# Volumetric Survey
# of
# LAKE PAT CLEBURNE

## July 2008 Survey

Prepared by:

## The Texas Water Development Board

October 2008

# Texas Water Development Board

J. Kevin Ward, Executive Administrator

## Texas Water Development Board

Prepared for:

**City of Cleburne**

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# Executive Summary

In April of 2008, the Texas Water Development Board (TWDB) entered into agreement with the City of Cleburne, Texas, for the purpose of performing a volumetric survey of Lake Pat Cleburne. Cleburne Dam and Lake Pat Cleburne are located on Nolan Creek in the Brazos River basin near Cleburne, Texas, in Johnson County. TWDB conducted the Lake Pat Cleburne survey on July 8th-10th, 2008 while the average water surface elevation of the lake was 732.29 feet above mean sea level (NGVD 29). The conservation pool elevation for the lake is 733.5 feet above mean sea level (NGDV 29).

**The results of the TWDB 2008 Volumetric Survey indicate Lake Pat Cleburne has a total reservoir capacity of 26,008 acre-feet and encompasses 1,568 acres at conservation pool elevation (733.5 feet above mean sea level, NGVD 29).** Lake Pat Cleburne capacity (at conservation pool elevation) was previously estimated at 25,730 acre-feet in 1998 (by TWDB[1]) and 25,560 acre-feet in 1958 (TWDB & Hunter Associates[2]). Due to differences in the methodologies used in calculating areas and capacities from this and previous Lake Pat Cleburne surveys, comparison of these values is not recommended. The TWDB considers the 2008 survey to be a significant improvement over previous methods and recommends that a similar methodology be used to resurvey Lake Pat Cleburne in approximately 10 years or after a major flood event.

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

# Lake Pat Cleburne General Information

Cleburne Dam and Lake Pat Cleburne are located on Nolan Creek, a tributary of the Brazos River, near Cleburne, Texas, in Johnson County[2] (Figure 1). The City of Cleburne, Texas owns and operates Lake Pat Cleburne. Construction of Cleburne Dam began on August 9, 1963, with deliberate impoundment beginning on August 4, 1964.[2] Lake Pat Cleburne serves as a municipal, industrial, and agricultural water supply for the city, also providing flood control and recreational opportunities for the local community.[1] Additional pertinent data about Cleburne Dam can be found in Table 1.
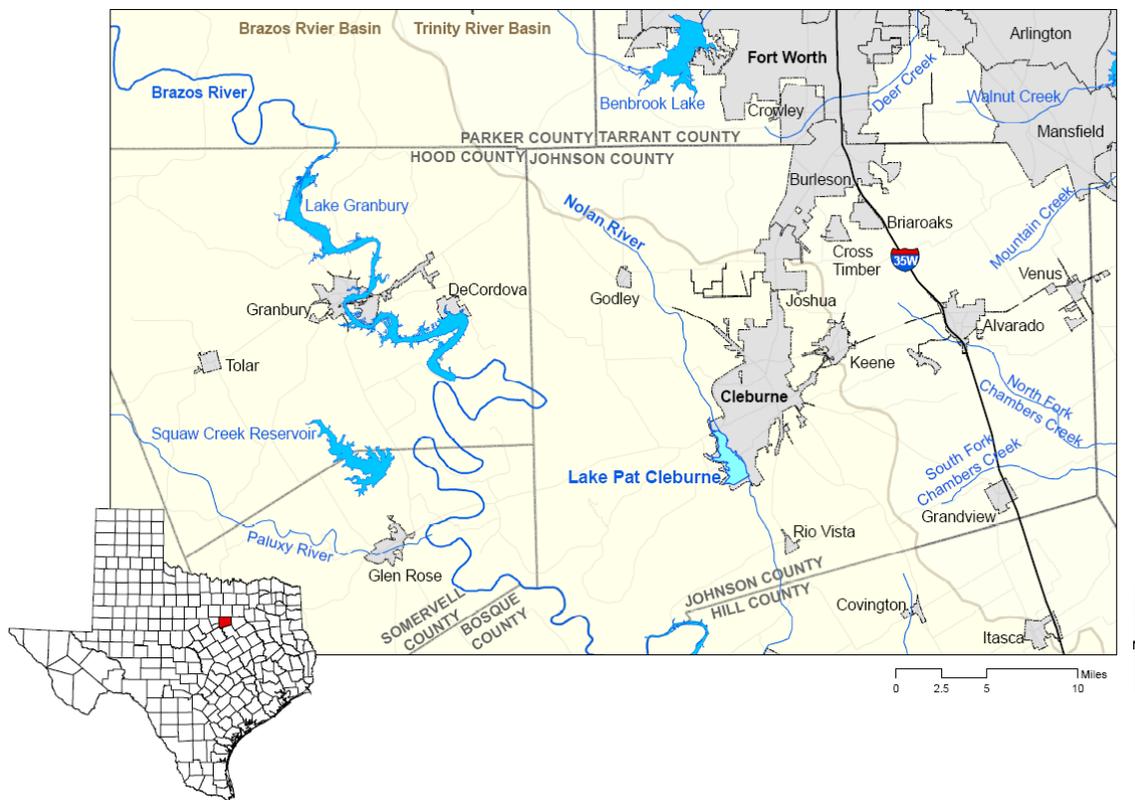


***Figure 1*** *- Location Map: Lake Pat Cleburne*

**Table 1. Pertinent Data for Cleburne Dam and Lake Pat Cleburne**[2]

**Owner**
    City of Cleburne
**Engineer (Design)**
    Hunter Associates
**Location of Dam**
    On Nolan River in Johnson County, 4 miles south of Cleburne, TX
**Drainage Area**
    100 square miles
**Dam**

| | |
|---|---|
| Type | Earthfill |
| Length | |
| (Does not include spillways) | 4,950 feet |
| Maximum height | 78 feet |
| Top width | 25 feet |

**Spillway (emergency)**

| | |
|---|---|
| Type | Excavated channel |
| Control | None |
| Elevation | 744.0 feet above mean sea level |
| Crest length | 500 feet |

**Spillway (service)**

| | |
|---|---|
| Type | Concrete ogee |
| Control | None |
| Elevation | 733.5 feet above mean sea level |
| Crest length | 150 feet |

