 2015 Survey
Prepared by: TWDB

Appendix C: Capacity curve




**Lake Cherokee**
April 2015 Survey
Prepared by: TWDB

Appendix D: Area curve

# Lake Cherokee

2' - contour map