Volumetric and Sedimentation Survey of LEWISVILLE LAKE

September 2007 Survey

Prepared by:

The Texas Water Development Board

December 2008

Texas Water Development Board

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Prepared for:

Dallas Water Utilities

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

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Executive Summary

In April of 2007, the Texas Water Development Board entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, for the purpose of performing a volumetric and sedimentation survey of Lewisville Lake. The U.S. Army Corps of Engineers, Fort Worth District, contributed 50% of the funding for this survey through their Planning Assistance to States Program, while Dallas Water Utilities contributed the remaining 50%. This survey was performed using a multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder. In addition, sediment core samples were collected in selected locations and were used in interpreting the multi-frequency depth sounder signal returns to derive sediment accumulation estimates.

Lewisville Dam and Lewisville Lake are located on the Elm Fork Trinity River in Denton County, Texas. Bathymetric data collection for Lewisville Lake occurred between July 18th and September 21st of 2007, while the water surface elevation ranged between 532.77 feet and 524.55 feet above mean sea level (NGVD29). Additional data was collected on January 30th, April 15th, May 13th-14th, and May 21st, of 2008, while the water surface elevation averaged 521.0 feet, 523.6 feet, 522.0 feet, 522.0 feet, and 521.9 feet above mean sea level (NGVD29), respectively. The conservation pool elevation of Lewisville Lake is 522.0 feet above mean sea level (NGVD29).

The results of the TWDB 2007 Volumetric Survey indicate Lewisville Lake has a total reservoir capacity of 598,902 acre-feet and encompasses 27,175 acres at conservation pool elevation. Previously published capacity estimates for Lewisville Lake are 648,400 acre-feet, 640,986 acre-feet, and 571,926 acre-feet, based on surveys conducted in 1960, 1965, and 1989, respectively.[1] Due to differences in the methodologies used in calculating capacities from this and previous Lewisville Lake surveys, comparison of these values is not recommended. TWDB recommends that a similar methodology be used to resurvey Lewisville Lake in approximately 10 years or after a major flood event.

The results of the TWDB 2007 Sedimentation Survey indicate Lewisville Lake has accumulated 28,603 acre-feet of sediment since impoundment in 1954. Based on this measured sediment volume and assuming a constant sediment accumulation rate, Lewisville Lake loses approximately 540 acre-feet of capacity per year. The thickest sediment deposits are located between Lewisville Dam and the breached Lake Dallas dam within the main body of the lake. The maximum sediment thickness observed in Lewisville Lake was 5.9 feet.

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Lewisville Lake General Information

Lewisville Dam and Lewisville Lake are located on the Elm Fork Trinity River, a tributary of the Trinity River, in the Trinity River Basin 22 miles northwest of Dallas in Denton County, Texas (Figure 1). Lewisville Lake is owned and operated by the U.S. Army Corps of Engineers, Fort Worth District. Construction on Lewisville Dam began on November 28, 1948, with deliberate impoundment beginning on November 1, 1954. The project was completed in August of 1955.[2]

During the 1920's the City of Dallas built a dam on the Elm Fork of the Trinity River upstream from the current Lewisville Dam. This dam was completed in 1927, creating Lake Dallas. However, significant silt accumulation in Lake Dallas prompted the U.S. Army Corps of Engineers to construct Lewisville Dam.[3] In 1957 the original dam was breached and Lake Dallas became part of Lewisville Lake.[3] Lewisville Lake serves mainly as a water supply source for the Cities of Dallas and Denton and surrounding communities, and also provides flood control and recreation.[4] Additional pertinent data about Lewisville Dam and Lewisville Lake can be found in Table 1.

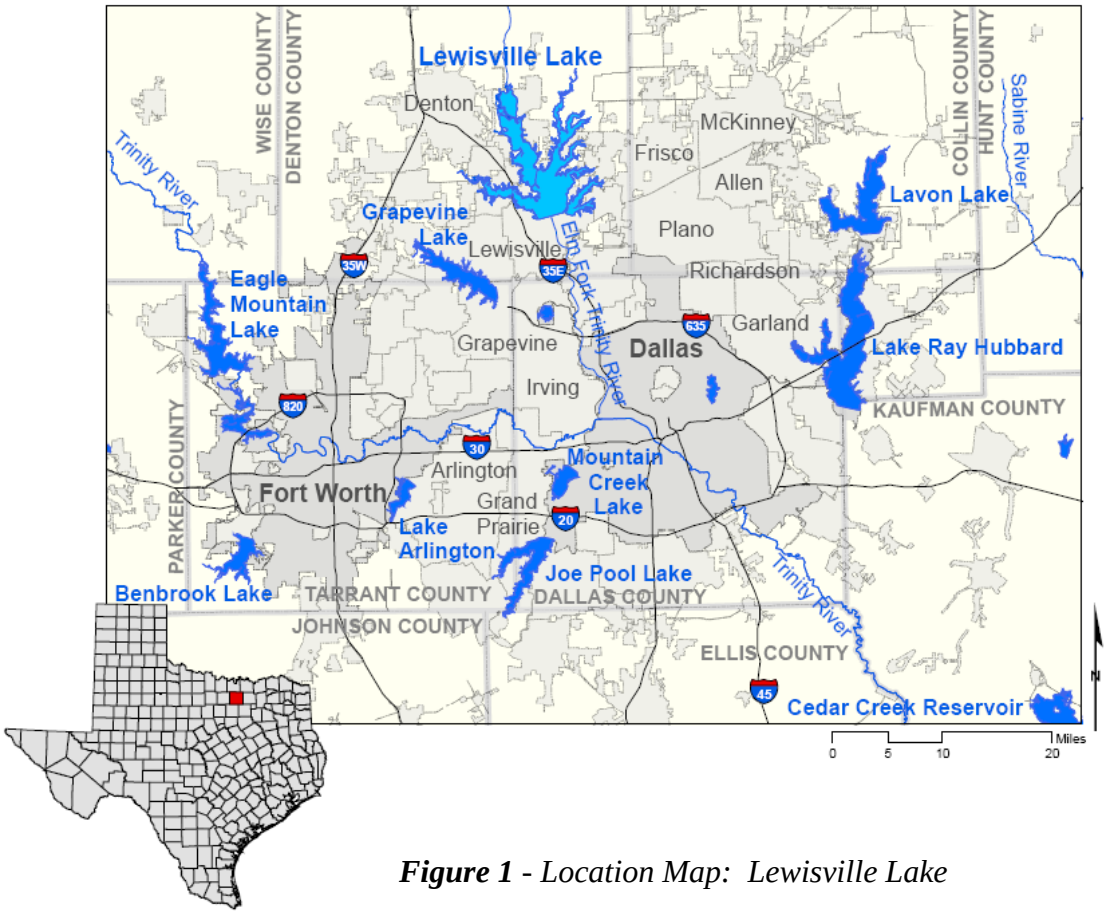


Figure 1 *- Location Map: Lewisville Lake*

Table 1. Pertinent Data for Lewisville Dam and Lewisville Lake[2,5]

Owner

The U.S. Government, Operated by the U.S. Army Corps of Engineers, Fort Worth District

Engineer (Design)

U.S Army Corps of Engineers

Location of Dam

River Mile 30.0 on the Elm Fork of the Trinity River in Denton County, 22 miles northwest of Dallas

Drainage Area

1,660 square miles, 968 square miles below Ray Roberts Dam

Dam

Type	Earthfill
Length	32,888 feet including the spillway
Maximum Height	125 feet
Top Width	20 feet

Spillway

Type	Ogee
Length	560 feet
Crest elevation	532.0 feet above mean sea level
Control	None

Low Flow Outlets

Type	2 steel pipes
Size	Each 60-inch diameter
Lowest invert elevation	481.0 feet above mean sea level
Control	48-inch valve on each pipe at downstream end

Floodwater Outlet Works

Type	1 conduit with 3 inlets
Size	16 foot diameter
Invert elevation	448.0 feet above mean sea level
Control	3 broome-type gates, each 6.5 by 13 feet

Hydropower Facilities

Installation by the City of Denton completed on October 23, 1991. The facility consists of one Horizontal S-shaped Kaplan Unit capable of producing 2,892 Kilowatts. The unit is a Run-of-river facility, where downstream water supply and small flood releases will be used to generate power. The hydropower facility is connected to the Brazos River Authority distribution network.

Reservoir Data (Based on TWDB 2007 Volumetric Survey)

Feature	**Elevation (feet above msl)**	**Capacity (Acre-feet)**	**Area (Acres)**
Top of Dam	560.0	N/A	N/A
Maximum design water surface	553.0	N/A	N/A
Top of flood-control storage space	532.0	N/A	N/A
Top of conservation storage space	522.0	598,902	27,175
Invert of low flow outlet (lowest)	481.0	35,674	4,410
Invert of floodwater outlet works	448.0	0	0
Streambed	435.0	0	0

Water Rights

The water rights for Lewisville Lake have been appropriated to the City of Dallas through Certificate of Adjudication No. 08-2456 and its amendments, and to the City of Denton through Certificate of Adjudication No. 08-2348. A brief summary of the certificates and each amendment follows. The complete certificates are on file in the Records Division of the Texas Commission on Environmental Quality.