**Outlet Works**

| | |
|---|---|
| Type | Tower and 30-inch diameter steel pipe inside of 36-inch concrete pipe |
| Control | 2 sluice gates |
| Invert elevation | 690.0 feet above mean sea level |

**Reservoir Data (Based on TWDB 2008 Volumetric Survey)**

| Feature | Elevation (feet above mean sea level) | Capacity (Acre-feet) | Area (Acres) |
|---|---|---|---|
| Top of Dam | 753.0 | N/A | N/A |
| Top of design flood pool | 752.3 | N/A | N/A |
| Emergency spillway crest | 744.0 | N/A | N/A |
| Service spillway crest | 733.5 | 26,008 | 1,568 |
| Invert of upper sluice gate | 722.0 | 11,050 | 969 |
| Invert of lower sluice gate | 690.0 | 0 | 0 |
| Usable conservation storage | - | 26,008 | |

## Water Rights

The water rights for Lake Pat Cleburne are owned by the City of Cleburne through Certificate of Adjudication No. 12-4106 and its amendments. A brief summary of each follows. The complete certificates are on file in the Records Department of the Texas Commission on Environmental Quality.

**Certificate of Adjudication No. 12-4106**

Priority Dates: August 6, 1962 & March 29, 1976.

Authorizes the City of Cleburne to maintain an existing dam and reservoir, Lake Pat Cleburne, on the Nolan River and impound therein a maximum of 25,600 acre-feet of water.  The City of Cleburne is authorized to divert and use a maximum of 5,760 acre-feet of water per year for municipal purposes. The City is also authorized to divert and use a maximum of 240 acre-feet of water per year to irrigate up to 80 acres of land that lies northeast of the reservoir.  All water that is diverted and not consumed is to be returned to Buffalo Creek, a tributary of the Nolan River.

**Amendment to Certificate of Adjudication No. 12-4106A**

Granted: October 11, 1996

Authorizes the City of Cleburne to divert and use the 5,760 acre-feet of water originally authorized for municipal purposes, for municipal and industrial purposes.  This amendment also requires the City of Cleburne to implement a water conservation plan and requires all industrial users to have a method of measuring the quantity of water diverted for that purpose.

**Amendment to Certificate of Adjudication No. 12-4106B**

Granted: January 15, 2002

Authorizes the City of Cleburne to use the bed and banks of Lake Pat Cleburne to deliver water purchased from the Brazos River Authority.  The City is then authorized to divert and use 5,300 acre-feet of contracted water, delivered by pipeline from Lake Aquilla, for municipal purposes (pursuant to the Water Sale Contract between the City of Cleburne and the Brazos River Authority, Certificate of Adjudication No. 12-5158).  The amendment also authorizes the City of Cleburne to divert, from currently authorized diversion points, and use, an additional 4,700 acre-feet of water per year of Lake Whitney contract water for municipal purposes (pursuant to a Water Sale Contract between the City of Cleburne and the Brazos River Authority, Certificate of Adjudication No. 12-5157). This amendment also requires the City to implement a water conservation plan, and requires every wholesale customer entered into contract with to implement a water conservation plan.

**Amendment to Certificate of Adjudication No. 12-4106C**

Granted: November 30, 2005

Authorizes the City of Cleburne to divert and reuse 8,400 acre-feet of existing and future return flows originating from two wastewater treatment plants for agricultural, industrial, and municipal purposes within the City's service area in Johnson County. The City is authorized to use the bed and banks of West Buffalo Creek, Buffalo Creek, and the Nolan River to convey return flows to the downstream diversion point. The priority date for diverting 8,400 acre-feet of water is August 20, 2004. The first 3,684 acre-feet of diversion is subject to call by senior water right holders, and is restricted by streamflow rates measured either directly downstream of the diversion point or at USGS Gage #08092000 Nolan River and Blum. The remaining 4,716 acre-feet of the authorized 8,400 acre-feet is not subject to call by senior water right holders nor instream flow restrictions.

## Volumetric Survey of Lake Pat Cleburne

### Introduction

The Hydrographic Survey Program of the Texas Water Development Board (TWDB) 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 April of 2008, the TWDB entered into agreement[3] with the City of Cleburne, Texas, for the purpose of performing a volumetric survey of Lake Pat Cleburne. This report describes the methods used in conducting the volumetric survey, including data collection methods and data processing techniques. This report serves as the final contract deliverable from TWDB to the City of Cleburne, and contains as deliverables: (1) an elevation-area-capacity table of the lake acceptable to the Texas Commission on Environmental Quality, (2) a bottom contour map, and (3) a shaded relief plot of the lake bottom.

**Datum**

The vertical datum used during this survey is that used by the United States Geological Survey, for the reservoir elevation gauge USGS 08091900 Lk Pat Cleburne nr Cleburne, TX.[4]  The datum for this gauge is reported as National Geodetic Vertical Datum 1929 (NGVD 29) or mean sea level, thus elevations reported here are in feet above mean sea level.  Volume and area calculations in this report are referenced to water levels provided by the USGS gauge. The horizontal datum used for this report is North American Datum of 1983 (NAD83) State Plane Texas North Central Zone (feet).

