Volumetric Survey
of
LAKE DIVERSION

June 2013 Survey

Texas Water
Development Board

March 2014

Texas Water Development Board

Prepared for:

American Electric Power, Oklaunion, Texas and Wichita County Water Improvement District No. 2 with the City of Wichita Falls, Texas

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Executive summary

In March 2013, the Texas Water Development Board entered into agreement with the Wichita County Water Improvement District No. 2 to perform a volumetric survey of Lake Diversion. Surveying was performed using a multi-frequency (200 kHz, 50 kHz, and 24 kHz), sub-bottom profiling depth sounder; only the 200 kHz frequency was analyzed for this report.

Lake Diversion Dam and Lake Diversion are located on the Wichita River in Archer and Baylor Counties, approximately 30 miles west of the City of Wichita Falls, Texas. The conservation pool elevation of Lake Diversion is 1,052.0 feet above mean sea level (NGVD29). TWDB collected bathymetric data for Lake Diversion between April 3, 2013, and June 7, 2013. The daily average water surface elevation during the survey ranged between 1,049.66 and 1,051.16 feet above mean sea level.

The 2013 TWDB volumetric survey indicates that Lake Diversion has a total reservoir capacity of 35,324 acre-feet and encompasses 3,397 acres at conservation pool elevation (1,052.0 feet above mean sea level, NGVD29). Lake Diversion was originally designed to hold an estimated 40,000 acre-feet encompassing 3,419 acres.

TWDB recommends that a similar methodology be used to resurvey Lake Diversion in 10 years or after a major flood event. To further improve estimates of capacity loss, TWDB recommends a volumetric and sedimentation survey. Sedimentation surveys include additional analysis of the multi-frequency data for post-impoundment sediment by correlation with sediment core samples and a map identifying the spatial distribution of sediment throughout the reservoir.

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 March 2013, the Texas Water Development Board entered into agreement with the Wichita County Water Improvement District No. 2 to perform a volumetric survey of Lake Diversion (TWDB, 2013). This report describes the methods used to conduct the volumetric survey, including data collection and processing techniques. This report serves as the final contract deliverable from TWDB to the Wichita County Water Improvement District No. 2 and contains as deliverables: (1) a shaded relief plot of the reservoir bottom [Figure 4], (2) a bottom contour map [Figure 6], and (3) an elevation-area-capacity table of the reservoir acceptable to the Texas Commission on Environmental Quality [Appendix A, B].

Lake Diversion general information

Lake Diversion Dam and Lake Diversion are located on the Wichita River, a tributary of the Red River, in Archer and Baylor Counties, approximately 30 miles west of the city of Wichita Falls, Texas (TPWD, 2013) (Figure 1). Land surrounding Lake Diversion is part of Waggoner Ranch, “the largest ranch in Texas under one fence” (Waggoner Ranch, 2014). Construction of Lake Diversion Dam began in 1922. The deliberate impoundment of water and completion of the dam occurred in 1924 (TWDB, 1974). Lake Diversion is owned by the City of Wichita Falls and the Wichita County Water Improvement District No. 2, and operated by the Wichita County Water Improvement District No. 2 (TWDB, 1974).

Lake Diversion is located approximately 20 miles downstream of Lake Kemp Dam and is operated with Lake Kemp as a system for water supply. The system provides water primarily for irrigation purposes to those served by the Wichita County Water Improvement District No. 2, for municipal purposes to the City of Wichita Falls (RRA, 2002), and for electric generation for American Electric Power at Oklaunion, Texas (WCWID, 2013). However, Lake Diversion does not have its own firm yield and is used mainly to distribute water that is released from Lake Kemp (RRA, 2002).Water that is released from Lake

Kemp to Lake Diversion is distributed through a series of canals located in Archer, Wichita, and Clay Counties for irrigation (Biggs & Mathews, Inc. et al., 2010). The Texas Parks and Wildlife Department diverts water from Lake Diversion to the state's largest fish hatchery, Dundee State Fish Hatchery, built in 1927 and located just downstream of Lake Diversion Dam (TPWD, 2014). However, if water levels at Lake Kemp fall to 1,131.55 feet above mean sea level or below, operation of the hatchery is suspended (TPWD, 2012, Kyle Miller, WCWID No. 2, personal communication, April 2014). Since 2008, the City of Wichita Falls has treated water from lakes Kemp and Diversion at a reverse osmosis plant as a secondary municipal water supply, accounting for approximately 13 percent of overall treatment capacity (COWF, 2013). Additional pertinent data about Lake Diversion Dam and Lake Diversion can be found in Table 1.