•Certificate of Adjudication No. 08-2456 Issued: July 22, 1983 and re-issued as **Amendment to Certificate of Adjudication No. 08-2456A** on November 10, 1983

Authorizes the City of Dallas to store 549,976 acre-feet of water in Lewisville Lake, up to elevation 522 feet above mean sea level. The City of Dallas is authorized to divert and use from Lewisville Lake a maximum of 403,700 acre-feet of water per annum for municipal water supply for the City of Dallas; a maximum of 134,976 acre-feet of water per annum for municipal and domestic purposes; a maximum of 800 acre-feet per annum from the reservoir and 9,500 acre-feet per annum from the Elm Fork Trinity River for industrial purposes; and a maximum of 1,000 acre-feet per annum for domestic purposes. Authorizes a time priority of January 25, 1924 to store 214,000 acre-feet of water, divert 293,700 acre-feet of water per annum for industrial use and 1,000 acre-feet for domestic use. Authorizes a time priority of October 5, 1948 to store 201,000 acre-feet of water and divert 110,000 acre-feet of water per annum for municipal purposes. Authorizes a time priority of November 24, 1975 to store 134,976 acre-feet of water and divert 134,976 acre-feet per annum for municipal and domestic use.

•Amendment to Certificate of Adjudication No. 08-2456C Issued: July 6, 1990

In addition to the uses currently authorized under Certificate No. 08-2456, as amended, the City of Dallas is also authorized to use a maximum of 451,030 acre-feet of water per annum of the 549,976 acre-feet currently authorized for use by the city, for diversion from Lewisville Lake for non-consumptive hydroelectric purposes on a non-priority basis.

•Amendment to Certificate of Adjudication No. 08-2456D Issued: September 21, 2000

Authorizes the City of Dallas to change the purpose of use of the 9,500 acre-feet of water per annum currently authorized in Certificate 08-2456, as amended, from industrial use to industrial and municipal use, and to relocate the point of diversion on the Elm Fork Trinity River to a point approximately 1 mile upstream from the existing point of diversion.

•Amendment to Certificate of Adjudication No. 08-2456E Issued: October 12, 2006

Authorizes the City of Dallas, in addition to existing authorizations, to store in Lewisville Lake, within the currently authorized capacity of 549,976 acre-feet, a maximum of 97,200 acre-feet of treated wastewater effluent return flows delivered by pipeline from Dallas' Central Wastewater Treatment Plant and Southside Wastewater Treatment Plant. In addition to the existing diversion authorization, the City of Dallas is also authorized to divert a maximum of 97,200 acre-feet of water per year of the documented amount of return flows, less carriage and evaporative losses, discharged by the City of Lewisville, the Town of Flower Mound, the Dallas Central Wastewater Treatment

Plant, and the Dallas Southside Wastewater Treatment Plant for the purposes authorized by Certificate No. 08-2456, as amended. The time priority for the use of the treated effluent in December 5, 2001. The City of Dallas will continue to discharge 114,000 acre-feet of water per year of treated effluent from Dallas' Central and Southside Wastewater Treatment Plants and leave that amount in the Trinity River Basin for instream flows.

•Amendment to Certificate of Adjudication No. 08-2456F Issued: April 20, 2006

In lieu of the previous "purpose of use" authorizations, this amendment authorizes the City of Dallas to divert and use a maximum 549,976 acre-feet of water per year (of which 540,476 acre-feet is from Lewisville Lake and 9,500 acre-feet is from the Elm Fork Trinity River) for multiple purposes (municipal, domestic, agricultural (irrigation), industrial, and recreation) and 451,030 acre-feet of water per year for non-consumptive hydroelectric purposes (on a non-priority basis). Authorizes a time priority of January 25, 1924 for the diversion and use of 305,000 acre-feet per year, a time priority of October 5, 1948 for the diversion and use of 110,000 acre-feet of water per year, and a time priority of November 24, 1975 for the diversion and use of 134,976 acre-feet of water per year.

•Certificate of Adjudication No. 08-2348 Issued: July 22, 1983

Authorizes the City of Denton to store 68,424 acre-feet of water in Lewisville Lake up to elevation 522 feet above mean sea level. The City of Denton is authorized to divert and use a maximum of 58,424 acre-feet of water per annum for municipal and domestic purposes within the area served or to be served by the city's distribution system, and to other communities in the Lewisville Dam Watershed. Authorizes a time priority of November 24, 1948 to store 21,000 acre-feet of water and divert and use 11,000 acre-feet of water for municipal and domestic purposes. Authorizes a time priority of November 24, 1975 for the storage and use of 47,424 acre-feet of water.

Volumetric and Sedimentation Survey of Lewisville Lake

The Texas Water Development Board's (TWDB) Hydrographic Survey Program was authorized by the state legislature in 1991. The Texas Water Code authorizes TWDB to perform surveys to determine reservoir storage capacity, sedimentation levels, rates of sedimentation, and projected water supply availability.

In April of 2007, TWDB entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, for the purpose of performing a volumetric and sedimentation survey of Lewisville Lake. The U.S. Army Corps of Engineers, Fort Worth District, contributed 50% of the funding for this survey through their Planning Assistance to States Program, while Dallas Water Utilities contributed the remaining 50%. These surveys were performed simultaneously using a single-beam multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder. The 200 kHz return measures the current bathymetric surface, while the combination of the three frequencies, along with core samples for correlating the pre-impoundment surface with the signal return, is analyzed for evidence of sediment accumulation throughout the reservoir.

Datum

The vertical datum used during this survey is that used by the United States Geological Survey (USGS) for the reservoir elevation gage USGS 08052800 Lewisville Lk nr Lewisville, TX.[6] The datum for this gage is reported as National Geodetic Vertical Datum 1929 (NGVD29) or mean sea level, thus elevations reported here are in feet above mean sea level. Volume and area calculations in this report are referenced to water levels provided by the USGS gage. The horizontal datum used for this report is North American Datum 1983 (NAD83) State Plane Texas North Central Zone.

TWDB Bathymetric Data Collection

Bathymetric data collection for Lewisville Lake began on July 18th and continued through September 21st of 2007. During the survey the water surface elevation ranged from 532.77 feet to 524.55 feet above mean sea level (NGVD29). Additional data was collected on January 30th, April 15th, and May 13th, May 14th, and May 21st, of 2008, while the water

surface elevation averaged 521.0 feet, 523.6 feet, 522.0 feet, 522.0 feet, and 521.9 feet above mean sea level, respectively. For data collection, TWDB used a Specialty Devices, Inc., multi-frequency sub-bottom profiling depth sounder integrated with Differential Global Positioning System (DGPS) equipment. Data collection occurred while navigating along pre-planned range lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 500 feet apart. The depth sounder was calibrated daily using a velocity profiler to measure the speed of sound in the water column and a weighted tape or stadia rod for depth reading verification. During the survey, team members collected approximately 410,500 data points over cross-sections totaling nearly 569 miles in length. Figure 2 shows where data points were collected during the TWDB 2007 survey.