**TWDB Bathymetric Data Collection**

Bathymetric data collection occurred July 8th through July 10th 2008 while the daily average water surface elevation of the lake was 732.29 feet above mean sea level (NGVD 29).  For data collection, TWDB used a Knudsen Engineering Ltd. single-frequency (200 kHz) depth sounder integrated with Differential Global Positioning System (DGPS) equipment. Data collection occurred while navigating along pre-planned range lines oriented perpendicular to the location of the original river channels and spaced approximately 500 feet apart. Data was also collected along some of the survey lines used during the 1998 Lake Pat Cleburne survey conducted by TWDB. For all data collection efforts, the depth sounder was calibrated daily by comparing depth readings recorded by the Knudsen echosounder to physical depth measurements made with a weighted tape and stadia rod.  During the 2008 survey, team members collected over 20,200 data points over cross-sections totaling nearly 38 miles in length.  Figure 2 shows where data points were collected during the TWDB 2008 survey.
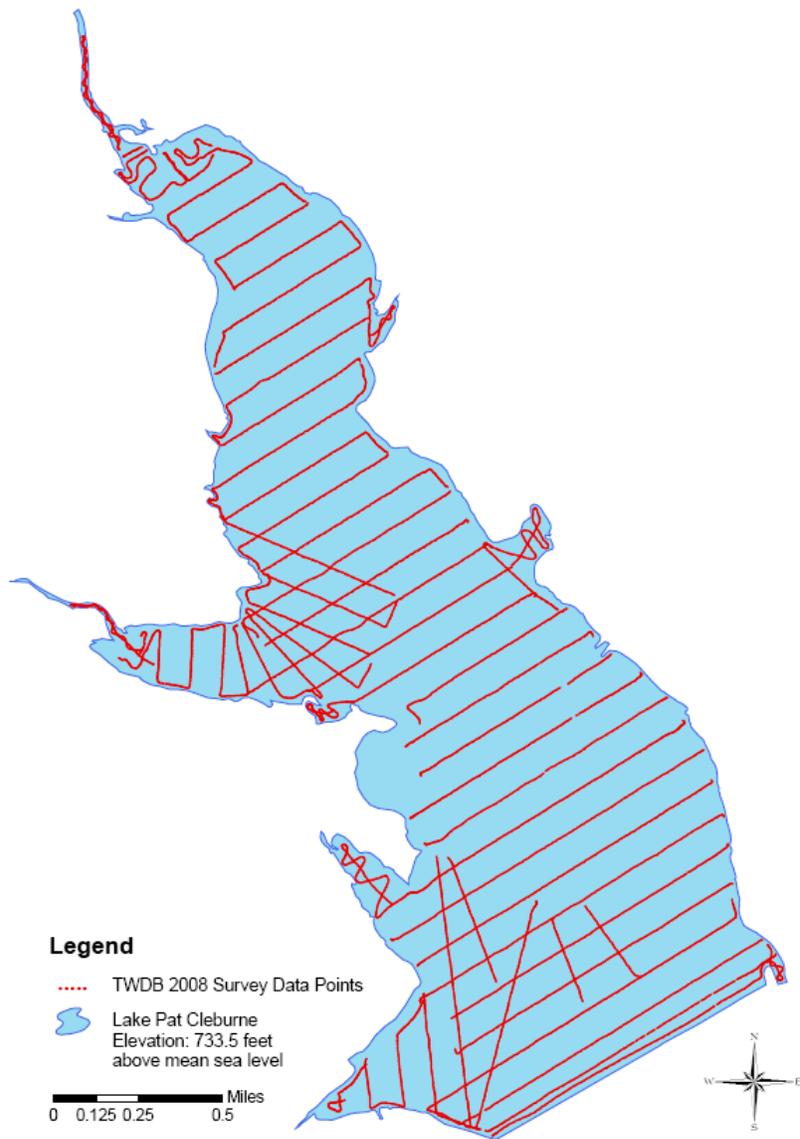
*Figure 2* – *TWDB 2008 survey data points for Lake Pat Cleburne*

## Data Processing

### Model Boundaries

The boundary of Lake Pat Cleburne was manually digitized from digital ortho quarter quadrangle (DOQQ) aerial photos[5] available from the Texas Natural Resources Information System (TNRIS).[6] The model boundary at conservation pool elevation (733.5.0 feet) was digitized from the Cleburne West NW, NE, SW, and SE DOQQs photographed on August 4, 2004 when the water surface elevation in Lake Pat Cleburne was 733.34 feet as measured by the United States Geological Survey (USGS) gauge at

6

Cleburne Dam. As the DOQQs used in digitizing the boundary are of 1-meter resolution, the physical boundary of Lake Pat Cleburne may be within ± 1 meter of the location derived from the manual delineation. For the purposes of this analysis it was assumed that the boundary of the lake at conservation pool elevation is closely represented by the August 4, 2004 DOQQ. Therefore for the purpose of calculating elevation-area-capacity tables, TWDB assigned the digitized boundary an elevation of 733.5 feet.

Additional lake boundary data were derived through digitization of DOQQs derived from aerial photographs taken on August 19, 2006. On this date, the water surface elevation in Lake Pat Cleburne averaged 730.31 feet according to the USGS gauge. This additional dataset was used as a supplement to the TWDB survey data in locations where the survey data alone was insufficient to properly represent the reservoir bathymetry.

**Triangular Irregular Network (TIN) Model**

Upon completion of the data collection effort, the raw data files collected by TWDB were edited using customized MATLAB processing scripts and the HydroEdit software package. Specifically, HydroEdit applies a median filter to the raw survey data and removes individual data anomalies or points with incorrect GPS coordinates. HydroEdit also uses the water surface elevations at the times of each sounding to convert sounding depths to corresponding bathymetric elevations[7]. The MATLAB processing scripts are then used to visually inspect each of the filtered cross-sections to indentify and rectify any series of data anomalies that were not edited using the HydroEdit filters. For processing outside of MATLAB and HydroEdit, the sounding coordinates (X,Y,Z) are exported as a MASS points file. TWDB also created a MASS points file of interpolated data located in-between surveyed cross sections. This points file is described in the section entitled "Self-Similar Interpolation."

To create a surface representation of the Lake Pat Cleburne bathymetry, the 3D Analyst Extension of ArcGIS (ESRI, Inc.) is used. This extension creates a triangulated irregular network (TIN) model of the bathymetry, where each MASS point and boundary node becomes the vertex of a triangular portion of the reservoir bottom surface.[8] From the TIN model, reservoir capacities and areas are calculated at one-tenth of a foot (0.1 foot) intervals, from elevation 692.0 feet to elevation 733.5 feet.

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

The Lake Pat Cleburne 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 representing the topography of the reservoir bottom (Figure 3), a map showing shaded depth ranges for Lake Pat Cleburne (Figure 4), and a 2-foot contour map (Figure 5 - attached). The reservoir extent depicted in these figures is that corresponding to the conservation pool elevation (733.5 feet).