Water rights for Lake Diversion have been appropriated to the Wichita County Water Improvement District No. 2 and the City of Wichita Falls through Certificate of Adjudication No. 02-5123. The complete certificate is on file in the Information Resources Division of the Texas Commission on Environmental Quality.

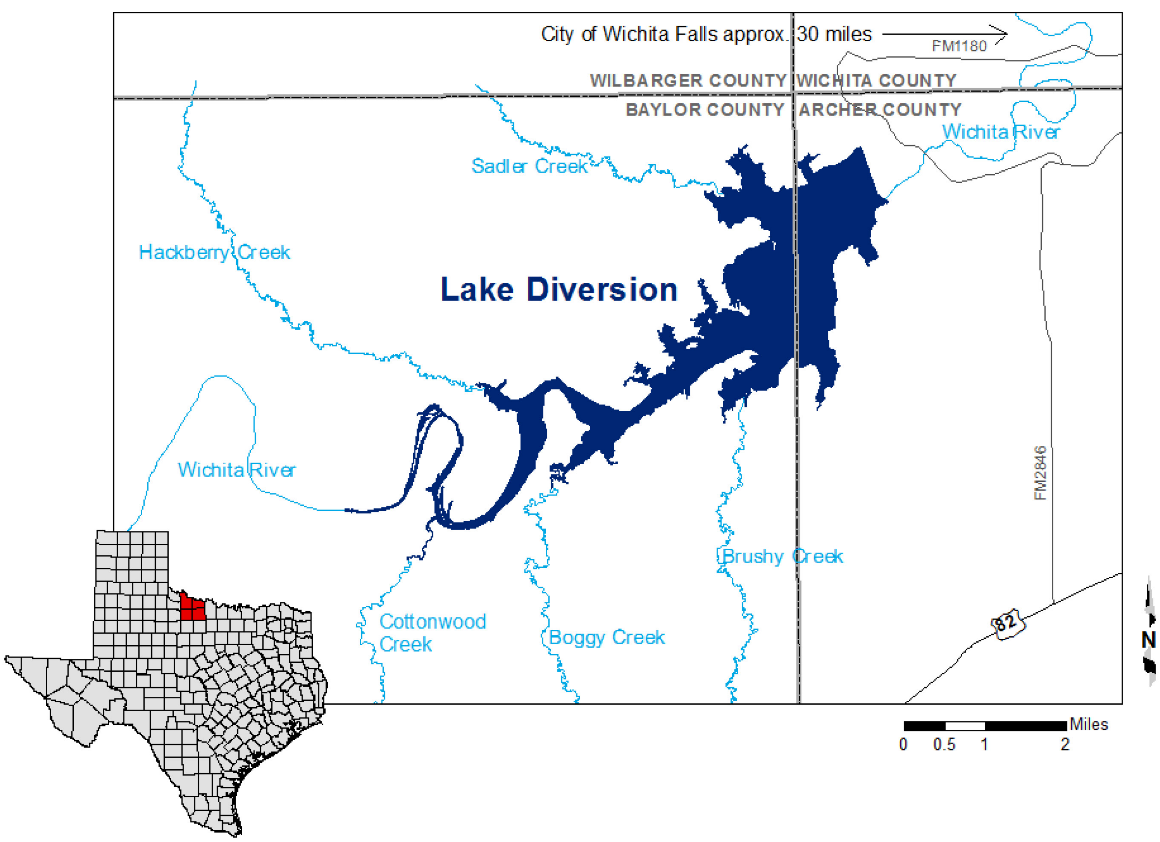


Figure 1. Location of Lake Diversion

Table 1.	Pertinent data for Lake Diversion Dam and Lake Diversion			
Owner				
	City of Wichita Falls and Wichita County Water Improvement District No. 2			
Engineer (Design)				
	R.A. Thompson			
Location of dam				
	On the Wichita River in Archer County, 20 miles downstream from Lake Kemp Dam			
Drainage area				
	2,164 square miles			
	Water is released from Lake Kemp to maintain water level at the desired elevation			
Dam				
	Type	Earthfill		
	Length	7,000feet		
	Height	55 feet		
	Top width	16 feet		
	Top elevation	1,070.0 feet above mean sea level		
Spillway (service with discharge to canal system)				
	Type	Gated concrete structure		
	Control	6 slide gates, each 3 by 5 feet		
	Crest length net	60 feet		
	Crest elevation	1,042.4 feet above mean sea level		
Spillway (emergency)				
	Type	Concrete ogee		
	Control	None		
	Crest length	308 feet		
	Crest elevation	1,052.0 feet above mean sea level		
Outlet works				
	Water is released through the service spillway (outlet works for canal) and over the emergency spillway[a]			
Reservoir data (Based on 2013 TWDB survey)				
	Feature	**Elevation (feet** NGVD29[b]**)**	**Capacity (acre-feet)**	**Area (acres)**
	Top of dam	N/A	N/A	N/A
	Conservation pool elevation	1,052.0	35,324	3,397
	Outlet works invert elevation/ Dead pool elevation	1,020.0	0	0
	Usable conservation storage space[c]	-	35,324	-