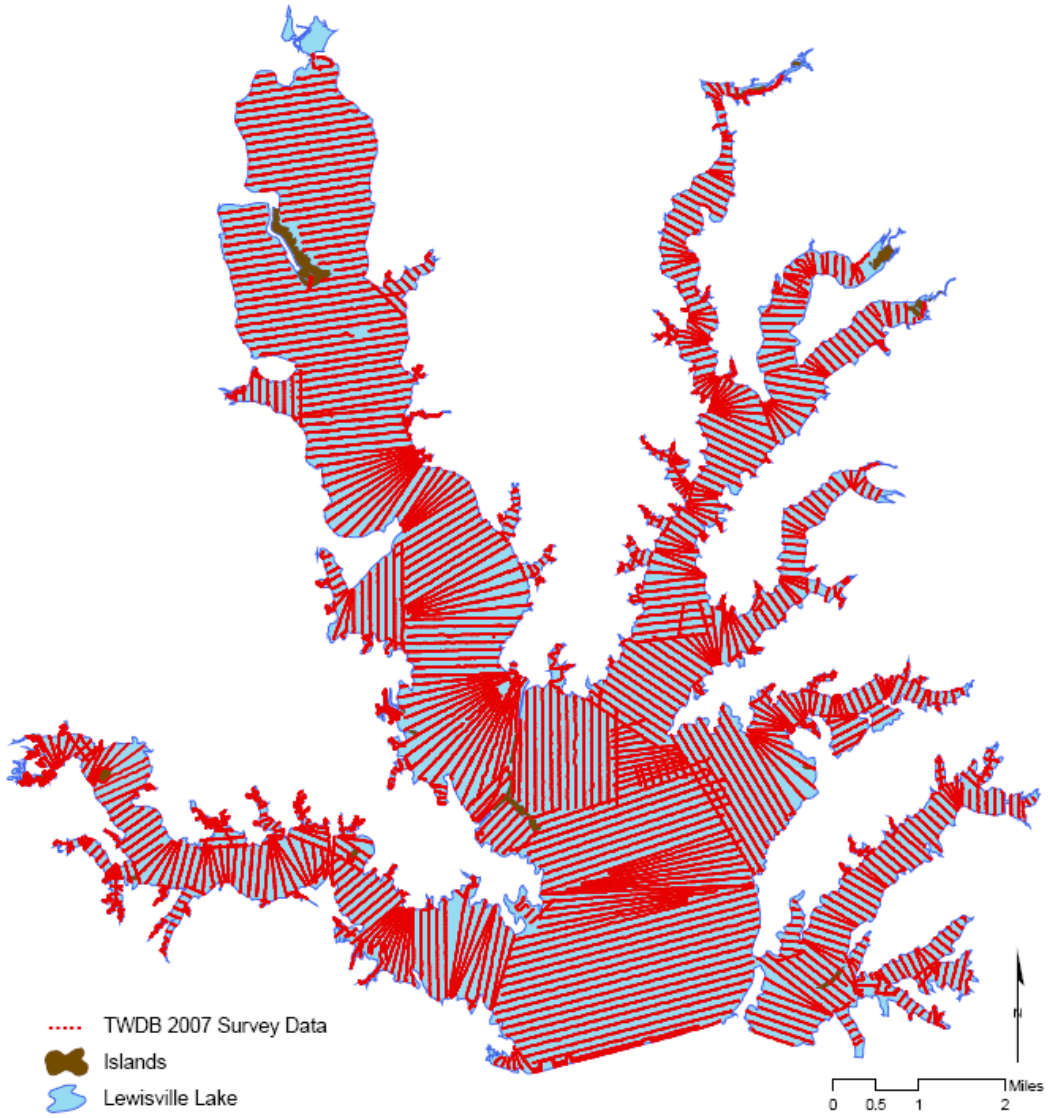


Figure 2 *- Data points collected during TWDB 2007 Survey*

Data Processing

Model Boundaries

The reservoir boundary was digitized from aerial photographs, also known as digital ortho quarter-quadrangle images (DOQQs)[7,8], using Environmental Systems Research Institute's (ESRI) ArcGIS 9.1 software. The quadrangles that cover Lewisville Lake are Little Elm, Denton East, Lewisville East, and Lewisville West. Each quarter-quadrangle image was photographed on September 10, 2004, August 3, 2004, or August 30, 2004, during which time the water surface elevation at Lewisville Lake measured 522.15 feet, 523.42 feet, and 522.39 feet above mean sea level, respectively. These photographs have a 1-meter resolution; therefore, the physical lake boundaries may be within ± 1 meter of the location derived from the manual delineation. As the majority of the lake is represented by photos taken on September 10, 2004 while the water surface elevation measured 522.15 feet, the boundary was digitized at the land water interface visible in the photos and labeled 522.0 feet, or conservation pool elevation.

More recent aerial photographs of Lewisville Lake were taken on August 2, 2006, August 9, 2006, and August 19, 2006, while the water surface elevation measured 512.24 feet, 512.03 feet, and 511.66 feet, respectively. From these, a 512.0 foot contour, verified for accuracy against the data collected during the survey, was digitized to supplement the TWDB survey data in locations where the survey data alone was insufficient to properly represent the reservoir bathymetry.

Triangulated Irregular Network (TIN) Model

Upon completion of data collection, the raw data files collected by TWDB were edited using HydroEdit and DepthPic to remove any data anomalies. HydroEdit is used to automate the editing of the 200 kHz frequency and determine the current bathymetric surface. DepthPic is used to display, interpret, and edit the multi-frequency data in tandem to correct any edits HydroEdit has flagged and to manually interpret the pre-impoundment surface. The water surface elevations at the times of each sounding are used to convert sounding depths to corresponding bathymetric elevations. For processing outside of DepthPic, 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 point file is described in the section entitled "Self-Similar Interpolation." To represent reservoir bathymetry in shallow regions, additional points were added using the "Line Extrapolation" technique.[9] These MASS points files along with the boundary files are used in creating a Triangulated Irregular Network (TIN) model with the 3D Analyst Extension of ArcGIS. The 3D Analyst algorithms use Delaunay's criteria for triangulation to place a triangle between three non-uniformly spaced points, including the boundary vertices.[10]

Using Arc/Info software, volumes and areas are calculated from the TIN model for the entire reservoir at one-tenth of a foot intervals, from elevation 452.9 feet to elevation 522.0 feet. The Elevation-Capacity Table and Elevation-Area Table, updated for 2007, are presented in Appendix A and B, respectively. The Area-Capacity Curves are presented in Appendix C.

The TIN model was interpolated and averaged using a cell size of 2 feet by 2 feet and converted to a raster. The raster was used to produce Figure 3, an Elevation Relief Map representing the topography of the reservoir bottom, Figure 4, a map showing shaded depth ranges for Lewisville Lake, and Figure 5, a 5-foot contour map (attached).

Self-Similar Interpolation

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

To ameliorate these problems, a Self-Similar Interpolation routine (developed by TWDB) was used to interpolate the bathymetry in between many 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.[13] In the case of Lewisville Lake, 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

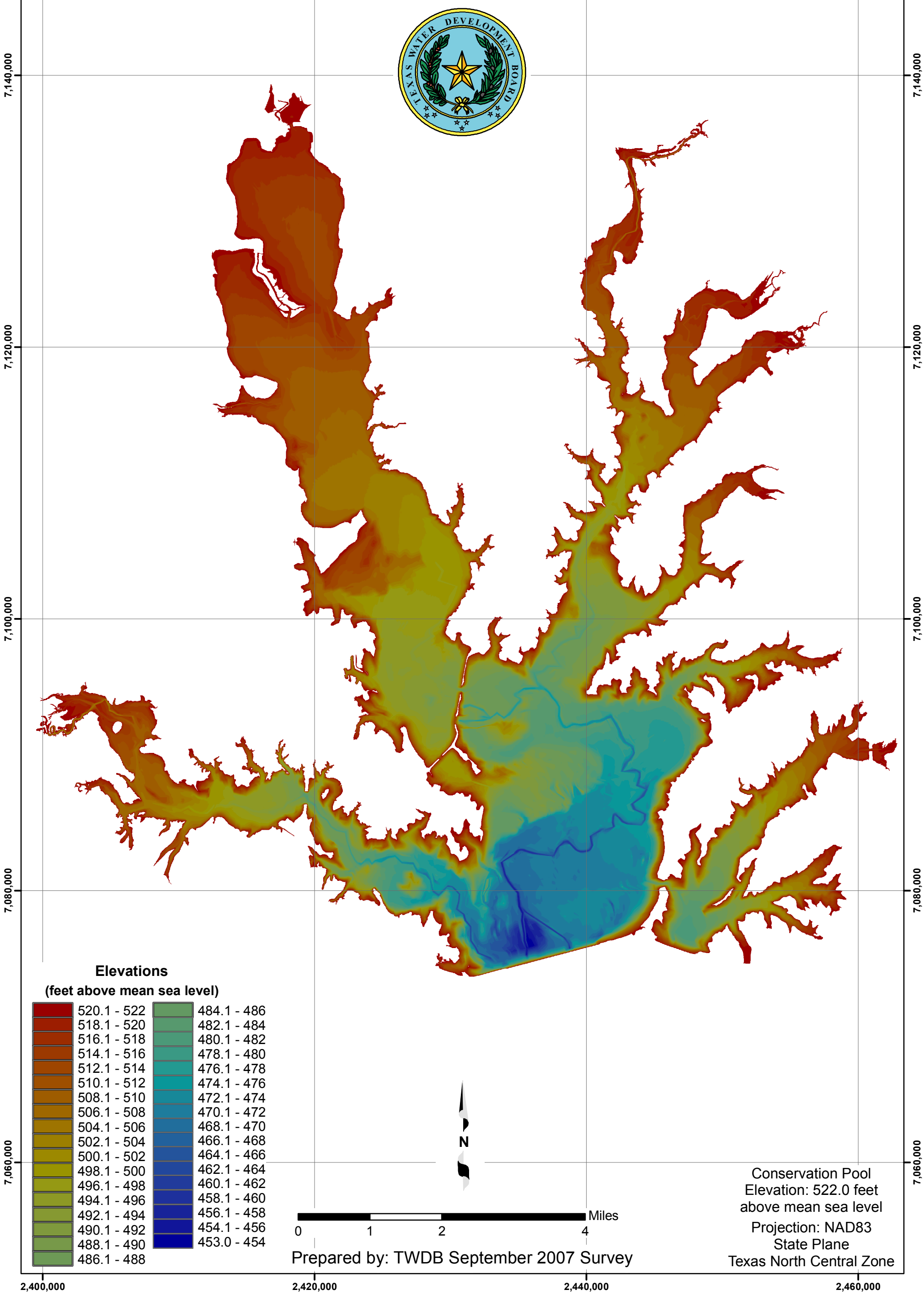
Figure 3

Lewisville Lake

Elevation Relief Map

2,400,000 2,420,000 2,440,000 2,460,000

7,140,000 7,120,000 7,100,000 7,080,000 7,060,000



Elevations

(feet above mean sea level)