**Self-Similar Interpolation**

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

To ameliorate these problems, a Self-Similar Interpolation routine (developed by TWDB) was used to interpolate the bathymetry between many 500 foot-spaced 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.[7] In the case of Lake Pat Cleburne, the application of Self-Similar Interpolation helped represent the lake morphology near the banks and improved the representation of the submerged river channel (Figure 6). In areas where obvious geomorphic features indicate a high-probability of cross-section shape changes (e.g. incoming tributaries, significant widening/narrowing of channel, etc.), the assumptions used in applying the Self-Similar Interpolation technique are not likely to be valid; therefore, self-similar interpolation was not used in areas of Lake Pat Cleburne where a high probability of change between cross-sections exists.[7]

**Figure 3**
# Lake Pat Cleburne
Elevation Relief Map

**Legend**
**ELEVATION**
**(in feet above**
**mean sea level)**

- 731.6 - 733.5
- 729.6 - 731.5
- 727.6 - 729.5
- 725.6 - 727.5
- 723.6 - 725.5
- 721.6 - 723.5
- 719.6 - 721.5
- 717.6 - 719.5
- 715.6 - 717.5
- 713.6 - 715.5
- 711.6 - 713.5
- 709.6 - 711.5
- 707.6 - 709.5
- 705.6 - 707.5
- 703.6 - 705.5
- 701.6 - 703.5
- 699.6 - 701.5
- 697.6 - 699.5
- 695.6 - 697.5
- 693.6 - 695.5
- 692.8 - 693.5

Conservation Pool Elevation:
733.5 feet above mean sea level

0   0.125   0.25        0.5   Miles
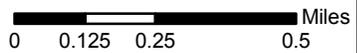
Prepared by: TEXAS WATER DEVELOPMENT BOARD  July 2008 Survey
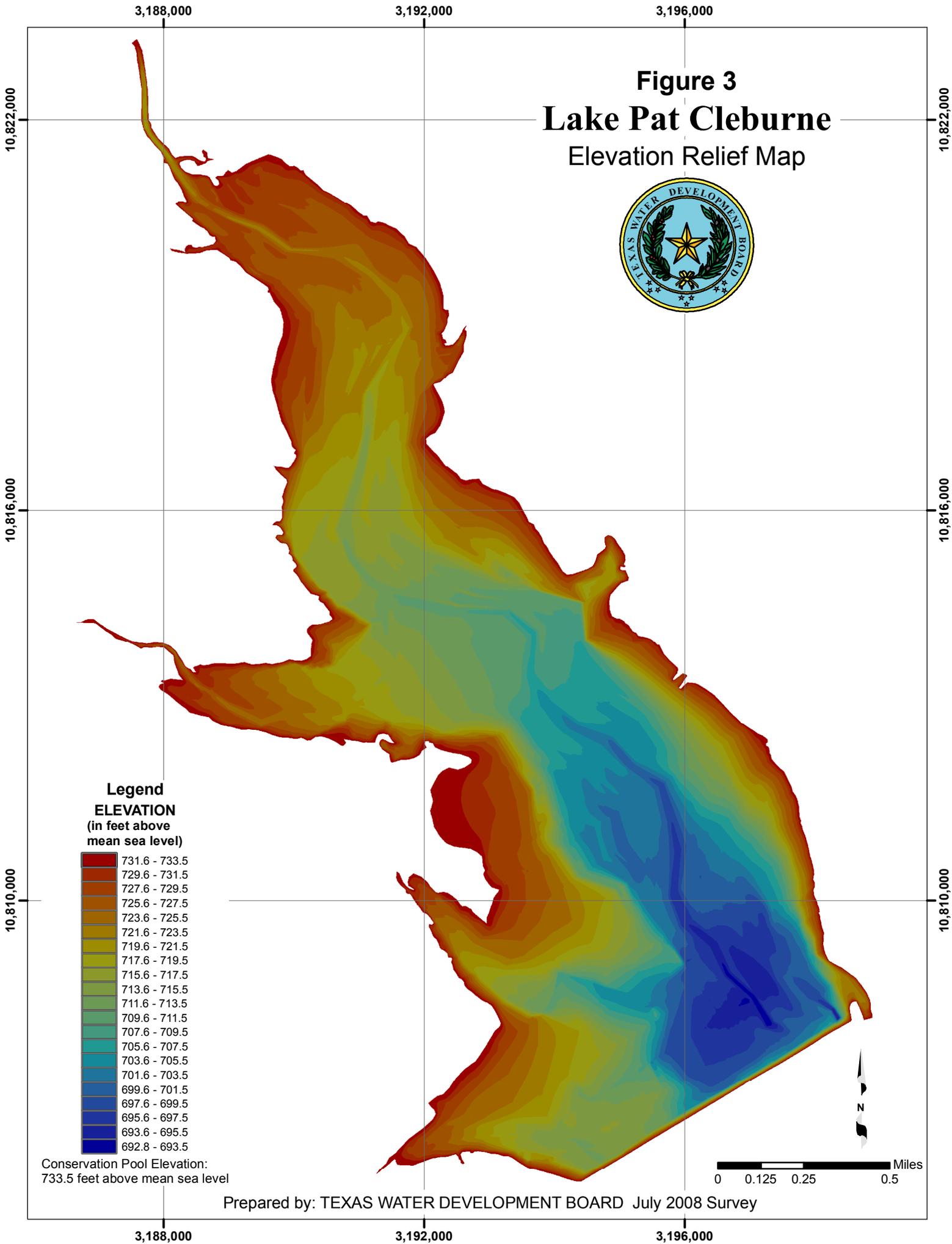
## Figure 4
# Lake Pat Cleburne
## Depth Ranges Map
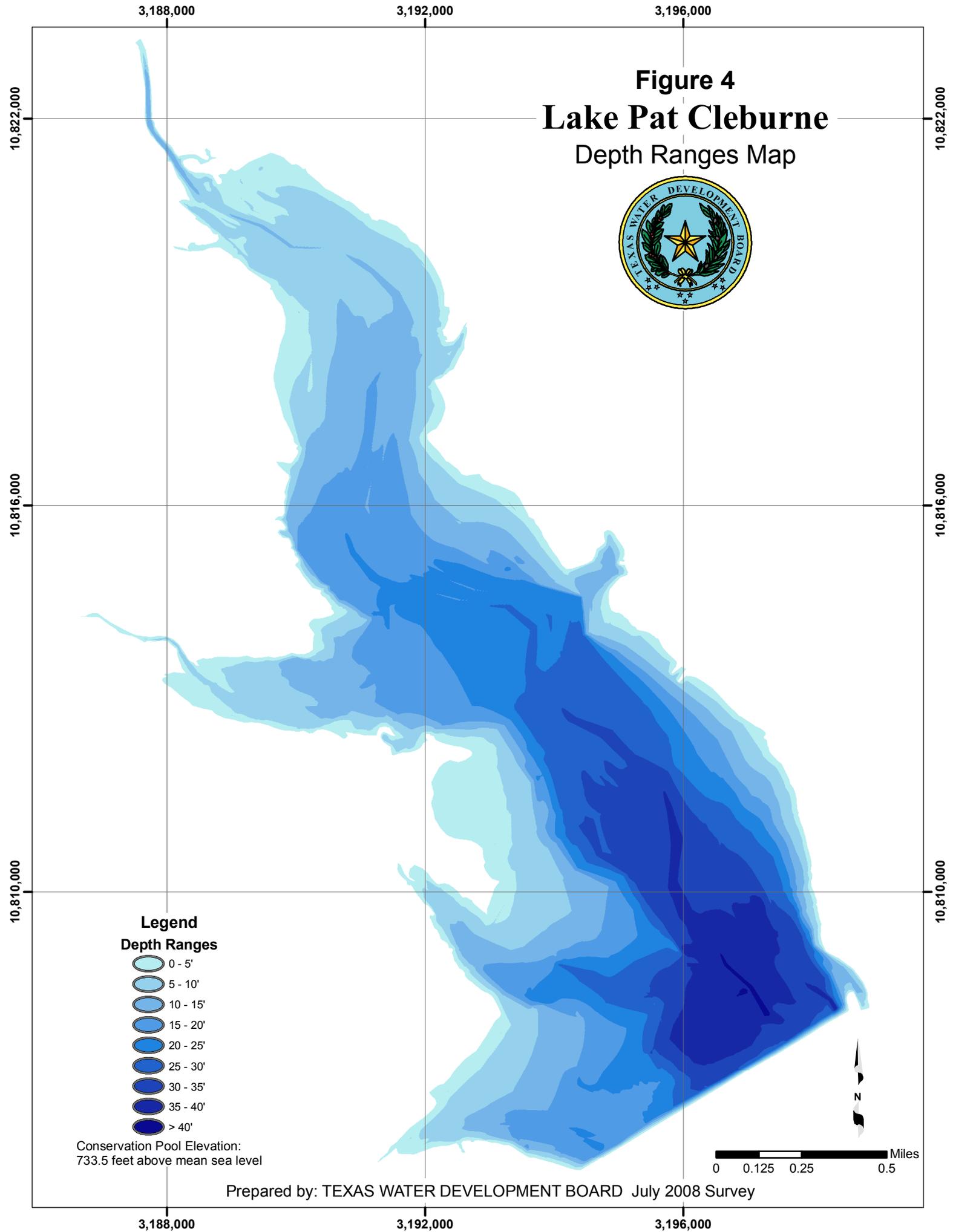
**Legend**