Source: (Kyle Miller, WCWID No. 2, personal communication, April 2014, TWDB, 1974, USGS, 2014)
[a] Two valve control pipes,, 4 feet in diameter, were grouted, closed, and abandoned in 1996 (Kyle Miller, WCWID No. 2, personal correspondence, April 2014)
[b] NGVD29 = National Geodetic Vertical Datum 1929
[c] Usable conservation storage space equals total capacity at conservation pool elevation minus dead pool capacity. Dead pool refers to water that cannot be drained by gravity through a dam's outlet works.

Volumetric survey of Lake Diversion

Datum

The vertical datum used during this survey is the National Geodetic Vertical Datum 1929 (NGVD29). This datum is also utilized by the United States Geological Survey (USGS) for the reservoir elevation gage *USGS 07312109 Diversion Lk nr Dundee, TX* (USGS, 2013). Elevations herein are reported in feet relative to the NGVD29 datum. Volume and area calculations in this report are referenced to water levels provided by the USGS gage. The horizontal datum used for this report is North American Datum 1983

(NAD83), and the horizontal coordinate system is State Plane Texas North Central Zone (feet).

TWDB bathymetric data collection

TWDB collected bathymetric data for Lake Diversion on April 3, 2013, April 16, 2013, May 14, 2013, June 4-5, 2013, and June 7, 2013. The daily average water surface elevations during the survey measured 1,051.16, 1,051.10, 1,050.47, 1,049.72, 1,049.66, and 1,049.69 feet above mean sea level (NGVD29), respectively. For data collection, TWDB used a Specialty Devices, Inc. (SDI), single-beam, multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder integrated with differential global positioning system (DGPS) equipment. Data collection occurred while navigating along pre-planned survey 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.