520.1 - 522	484.1 - 486
518.1 - 520	482.1 - 484
516.1 - 518	480.1 - 482
514.1 - 516	478.1 - 480
512.1 - 514	476.1 - 478
510.1 - 512	474.1 - 476
508.1 - 510	472.1 - 474
506.1 - 508	470.1 - 472
504.1 - 506	468.1 - 470
502.1 - 504	466.1 - 468
500.1 - 502	464.1 - 466
498.1 - 500	462.1 - 464
496.1 - 498	460.1 - 462
494.1 - 496	458.1 - 460
492.1 - 494	456.1 - 458
490.1 - 492	454.1 - 456
488.1 - 490	453.0 - 454
486.1 - 488	

N

0 1 2 4 Miles

Prepared by: TWDB September 2007 Survey

Conservation Pool
Elevation: 522.0 feet
above mean sea level

Projection: NAD83
State Plane
Texas North Central Zone

Figure 4

Lewisville Lake

Depth Ranges Map

2,400,000 2,420,000 2,440,000 2,460,000

7,140,000 7,120,000 7,100,000 7,080,000 7,060,000

Depth Ranges

- 0 - 5'
- 5 - 10'
- 10 - 15'
- 15 - 20'
- 20 - 25'
- 25 - 30'
- 30 - 35'
- 35 - 40'
- 40 - 45'
- 45 - 50'
- 50 - 55'
- 55 - 60'
- 60 - 65'
- 65 - 70'
- 70 - 75'
- Islands

N

0 1 2 4 Miles

Prepared by: TWDB September 2007 Survey

Conservation Pool
Elevation: 522.0 feet
above mean sea level

Projection: NAD83
State Plane
Texas North Central Zone

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 Iinterpolation was not used in areas of Lewisville Lake where a high probability of change between cross-sections exists.[9] Figure 6 illustrates typical results of the application of the Self-Similar Interpolation routine in Lewisville Lake, and the bathymetry shown in Figure 6C was used in computing reservoir capacity and area tables (Appendix A, B).

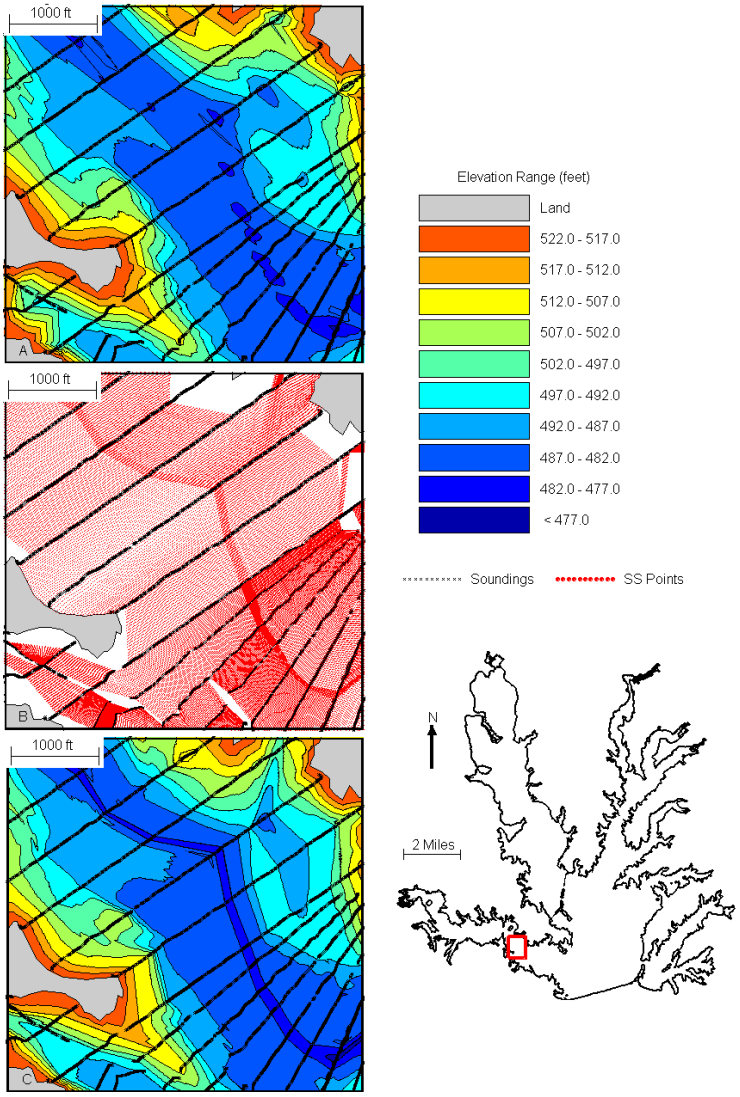


Figure 6 *- Application of the Self-Similar Interpolation technique to Lewisville Lake sounding data – A) bathymetric contours without interpolated points, B) Sounding points (black) and interpolated points (red) with reservoir boundary shown at elevation 522.0 (black), C) bathymetric contours with the interpolated points. Note: In 6A the submerged river channel indicated by the surveyed cross sections is not represented for the areas in-between the cross sections. This is an artifact of the TIN generation routine. Inclusion of the interpolated points (6C) corrects this and smoothes the bathymetric contours.*

Survey Results

Volumetric Survey

The results of the TWDB 2007 Volumetric Survey indicate Lewisville Lake has a total reservoir capacity of 598,902 acre-feet and encompasses 27,175 acres at conservation pool elevation (522.0 feet above mean sea level, NGVD29). In 1960 the U.S. Army Corps of Engineers estimated the capacity of Lewisville Lake (at conservation pool elevation, 522.0 feet above mean sea level) at 648,400 acre-feet.[1,2] The U.S. Army Corps of Engineers resurveyed Lewisville Lake in 1965 and estimated the capacity to be 640,986 acre-feet. In 1989, Turner Collie & Braden Inc. calculated a reservoir capacity of 571,926 acre-feet.[1] Due to differences in the methodologies used in calculating areas and capacities from this and previous Lewisville Lake surveys, comparison of these values is not recommended. TWDB considers the 2007 survey to be a significant improvement over previous methods and recommends that a similar methodology be used to resurvey Lewisville Lake in approximately 10 years or after a major flood event.

Sedimentation Survey

The 200 kHz, 50 kHz, and 24 kHz frequency data were used to interpret sediment distribution and accumulation throughout Lewisville Lake. Figure 7 shows the thickness of sediment throughout the reservoir. To assist in the interpretation of post-impoundment sediment accumulation, ancillary data was collected in the form of five core samples. Sediment cores were collected on May 14, 2008 using a Specialty Devices, Inc. VibraCore system.

The results of the TWDB 2007 Sedimentation Survey indicate Lewisville Lake has accumulated 28,603 acre-feet of sediment since impoundment in 1954. Based on this measured sediment volume and assuming a constant sediment accumulation rate, Lewisville Lake loses approximately 540 acre-feet of capacity per year. The majority of the sediment accumulation has occurred between the current Lewisville Lake dam and the breached Lake Dallas dam within the main body of the lake. This suggests that some of the Lake Dallas sediments may have been re-deposited further downstream in Lewisville Lake after the 1957 Lake Dallas dam breach. The maximum sediment thickness observed

in Lewisville Lake was 5.9 feet. A complete description of the sediment measurement methodology and sample results is presented in Appendix D.