**Depth Ranges**

- 0 - 5'
- 5 - 10'
- 10 - 15'
- 15 - 20'
- 20 - 25'
- 25 - 30'
- 30 - 35'
- 35 - 40'
- > 40'

Conservation Pool Elevation:
733.5 feet above mean sea level

N

0   0.125   0.25                0.5  Miles
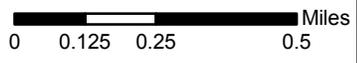
Prepared by: TEXAS WATER DEVELOPMENT BOARD  July 2008 Survey
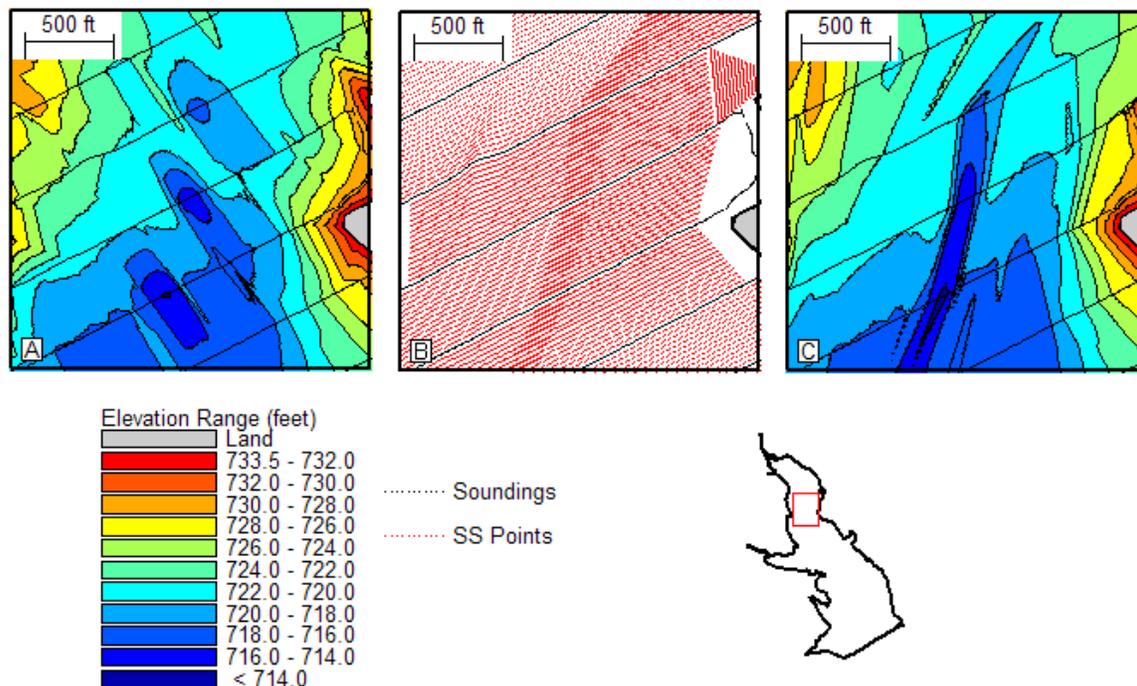
*Figure 6* - *Application of the Self-Similar Interpolation technique to Lake Pat Cleburne sounding data – A) bathymetric contours without interpolated points, B) Sounding points (black) and interpolated points (red) with reservoir boundary shown at elevation 733.5 feet (black), C) bathymetric contours with the interpolated points. Note: In 6A the deep channel indicated by the surveyed cross sections is not continuous within the areas in-between the cross sections. This is an artifact of the TIN generation routine when data points are not collected perpendicular to the channel axis. Inclusion of the interpolated points (6C) corrects this and smoothes the bathymetric contours.*