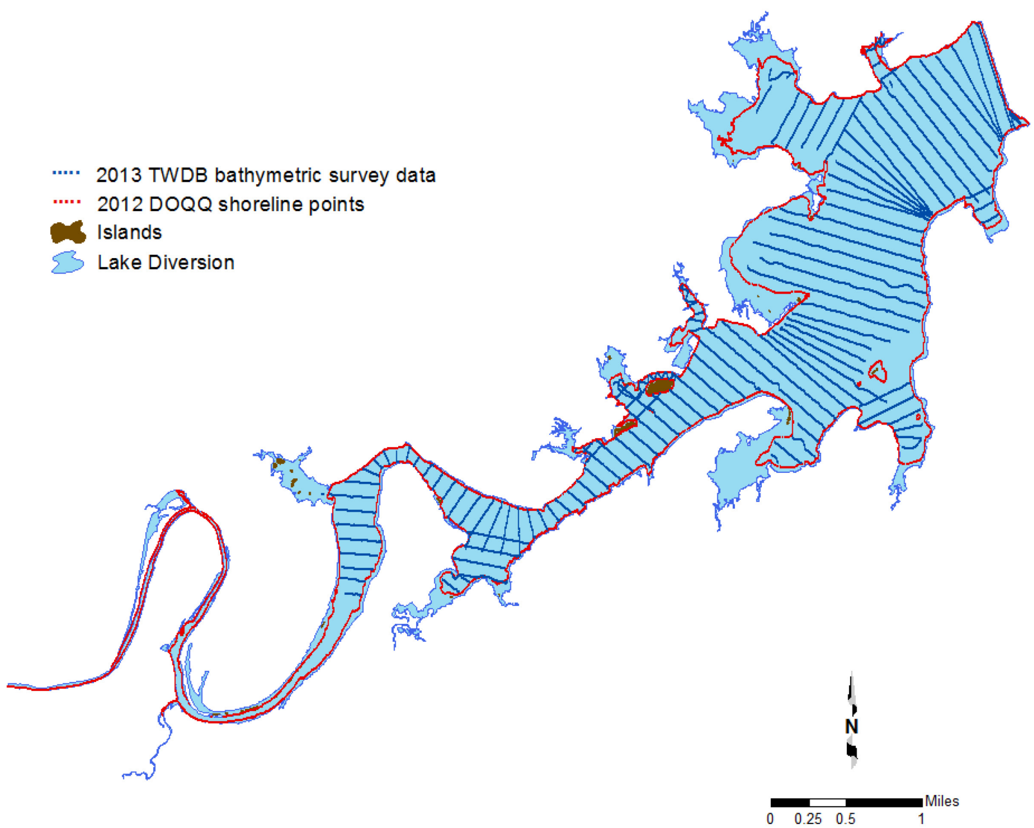


Figure 2. Data collected during 2013 TWDB Lake Diversion survey

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, 2013) using Environmental Systems Research Institute's ArcGIS software. The quarter-quadrangles that cover Lake Diversion are Lake Diversion (NW, NE, SW) and Franklin Bend (SE). The DOQQs were photographed on August 2, 2010, while the daily average water surface elevation measured 1,052.31 feet (NGVD29). According to metadata associated with the 2010 DOQQs, the photographs have a resolution or ground sample distance of 1.0-meters and a horizontal accuracy within ± 6 meters to true ground (TNRIS, 2010, USDA, 2013). For this analysis, the boundary was digitized at the land-water interface in the 2010 photographs and assigned an elevation of 1,052.31 feet. Additional boundary information was obtained from aerial photographs taken on July 6, 2012, and August 3, 2012, while the daily average water surface elevation measured 1,047.54 and 1,049.00 feet, respectively. The 2012 boundary information was added to the lake model as points. According to metadata associated with the 2012 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, 2012, USDA, 2013).

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. For processing outside of DepthPic©, an in-house software package, HydroTools, was used to identify the current reservoir-bottom surface to 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., 2011a). Finally, the point file resulting from spatial interpolation was used in conjunction with sounding and boundary data to create the volumetric Triangulated Irregular Network (TIN) model 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 TIN model 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 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 is 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 the volumetric TIN model representing the reservoir bathymetry. Specific details of this interpolation technique can be found in the HydroTools manual (McEwen et al., 2011a) and in McEwen et al., 2011b.

In areas inaccessible to survey data collection such as small coves and shallow upstream areas of the reservoir, linear extrapolation is used for volumetric estimations. The linear extrapolation follows a linear definition file linking the survey points file to the lake boundary file (McEwen et al., 2011a). Without extrapolated 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 extrapolation improves the elevation-capacity and elevation-area calculations. It is not always possible to remove all flat triangles, and linear extrapolation is only applied where adding bathymetry is deemed reasonable. For example, linear extrapolation was deemed reasonable and applied to Lake Diversion in the following situations: in small coves and un-surveyed areas using the aerial photographs taken on July 6 and August 3, 2012, as guidance.

Figure 3 illustrates typical results from application of the anisotropic interpolation and linear extrapolation techniques to Lake Diversion. The bathymetry shown in Figure 3C was used in computing reservoir capacity and area tables (Appendix A, B). 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, represented in Figure 3C, in creation of the volumetric TIN model directs Delaunay triangulation to better represent the lake bathymetry between survey cross-sections.