TWDB Contact Information

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

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

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

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Or

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Phone: (512) 463-2465
Email: Jason.Kemp@twdb.state.tx.us

Figure 7

Lewisville Lake

Sediment Thickness Map

2,400,000 2,420,000 2,440,000 2,460,000

7,140,000 7,120,000 7,100,000 7,080,000 7,060,000

Sediment Thickness

(in feet)

- 0 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- 1.01 - 1.25
- 1.26 - 1.5
- 1.51 - 1.75
- 1.76 - 2
- 2.01 - 2.25
- 2.26 - 2.5
- 2.51 - 2.75
- 2.76 - 3
- 3.01 - 3.25
- 3.26 - 3.5
- 3.51 - 3.75
- 3.76 - 4
- 4.01 - 4.25
- 4.26 - 4.5
- 4.51 - 4.75
- 4.76 - 5
- 5.01 - 5.25
- 5.26 - 5.5
- 5.51 - 5.75
- Islands

N

0 1 2 4 Miles

Prepared by: TWDB September 2007 Survey

Projection: NAD83
State Plane
Texas North Central Zone

References

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Appendix A

Lewisville Lake

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — September 2007 Survey

CAPACITY IN ACRE-FEET — Conservation Pool Elevation522.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
452	0	0	0	0	0	0	0	0	0	0
453	0	0	0	0	0	0	0	1	1	1
454	2	3	4	5	6	7	8	9	11	13
455	14	16	18	20	22	24	26	29	31	34
456	37	39	42	45	48	52	55	58	62	65
457	69	72	76	80	84	89	94	99	105	111
458	117	124	130	137	145	152	160	168	176	184
459	192	201	210	219	228	237	247	257	267	278
460	288	299	310	321	332	344	356	368	380	393
461	406	419	432	446	459	473	488	502	517	532
462	547	562	578	594	610	626	643	660	677	694
463	712	730	748	766	785	804	824	843	863	884
464	904	925	946	968	989	1,011	1,034	1,057	1,080	1,103
465	1,127	1,152	1,177	1,202	1,228	1,254	1,281	1,308	1,336	1,365
466	1,394	1,424	1,454	1,485	1,516	1,548	1,580	1,613	1,646	1,680
467	1,715	1,750	1,786	1,823	1,860	1,898	1,937	1,977	2,019	2,062
468	2,107	2,153	2,201	2,251	2,302	2,356	2,411	2,468	2,527	2,588
469	2,650	2,715	2,782	2,851	2,923	2,996	3,072	3,151	3,233	3,318
470	3,406	3,499	3,599	3,704	3,816	3,933	4,054	4,181	4,311	4,446
471	4,584	4,726	4,873	5,024	5,179	5,340	5,504	5,672	5,844	6,021
472	6,201	6,387	6,578	6,776	6,980	7,190	7,406	7,626	7,850	8,079
473	8,313	8,550	8,790	9,033	9,280	9,531	9,785	10,042	10,301	10,564
474	10,830	11,098	11,369	11,642	11,919	12,198	12,480	12,764	13,052	13,342
475	13,634	13,929	14,226	14,525	14,825	15,128	15,432	15,739	16,047	16,357
476	16,669	16,983	17,300	17,619	17,940	18,264	18,590	18,919	19,250	19,584
477	19,920	20,259	20,600	20,945	21,292	21,642	21,997	22,355	22,716	23,081
478	23,449	23,820	24,195	24,572	24,952	25,335	25,722	26,111	26,502	26,896
479	27,292	27,690	28,090	28,493	28,898	29,305	29,714	30,126	30,540	30,956
480	31,375	31,796	32,218	32,643	33,069	33,498	33,929	34,362	34,797	35,234
481	35,674	36,116	36,561	37,007	37,456	37,907	38,361	38,818	39,277	39,739
482	40,205	40,674	41,147	41,623	42,102	42,585	43,071	43,560	44,051	44,546
483	45,043	45,543	46,046	46,552	47,061	47,574	48,090	48,608	49,130	49,654
484	50,182	50,712	51,245	51,781	52,320	52,863	53,409	53,959	54,512	55,069
485	55,629	56,192	56,759	57,329	57,903	58,481	59,062	59,648	60,238	60,832
486	61,431	62,034	62,641	63,252	63,868	64,489	65,114	65,744	66,377	67,016
487	67,658	68,303	68,953	69,606	70,264	70,927	71,595	72,267	72,944	73,625
488	74,311	75,001	75,695	76,393	77,095	77,800	78,510	79,224	79,941	80,661
489	81,385	82,112	82,843	83,576	84,313	85,053	85,797	86,543	87,293	88,047
490	88,804	89,564	90,328	91,095	91,866	92,642	93,421	94,204	94,991	95,781
491	96,575	97,373	98,174	98,979	99,787	100,598	101,413	102,231	103,052	103,876
492	104,704	105,535	106,370	107,207	108,048	108,892	109,740	110,591	111,446	112,306
493	113,169	114,036	114,907	115,782	116,660	117,543	118,429	119,320	120,214	121,113
494	122,017	122,928	123,844	124,767	125,696	126,630	127,569	128,513	129,461	130,414
495	131,371	132,333	133,299	134,268	135,242	136,220	137,201	138,186	139,174	140,167
496	141,164	142,165	143,171	144,181	145,196	146,215	147,239	148,267	149,298	150,334
497	151,374	152,419	153,468	154,522	155,580	156,642	157,708	158,778	159,851	160,929
498	162,011	163,097	164,188	165,282	166,382	167,486	168,596	169,712	170,834	171,963
499	173,098	174,238	175,383	176,533	177,688	178,847	180,010	181,177	182,348	183,523
500	184,702	185,885	187,071	188,261	189,454	190,652	191,853	193,059	194,268	195,482

Appendix A (Continued)

Lewisville Lake

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — September 2007 Survey

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 522.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
501	196,700	197,922	199,148	200,378	201,612	202,850	204,093	205,340	206,592	207,849
502	209,110	210,375	211,645	212,919	214,198	215,483	216,773	218,068	219,368	220,675
503	221,986	223,303	224,626	225,952	227,285	228,622	229,964	231,311	232,662	234,019
504	235,381	236,748	238,120	239,497	240,879	242,267	243,660	245,058	246,460	247,867
505	249,279	250,696	252,119	253,547	254,981	256,421	257,868	259,322	260,784	262,254
506	263,731	265,216	266,708	268,206	269,712	271,224	272,743	274,269	275,800	277,339
507	278,884	280,437	281,995	283,560	285,131	286,708	288,292	289,883	291,479	293,082
508	294,693	296,311	297,936	299,568	301,209	302,857	304,515	306,183	307,859	309,544
509	311,237	312,939	314,648	316,366	318,091	319,824	321,565	323,313	325,069	326,831
510	328,602	330,379	332,164	333,955	335,753	337,558	339,370	341,188	343,013	344,845
511	346,683	348,529	350,383	352,243	354,111	355,986	357,868	359,757	361,653	363,557
512	365,468	367,387	369,315	371,248	373,190	375,139	377,094	379,059	381,029	383,007
513	384,991	386,982	388,983	390,992	393,014	395,045	397,087	399,140	401,202	403,275
514	405,356	407,448	409,550	411,659	413,778	415,905	418,039	420,184	422,338	424,504
515	426,679	428,863	431,058	433,261	435,473	437,692	439,920	442,158	444,403	446,659
516	448,922	451,194	453,476	455,765	458,065	460,372	462,689	465,015	467,348	469,692
517	472,043	474,402	476,771	479,146	481,532	483,924	486,325	488,735	491,151	493,577
518	496,009	498,449	500,897	503,352	505,816	508,286	510,763	513,249	515,741	518,242
519	520,748	523,262	525,784	528,311	530,846	533,387	535,934	538,489	541,049	543,617
520	546,189	548,767	551,352	553,941	556,538	559,139	561,746	564,360	566,979	569,605
521	572,236	574,872	577,516	580,165	582,822	585,483	588,151	590,828	593,511	596,203
522	598,902									

Appendix B

Lewisville Lake

RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD — September 2007 Survey

AREA IN ACRES — Conservation Pool Elevation 522.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
452	0	0	0	0	0	0	0	0	0	0
453	0	0	0	1	1	2	2	3	4	5
454	7	8	9	10	11	12	13	14	15	16
455	17	18	19	20	21	22	23	25	26	27
456	28	29	30	31	32	32	33	34	35	36
457	36	37	38	40	44	48	51	55	58	61
458	64	67	69	72	74	76	78	79	81	83
459	85	87	89	91	93	96	98	100	102	104
460	106	108	110	112	115	117	120	122	125	127
461	130	132	134	137	139	141	143	146	148	151
462	153	155	158	160	163	165	167	170	172	175
463	178	180	183	186	189	192	195	198	201	204
464	207	210	213	216	219	222	226	230	234	238
465	242	246	251	256	261	266	271	277	282	288
466	294	300	305	310	315	321	326	331	337	343
467	349	355	362	370	377	386	396	409	423	439
468	455	472	489	506	523	542	560	579	600	620
469	638	658	679	702	725	748	773	803	835	866
470	903	961	1,025	1,088	1,142	1,195	1,240	1,285	1,325	1,363
471	1,404	1,445	1,486	1,533	1,581	1,623	1,663	1,702	1,742	1,782
472	1,829	1,886	1,946	2,007	2,074	2,130	2,177	2,223	2,269	2,314
473	2,351	2,385	2,418	2,454	2,487	2,520	2,553	2,584	2,613	2,641
474	2,669	2,694	2,722	2,750	2,778	2,806	2,833	2,861	2,888	2,913
475	2,936	2,958	2,978	2,997	3,016	3,035	3,054	3,073	3,092	3,111
476	3,130	3,151	3,175	3,205	3,227	3,250	3,275	3,300	3,325	3,350
477	3,374	3,400	3,428	3,456	3,487	3,525	3,561	3,600	3,633	3,664
478	3,695	3,726	3,757	3,787	3,818	3,849	3,877	3,902	3,925	3,950
479	3,971	3,993	4,016	4,039	4,059	4,081	4,105	4,129	4,152	4,175
480	4,196	4,216	4,236	4,256	4,276	4,297	4,319	4,340	4,361	4,385
481	4,410	4,433	4,456	4,478	4,501	4,525	4,551	4,578	4,605	4,638
482	4,675	4,711	4,746	4,778	4,811	4,844	4,873	4,901	4,930	4,958
483	4,986	5,016	5,045	5,078	5,109	5,139	5,173	5,203	5,230	5,257
484	5,287	5,315	5,345	5,376	5,411	5,445	5,482	5,516	5,549	5,581
485	5,614	5,648	5,686	5,723	5,760	5,796	5,834	5,879	5,922	5,965
486	6,006	6,049	6,092	6,136	6,183	6,229	6,275	6,319	6,361	6,400
487	6,438	6,476	6,515	6,557	6,603	6,651	6,700	6,745	6,792	6,834
488	6,878	6,921	6,960	6,999	7,039	7,079	7,118	7,154	7,188	7,222
489	7,254	7,287	7,320	7,352	7,384	7,416	7,450	7,484	7,517	7,552
490	7,587	7,623	7,656	7,691	7,731	7,773	7,813	7,849	7,885	7,922
491	7,960	7,995	8,029	8,062	8,097	8,130	8,163	8,195	8,228	8,261
492	8,294	8,326	8,358	8,393	8,426	8,460	8,495	8,532	8,571	8,612
493	8,651	8,691	8,730	8,767	8,804	8,843	8,885	8,927	8,966	9,013
494	9,071	9,132	9,201	9,261	9,315	9,364	9,413	9,461	9,506	9,550
495	9,595	9,637	9,680	9,719	9,756	9,793	9,829	9,866	9,908	9,947
496	9,991	10,037	10,078	10,124	10,171	10,216	10,257	10,296	10,335	10,379
497	10,427	10,473	10,516	10,558	10,599	10,639	10,679	10,719	10,758	10,799
498	10,840	10,881	10,925	10,970	11,017	11,070	11,130	11,193	11,255	11,317
499	11,376	11,426	11,477	11,523	11,568	11,612	11,652	11,690	11,729	11,769
500	11,807	11,844	11,881	11,918	11,956	11,994	12,034	12,074	12,117	12,159