## Volumetric Survey Results

**The results of the TWDB 2008 Volumetric Survey indicate Lake Pat Cleburne has a total reservoir capacity of 26,008 acre-feet and encompasses 1,568 acres at conservation pool elevation (733.5 feet above mean sea level, NGVD 29).** Lake Pat Cleburne capacity (at conservation pool elevation) was previously estimated at 25,730 acre-feet in 1998 (by TWDB[1]) and 25,560 acre-feet in 1958 (TWDB & Hunter Associates[2]). Due to differences in the methodologies used in calculating areas and capacities from this and previous Lake Pat Cleburne surveys, comparison of these values is not recommended.[9] The TWDB considers the 2008 survey to be a significant improvement over previous methods and recommends that a similar methodology be used to resurvey Lake Pat Cleburne in approximately 10 years or after a major flood event.

## TWDB Contact Information

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

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

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

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

Or

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

# References

1. Texas Water Development Board, 1998, "Volumetric Survey of Lake Pat Cleburne"

2. Texas Water Development Board, Report 126, Engineering Data on Dams and Reservoirs in Texas, Part II, November 1973.

3. Texas Water Development Board Contract No. 0804800813 with the City of Cleburne, executed on 4/15/2008.

4. United States Geological Survey, Site 08091900 Lk Pat Cleburne nr Cleburne, TX http://waterdata.usgs.gov/tx/nwis/uv/?site_no=08091900  viewed on 18 July 2008.

5. U.S Department of Agriculture, Farm Service Agency, Aerial Photography Field Office, National Agriculture Imagery Program, http://www.apfo.usda.gov/NAIP.html viewed 10 February 2006.

6. Texas Natural Resources Information System, TNRIS Home, http://www.tnris.state.tx.us/ viewed 18 July 2008.

7. Furnans, Jordan. Texas Water Development Board. 2006.  "HydroEdit User's Manual."

8. ESRI, Environmental Systems Research Institute. 1995. ARC/INFO Surface Modeling and Display, TIN Users Guide.

9. United States Department of Agriculture, Natural Resource Conservation Service, National Engineering Handbook, Section 3, Sedimentation, Chapter 7, Field Investigations and Surveys, December 1983.

Appendix A
# Lake Pat Cleburne
## RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD    JULY 2008 SURVEY
CAPACITY IN ACRE-FEET    Conservation Pool Elevation 733.5 Feet NGVD 29
ELEVATION INCREMENT IS ONE TENTH FOOT

| ELEVATION in Feet | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 692 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 693 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 |
| 694 | 2 | 3 | 3 | 4 | 4 | 5 | 6 | 6 | 7 | 8 |
| 695 | 10 | 11 | 12 | 14 | 15 | 17 | 19 | 21 | 24 | 26 |
| 696 | 29 | 31 | 35 | 38 | 41 | 45 | 49 | 52 | 57 | 61 |
| 697 | 66 | 70 | 76 | 81 | 86 | 92 | 98 | 104 | 111 | 117 |
| 698 | 124 | 131 | 139 | 147 | 154 | 163 | 171 | 180 | 188 | 197 |
| 699 | 207 | 216 | 226 | 236 | 246 | 257 | 268 | 279 | 290 | 302 |
| 700 | 314 | 327 | 340 | 352 | 366 | 379 | 393 | 406 | 421 | 435 |
| 701 | 449 | 464 | 479 | 494 | 510 | 526 | 542 | 558 | 575 | 592 |
| 702 | 610 | 627 | 645 | 663 | 682 | 701 | 720 | 739 | 759 | 779 |
| 703 | 799 | 820 | 841 | 862 | 884 | 906 | 928 | 950 | 973 | 996 |
| 704 | 1,020 | 1,044 | 1,068 | 1,092 | 1,117 | 1,142 | 1,167 | 1,193 | 1,218 | 1,244 |
| 705 | 1,271 | 1,297 | 1,324 | 1,352 | 1,379 | 1,407 | 1,435 | 1,464 | 1,493 | 1,522 |
| 706 | 1,552 | 1,582 | 1,612 | 1,643 | 1,674 | 1,705 | 1,736 | 1,768 | 1,800 | 1,832 |
| 707 | 1,864 | 1,897 | 1,930 | 1,964 | 1,997 | 2,031 | 2,066 | 2,100 | 2,135 | 2,170 |
| 708 | 2,205 | 2,240 | 2,276 | 2,312 | 2,348 | 2,384 | 2,421 | 2,458 | 2,495 | 2,532 |
| 709 | 2,570 | 2,608 | 2,647 | 2,685 | 2,724 | 2,763 | 2,803 | 2,843 | 2,883 | 2,923 |
| 710 | 2,964 | 3,004 | 3,046 | 3,087 | 3,129 | 3,172 | 3,214 | 3,257 | 3,301 | 3,344 |
| 711 | 3,389 | 3,433 | 3,478 | 3,523 | 3,569 | 3,615 | 3,662 | 3,709 | 3,757 | 3,804 |
| 712 | 3,853 | 3,901 | 3,950 | 4,000 | 4,049 | 4,099 | 4,150 | 4,201 | 4,252 | 4,304 |
| 713 | 4,356 | 4,409 | 4,462 | 4,515 | 4,569 | 4,623 | 4,678 | 4,734 | 4,789 | 4,846 |
| 714 | 4,903 | 4,960 | 5,018 | 5,077 | 5,136 | 5,196 | 5,256 | 5,317 | 5,379 | 5,440 |
| 715 | 5,503 | 5,565 | 5,629 | 5,692 | 5,757 | 5,821 | 5,886 | 5,952 | 6,018 | 6,085 |
| 716 | 6,152 | 6,219 | 6,287 | 6,356 | 6,424 | 6,494 | 6,563 | 6,634 | 6,704 | 6,775 |
| 717 | 6,847 | 6,919 | 6,991 | 7,065 | 7,138 | 7,212 | 7,287 | 7,363 | 7,438 | 7,515 |
| 718 | 7,592 | 7,669 | 7,747 | 7,826 | 7,904 | 7,984 | 8,063 | 8,143 | 8,224 | 8,305 |
| 719 | 8,386 | 8,468 | 8,551 | 8,633 | 8,717 | 8,800 | 8,884 | 8,969 | 9,054 | 9,140 |
| 720 | 9,225 | 9,312 | 9,399 | 9,486 | 9,574 | 9,662 | 9,751 | 9,841 | 9,930 | 10,021 |
| 721 | 10,112 | 10,203 | 10,295 | 10,387 | 10,480 | 10,573 | 10,667 | 10,762 | 10,857 | 10,953 |
| 722 | 11,050 | 11,147 | 11,245 | 11,343 | 11,442 | 11,541 | 11,641 | 11,742 | 11,843 | 11,944 |
| 723 | 12,046 | 12,149 | 12,252 | 12,355 | 12,459 | 12,564 | 12,669 | 12,774 | 12,881 | 12,988 |
| 724 | 13,095 | 13,203 | 13,312 | 13,422 | 13,532 | 13,642 | 13,754 | 13,865 | 13,978 | 14,091 |
| 725 | 14,205 | 14,319 | 14,434 | 14,549 | 14,665 | 14,782 | 14,899 | 15,017 | 15,135 | 15,254 |
| 726 | 15,374 | 15,494 | 15,615 | 15,737 | 15,859 | 15,982 | 16,105 | 16,230 | 16,355 | 16,480 |
| 727 | 16,607 | 16,734 | 16,861 | 16,990 | 17,119 | 17,249 | 17,380 | 17,511 | 17,643 | 17,776 |
| 728 | 17,910 | 18,044 | 18,178 | 18,314 | 18,450 | 18,587 | 18,724 | 18,862 | 19,001 | 19,140 |
| 729 | 19,280 | 19,421 | 19,562 | 19,704 | 19,847 | 19,990 | 20,134 | 20,278 | 20,422 | 20,567 |
| 730 | 20,712 | 20,858 | 21,004 | 21,150 | 21,298 | 21,445 | 21,593 | 21,742 | 21,890 | 22,039 |
| 731 | 22,188 | 22,337 | 22,487 | 22,637 | 22,787 | 22,938 | 23,088 | 23,240 | 23,391 | 23,543 |
| 732 | 23,694 | 23,847 | 23,999 | 24,152 | 24,305 | 24,458 | 24,612 | 24,766 | 24,920 | 25,075 |
| 733 | 25,229 | 25,385 | 25,540 | 25,696 | 25,852 | 26,008 | | | | |