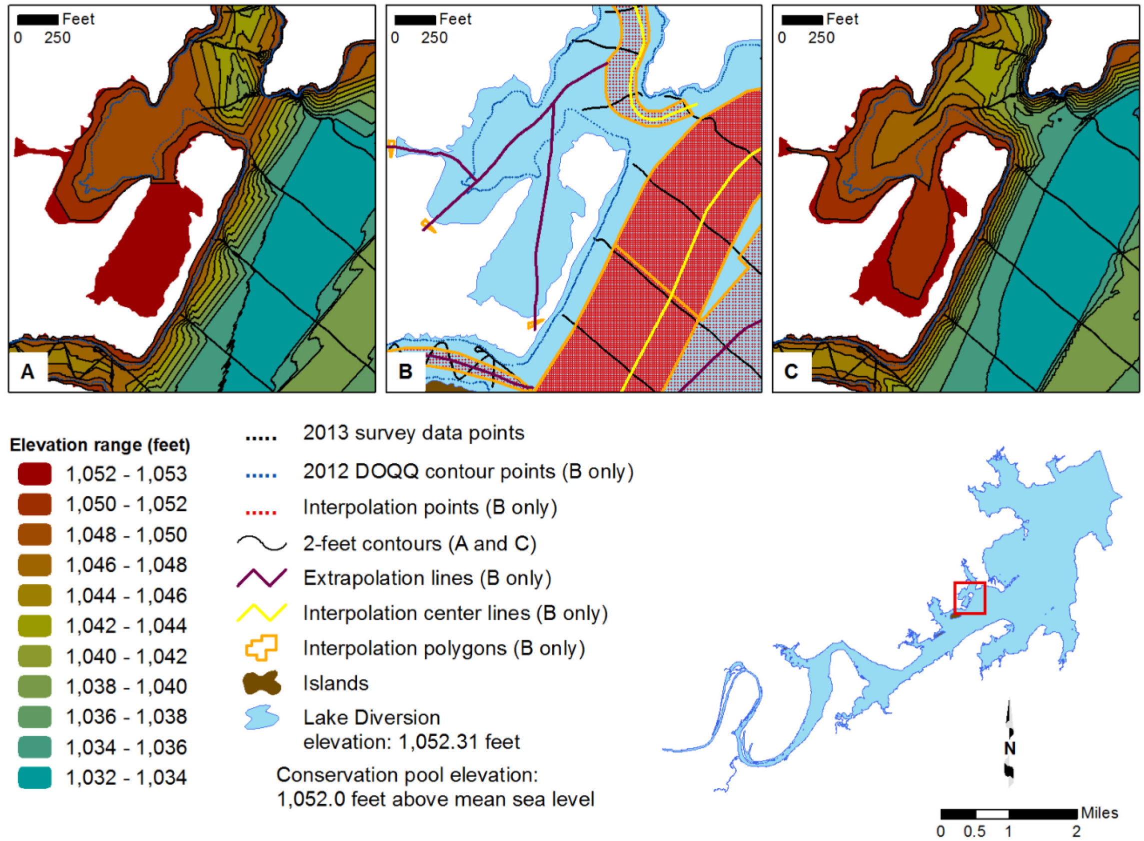


Figure 3. Anisotropic spatial interpolation and linear extrapolation of Lake Diversion sounding data - A) bathymetric contours without interpolated points, B) sounding points (black) and interpolated points (red), C) bathymetric contours with the interpolated points

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 feet intervals, from 1,022.0 to 1,052.3 feet. The use of contour data from the 2012 DOQQs helped provide otherwise unavailable topographic data in areas that were inaccessible by boat or too shallow for the instruments to work properly. However, the TIN models developed in these areas led to the creation of anomalous "flat triangles", that is triangles whose three vertices all have the same elevation. The flat triangles in turn lead to anomalous calculations of surface area and volume at the boundary elevations, 1,047.54 feet, 1,049.0 feet, and 1,052.31 feet. To eliminate the effects of the flat triangles on area and volume calculations, areas between elevations 1,048.7 feet and 1,052.31 feet were linearly interpolated between the computed values, and volumes above elevation 1,048.7 were calculated based on the corrected areas. The elevation-capacity table and elevation-area table, updated for 2013, 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.

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

Survey results

Volumetric survey

The results of the 2013 TWDB volumetric survey indicate Lake Diversion has a total reservoir capacity of 35,324 acre-feet and encompasses 3,397 acres at conservation pool elevation (1,052.0 feet above mean sea level, NGVD29). Lake Diversion was originally designed to hold an estimated 40,000 acre-feet encompassing 3,419 acres (TWDB, 1974) 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.