Appendix B (Continued)

Lewisville Lake

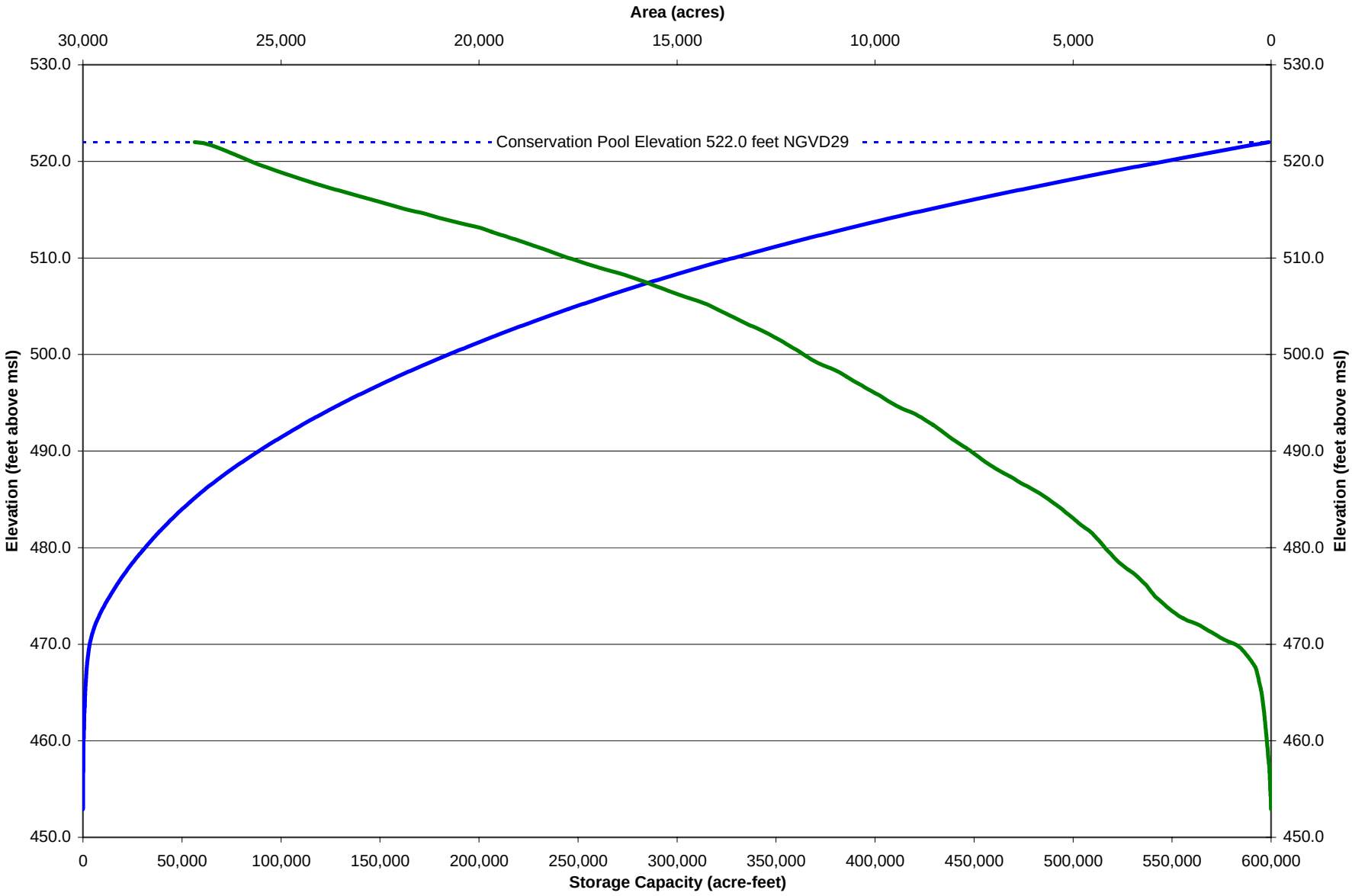
RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD — September 2007 Survey

AREA IN ACRES — Conservation Pool Elevation 522.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
501	12,200	12,241	12,280	12,320	12,360	12,402	12,452	12,498	12,542	12,586
502	12,631	12,674	12,722	12,770	12,819	12,871	12,925	12,979	13,034	13,088
503	13,145	13,195	13,245	13,296	13,348	13,396	13,444	13,491	13,540	13,593
504	13,645	13,696	13,746	13,797	13,851	13,902	13,952	13,999	14,048	14,097
505	14,147	14,198	14,252	14,310	14,369	14,433	14,503	14,582	14,661	14,736
506	14,810	14,881	14,952	15,022	15,091	15,159	15,223	15,285	15,351	15,419
507	15,489	15,554	15,617	15,681	15,743	15,805	15,870	15,934	16,001	16,070
508	16,142	16,214	16,286	16,364	16,444	16,531	16,630	16,719	16,806	16,891
509	16,975	17,055	17,134	17,216	17,292	17,370	17,445	17,520	17,591	17,664
510	17,738	17,810	17,880	17,951	18,016	18,081	18,149	18,216	18,283	18,352
511	18,423	18,495	18,569	18,642	18,713	18,784	18,856	18,929	19,001	19,072
512	19,160	19,234	19,303	19,377	19,451	19,525	19,599	19,672	19,742	19,811
513	19,880	19,953	20,043	20,154	20,263	20,372	20,476	20,574	20,671	20,769
514	20,870	20,969	21,057	21,142	21,225	21,309	21,395	21,490	21,595	21,703
515	21,805	21,898	21,987	22,072	22,158	22,242	22,328	22,414	22,502	22,591
516	22,678	22,767	22,857	22,946	23,035	23,123	23,210	23,298	23,383	23,471
517	23,556	23,638	23,722	23,806	23,887	23,969	24,051	24,132	24,210	24,287
518	24,364	24,441	24,517	24,592	24,667	24,741	24,815	24,889	24,962	25,035
519	25,106	25,176	25,244	25,311	25,377	25,443	25,510	25,575	25,638	25,698
520	25,756	25,814	25,872	25,930	25,987	26,045	26,104	26,164	26,223	26,282
521	26,341	26,401	26,463	26,525	26,589	26,654	26,723	26,794	26,870	26,953
522	27,175									



Lewisville Lake
September 2007 Survey
Prepared by: TWDB

Appendix C: Area and Capacity Curves

Appendix D

Analysis of Sediment Accumulation Data from Lewisville Lake

Executive Summary

The results of the TWDB 2007 Sedimentation Survey indicate Lewisville Lake has accumulated 28,603 acre-feet of sediment since impoundment in 1954. Based on this measured sediment volume and assuming a constant rate of sediment accumulation over the 53 years since impoundment, Lewisville Lake loses approximately 540 acre-feet of capacity per year. This sediment accumulation rate is likely to overestimate the actual rate of sediment influx to Lewisville Lake, as it is impossible to determine the amount of sediment that accumulated in Lake Dallas before creation of Lewisville Lake. The thickest sediment deposits are located between the current Lewisville Lake dam and the breached Lake Dallas dam within the main body of the lake. The maximum sediment thickness observed in Lewisville Lake was 5.9 feet.