Appendix B
# Lake Pat Cleburne
## RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD     JULY 2008 SURVEY
AREA IN ACRES     Conservation Pool Elevation 733.5 Feet NGVD 29
ELEVATION INCREMENT IS ONE TENTH FOOT

| ELEVATION in Feet | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 692 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 693 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| 694 | 4 | 4 | 5 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 695 | 12 | 13 | 15 | 16 | 17 | 19 | 20 | 22 | 24 | 25 |
| 696 | 27 | 29 | 31 | 33 | 35 | 37 | 39 | 41 | 43 | 45 |
| 697 | 47 | 49 | 52 | 54 | 56 | 58 | 61 | 63 | 66 | 68 |
| 698 | 71 | 73 | 75 | 78 | 80 | 82 | 85 | 87 | 90 | 92 |
| 699 | 94 | 97 | 99 | 102 | 104 | 106 | 109 | 113 | 117 | 120 |
| 700 | 123 | 126 | 128 | 131 | 133 | 135 | 137 | 139 | 142 | 144 |
| 701 | 146 | 148 | 151 | 154 | 157 | 160 | 163 | 166 | 169 | 172 |
| 702 | 175 | 178 | 181 | 184 | 187 | 190 | 193 | 196 | 199 | 202 |
| 703 | 205 | 207 | 211 | 214 | 217 | 221 | 224 | 227 | 230 | 233 |
| 704 | 237 | 240 | 243 | 245 | 248 | 251 | 254 | 257 | 259 | 262 |
| 705 | 265 | 268 | 271 | 274 | 278 | 281 | 285 | 288 | 292 | 295 |
| 706 | 298 | 301 | 304 | 307 | 310 | 312 | 315 | 318 | 321 | 324 |
| 707 | 327 | 330 | 332 | 335 | 338 | 341 | 343 | 346 | 348 | 350 |
| 708 | 353 | 355 | 357 | 360 | 362 | 365 | 368 | 370 | 373 | 376 |
| 709 | 379 | 382 | 385 | 388 | 391 | 393 | 396 | 399 | 402 | 405 |
| 710 | 408 | 411 | 414 | 418 | 421 | 424 | 428 | 432 | 436 | 440 |
| 711 | 444 | 448 | 452 | 456 | 460 | 464 | 468 | 472 | 476 | 480 |
| 712 | 484 | 488 | 492 | 495 | 499 | 503 | 507 | 511 | 515 | 519 |
| 713 | 523 | 528 | 532 | 537 | 541 | 546 | 551 | 556 | 561 | 567 |
| 714 | 572 | 578 | 584 | 590 | 595 | 600 | 606 | 611 | 616 | 620 |
| 715 | 625 | 630 | 635 | 639 | 644 | 649 | 654 | 659 | 664 | 668 |
| 716 | 673 | 677 | 682 | 686 | 691 | 695 | 700 | 704 | 708 | 713 |
| 717 | 718 | 723 | 728 | 734 | 739 | 745 | 750 | 756 | 762 | 767 |