Introduction

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

Data Collection & Processing Methodology

TWDB conducted the main Lewisville Lake bathymetric survey between July 18th, 2007 and September 21st, 2007 and collected additional data on January 30th, April 15th, May 13th, May 14th, and May 21st of 2008. For all data collection efforts, TWDB used a Specialty Devices, Inc. (SDI), multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder integrated with Differential Global Positioning System (DGPS) equipment. Data collection occurred while navigating along pre-planned range lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 500 feet apart. For all data collection efforts, the depth sounder was calibrated daily using a velocity profiler to measure the speed of sound in the water column and a weighted tape or stadia rod for depth reading verification. During the 2007 survey, team members collected approximately 410,500 data points over cross-sections totaling nearly 569 miles in length. Figure D1 shows where data points were collected during the TWDB 2007 Lewisville Lake survey.

Core samples collected by TWDB were collected at locations where sounding data had been previously collected (Figure E1). All cores were collected with a custom-coring boat and SDI VibraCore system. Cores were analyzed by TWDB, and both the sediment thickness and the distance the core penetrated the pre-impoundment boundary were recorded. The coordinates and a description of each core sample are provided in Table D1. Figure D2 shows the cross-section of sediment core L3. At this location, TWDB collected 20 inches of sediment, with the upper sediment layers (Figure E2) having high water content, consisting of clay material and lacking in vegetation. The pre-impoundment boundary was evident from this core at a distance of 10 inches above the core base; above this location, the moisture content in the sediment greatly increases (Figure E2).

Table D1 – Core Sampling Analysis Data – Lewisville Lake

Core	Easting** (ft)	Northing** (ft)	Description
L1	2449484.76	7077758.24	21” of muddy sediment without plant material visible
L3	2435415.06	7091263.93	20” of sediment with little plant material visible.
L4	2429376.34	7100598.46	12” of sandy sediment, with slight organic material (twigs and sticks)
L5	2419384.28	7114250.12	12” of wet, fine grained sediment (clay)
L8	2423903.98	7081381.09	3” of sandy sediment with pebbles and plant material

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

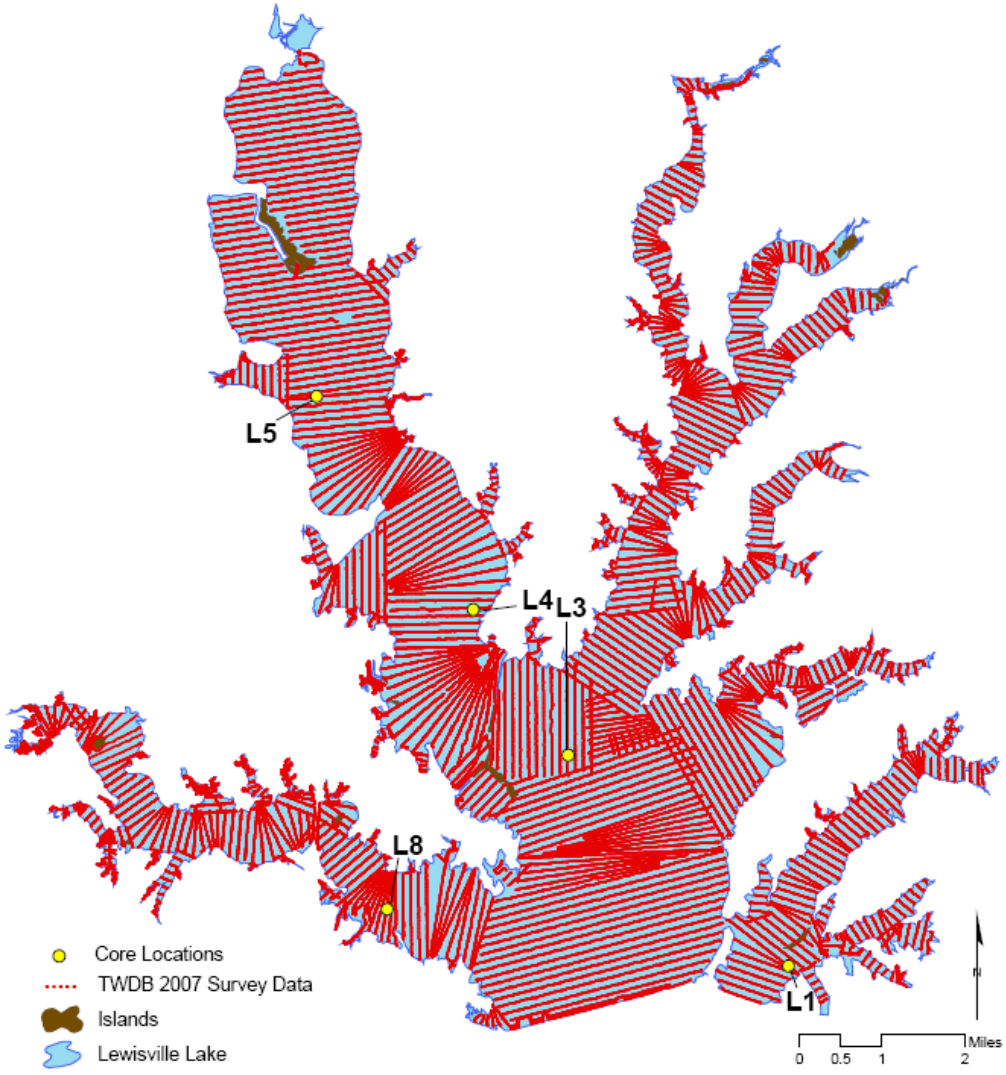


Figure D1 – TWDB 2007 survey data points for Lewisville Lake

Figure D2 – Sediment Core L3 from Lewisville Lake, showing the pre-impoundment boundary 10 inches above the base of the core (left). The pre-impoundment boundary is marked by the change in sediment moisture content below and above the area 10 inches up from the core base.

All sounding data is processed using the DepthPic software, within which both the pre-impoundment and current bathymetric surfaces are identified and digitized manually. These surfaces are first identified along cross-sections for which core samples have been collected – thereby allowing the user to identify color bands in the DepthPic display that correspond to the sediment layer(s) observed in the core samples. This process is illustrated in Figure D3 where core sample L3 is shown with its corresponding sounding data. Core sample L3 contained 20 inches of sediment above the pre-impoundment boundary, as indicated by the yellow and green boxes, respectively, representing the core sample in Figure D3. The pre-impoundment surface is usually identified within the core sample by one of the following methods: (1) a visual examination of the core for in-place terrestrial materials, such as leaf litter, tree bark, twigs, intact roots, etc., concentrations of which tend to occur on or just below the pre-impoundment surface, (2) changes in texture from well sorted, relatively fine-grained sediment to poorly sorted mixtures of coarse and fine-grained materials, and (3) variations in the physical properties of the sediment, particularly sediment water content and penetration resistance with depth.

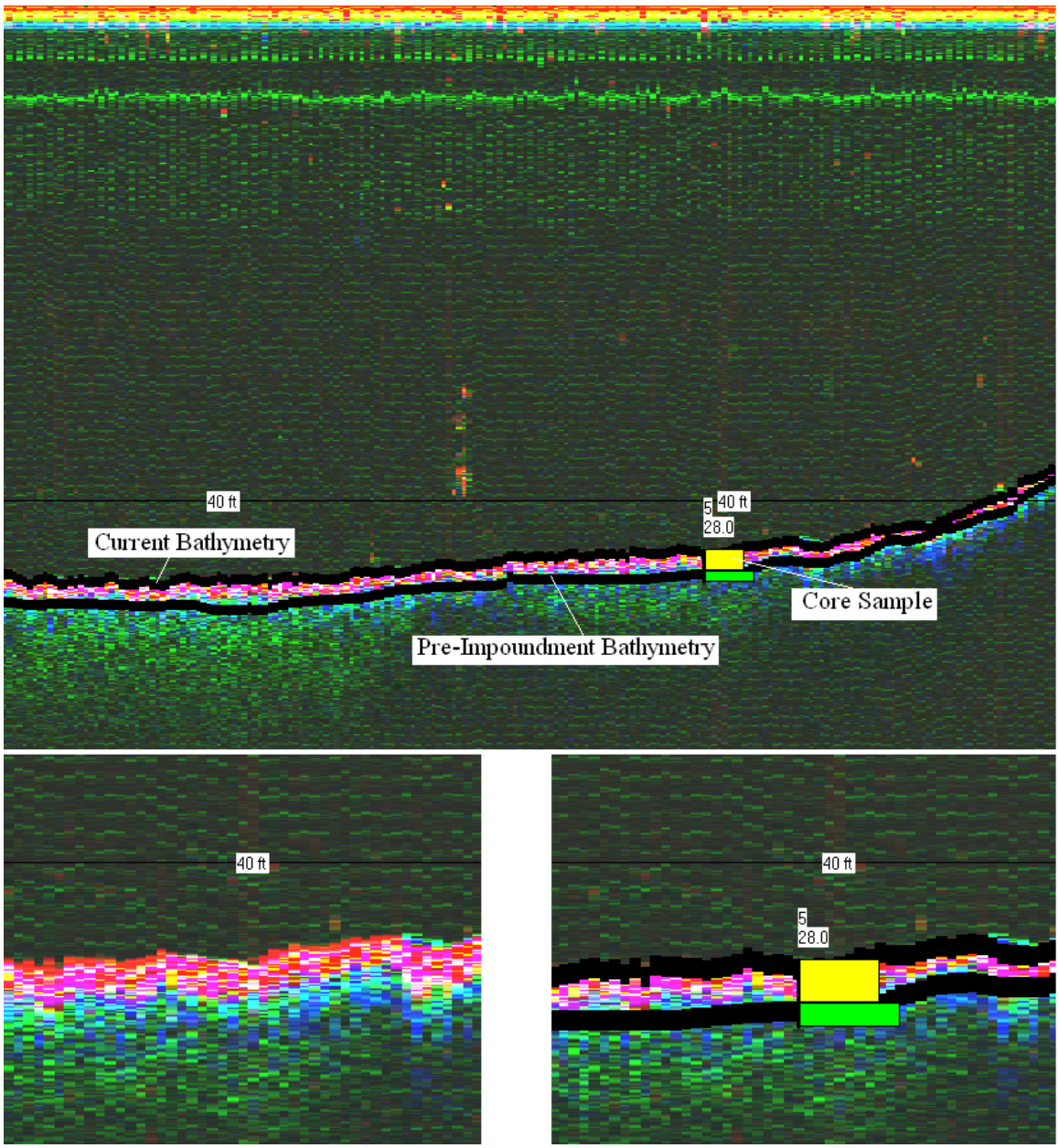


Figure E3 – DepthPic and core sample use in identifying the pre-impoundment bathymetry.

Within DepthPic, the current surface is automatically determined based on the signal returns from the 200 kHz transducer. The pre-impoundment surface must be determined visually based on the pixel color display and any available core sample data. Based on core sample L3, it is clear that sediment layer is indicated by the pink and red pixels. The pre-impoundment bathymetric surface for this cross-section is therefore

identified as the base of the bright-colored pink pixels in the DepthPic display, and the current bathymetric surface is located at the top of the band of red and pink pixels. (Figure E3).

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

After manually digitizing the pre-impoundment surface from all cross-sections, both the pre-impoundment and current bathymetric surfaces are exported as X-,Y-,Z-coordinates from DepthPic into text files suitable for use in ArcGIS. Within ArcGIS, the sounding points are then processed into TIN models following standard GIS techniques[1]. The accumulated sediment volume for Lewisville Lake was calculated from a sediment thickness TIN model created in ArcGIS. Sediment thicknesses were computed as the difference in elevations between the current and pre-impoundment bathymetric surfaces as determined with the DepthPic software. Sediment thicknesses were interpolated for locations between surveyed cross-sections using the TWDB self-similar interpolation technique[2]. For the purposes of the TIN model creation, TWDB assumed 0-feet sediment thicknesses at the model boundaries (defined as the 522.0 foot NGVD29 elevation contour).

Results

The results of the TWDB 2007 Sedimentation Survey indicate Lewisville Lake has accumulated 28,603 acre-feet of sediment since impoundment in 1954. The thickest sediment deposits are located between Lewisville Dam and the breached Lake Dallas Dam within the main body of the lake. The maximum sediment thickness observed in Lewisville Lake is 5.9 feet. Figure D4 depicts the sediment thickness in Lewisville Lake.

Based on the measured sediment volume in Lewisville Lake and assuming a constant rate of sediment accumulation over the 53 years since impoundment, Lewisville

Lake loses approximately 540 acre-feet of capacity per year. This sediment accumulation rate is likely an overestimation of the actual rate of sediment influx to the lake, as it is difficult to determine the amount of sediment that accumulated in Lake Dallas before creation of Lewisville Lake. The relatively thick sediment deposits in Lewisville Lake between the Lake Dallas dam and the Lewisville Dam suggests that Lake Dallas sediments may have been re-deposited further downstream in Lewisville Lake after the 1957 Lake Dallas dam breach. Accounting for the lifespan of Lake Dallas (from 1927 to 1957), an alternative sediment accumulation rate estimate for Lewisville Lake (over the period 1927-2007) is 353 acre-feet per year. To improve the sediment accumulation rate estimates, TWDB recommends Lewisville Lake be re-surveyed using similar methods in approximately 10 years or after a major flood event.

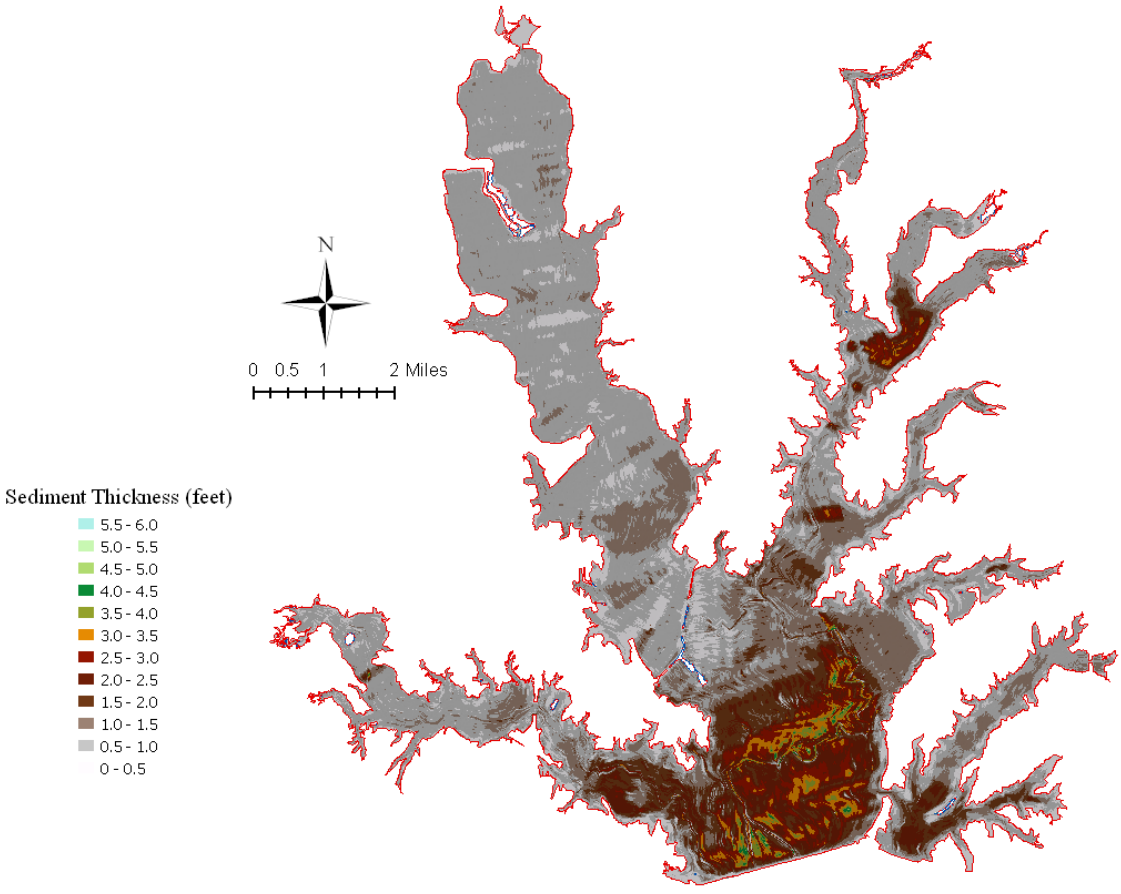


Figure D4 - Sediment thicknesses in Lewisville Lake derived from multi-frequency sounding data.

References

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

Figure 5

Lewisville Lake

5' - Contour Map

CONTOURS
(in feet above mean sea level)

- 455
- 460
- 465
- 470
- 475
- 480
- 485
- 490
- 495
- 500
- 505
- 510
- 515
- 520
- Islands
- Lewisville Lake

Conservation Pool Elevation
522.0 feet above mean sea level

Projection: NAD83
State Plane
Texas North Central Zone

This map is the product of a survey conducted by the Texas Water Development Board's Hydrographic Survey Program to determine the capacity of Lewisville Lake. The Texas Water Development Board makes no representations nor assumes any liability.

N

1 0.5 0 1 2 Miles

Prepared by: TEXAS WATER DEVELOPMENT BOARD September 2007 Survey

2,420,000 2,440,000 2,460,000

7,140,000 7,120,000 7,100,000 7,080,000