| 718 | 772 | 777 | 781 | 786 | 790 | 795 | 799 | 804 | 808 | 812 |
| 719 | 817 | 821 | 825 | 830 | 834 | 839 | 843 | 848 | 853 | 857 |
| 720 | 862 | 866 | 871 | 876 | 881 | 886 | 891 | 896 | 901 | 906 |
| 721 | 911 | 916 | 921 | 926 | 931 | 937 | 943 | 949 | 956 | 963 |
| 722 | 969 | 975 | 981 | 987 | 992 | 997 | 1,002 | 1,007 | 1,012 | 1,016 |
| 723 | 1,022 | 1,027 | 1,032 | 1,038 | 1,043 | 1,049 | 1,054 | 1,060 | 1,066 | 1,072 |
| 724 | 1,078 | 1,085 | 1,092 | 1,098 | 1,104 | 1,110 | 1,116 | 1,121 | 1,128 | 1,134 |
| 725 | 1,140 | 1,146 | 1,152 | 1,158 | 1,164 | 1,169 | 1,175 | 1,181 | 1,187 | 1,193 |
| 726 | 1,199 | 1,205 | 1,212 | 1,219 | 1,226 | 1,233 | 1,239 | 1,246 | 1,253 | 1,260 |
| 727 | 1,267 | 1,274 | 1,281 | 1,288 | 1,296 | 1,303 | 1,311 | 1,318 | 1,324 | 1,331 |
| 728 | 1,338 | 1,345 | 1,351 | 1,358 | 1,364 | 1,371 | 1,377 | 1,384 | 1,390 | 1,396 |
| 729 | 1,403 | 1,410 | 1,417 | 1,424 | 1,429 | 1,434 | 1,438 | 1,442 | 1,446 | 1,450 |
| 730 | 1,454 | 1,458 | 1,462 | 1,473 | 1,476 | 1,479 | 1,481 | 1,484 | 1,487 | 1,490 |
| 731 | 1,492 | 1,495 | 1,498 | 1,501 | 1,503 | 1,506 | 1,509 | 1,512 | 1,515 | 1,518 |
| 732 | 1,520 | 1,523 | 1,526 | 1,529 | 1,532 | 1,535 | 1,538 | 1,541 | 1,544 | 1,547 |
| 733 | 1,550 | 1,553 | 1,556 | 1,559 | 1,563 | 1,568 | | | | |
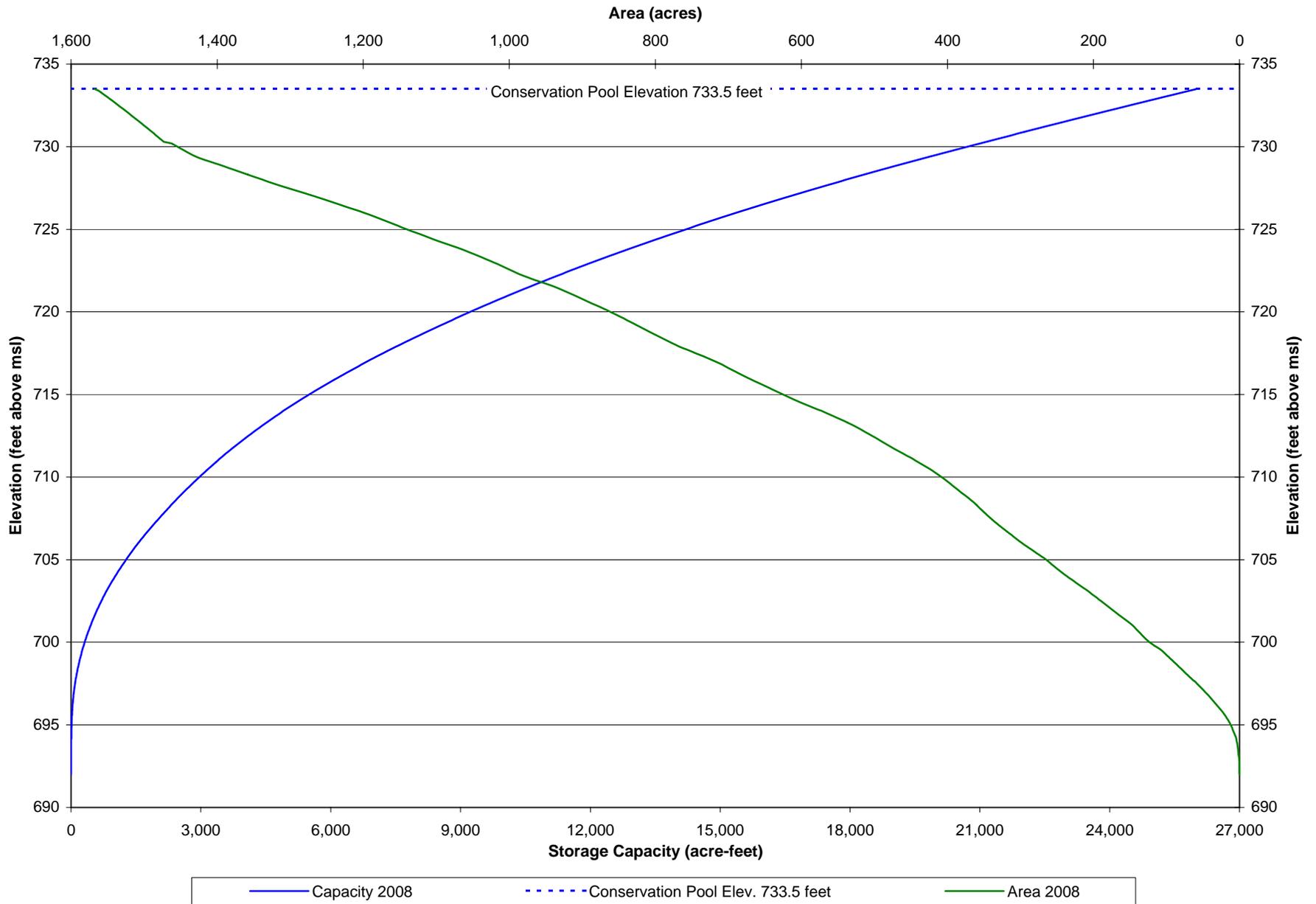
**Lake Pat Cleburne**
July 2008 Survey
Prepared by: TWDB

Appendix C: Area and Capacity Curves

# Figure 5

## CONTOURS
(in feet above mean sea level)

- 732
- 730
- 728
- 726
- 724
- 722
- 720
- 718
- 716
- 714
- 712
- 710
- 708
- 706
- 704
- 702
- 700
- 698
- 696
- 694

Lake Pat Cleburne

Conservation Pool Elevation:
733.5 feet above mean sea level

Projection: NAD83
State Plane
Texas North Central Zone

Johnson County

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

# LAKE PAT CLEBURNE
## 2' - Contour Map

TEXAS WATER DEVELOPMENT BOARD

N

| 0 | 0.125 | 0.25 | 0.5 |
Miles

Prepared by: Texas Water Development Board   July 2008 Survey