Table 2. Capacity loss comparisons for Lake Diversion

Survey	Volume comparisons at conservation pool elevation (acre-feet)
Original[a]	40,000
2013 volumetric survey	35,324
Volume difference (acre-feet)	4,676 (11.7%)
Number of years	89
Capacity loss rate (acre-feet/year)	53

[a] Source: (TWDB, 1974) Note: Impoundment of Lake Diversion began in 1922 and the dam was completed in 1924.

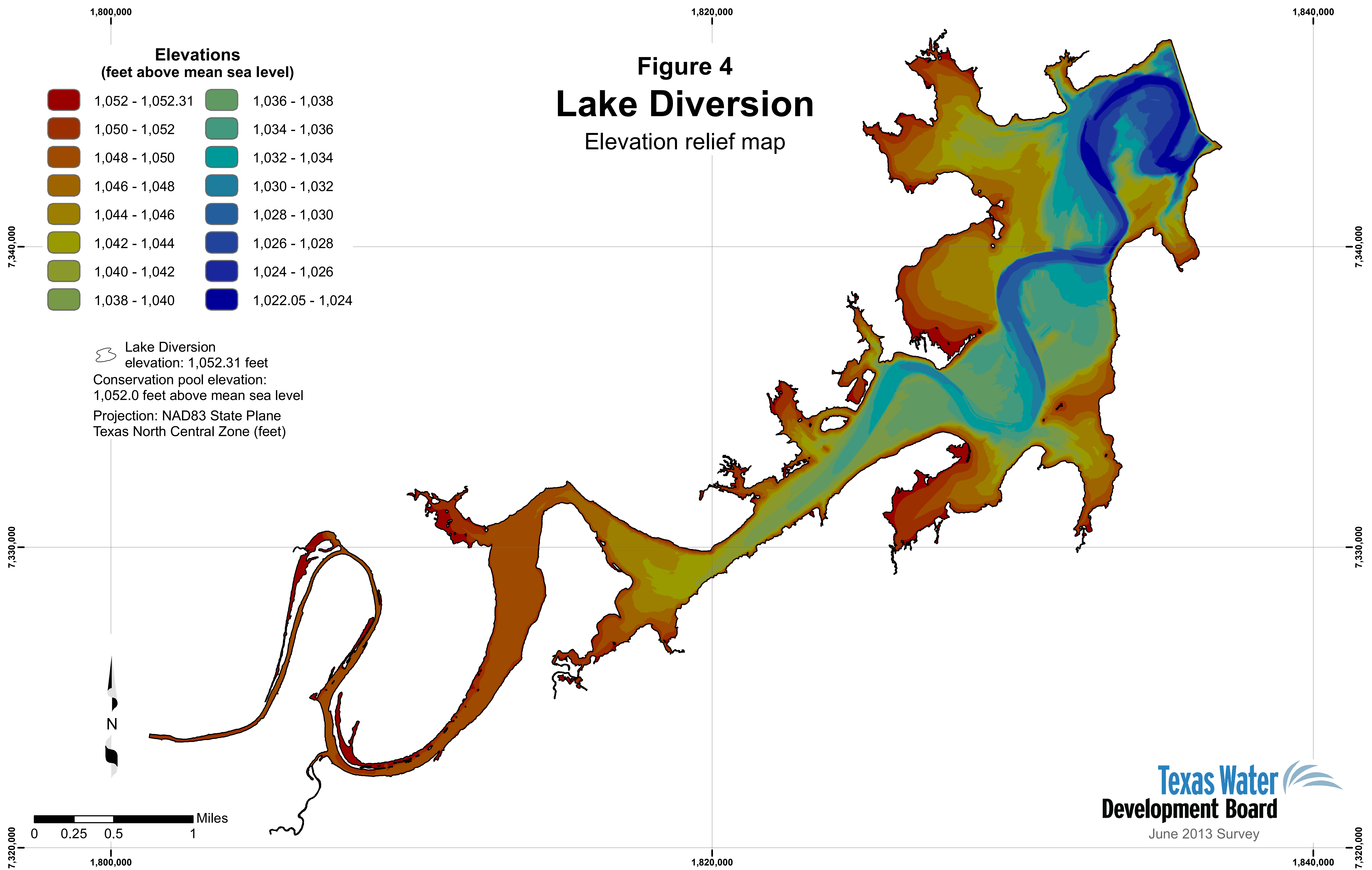
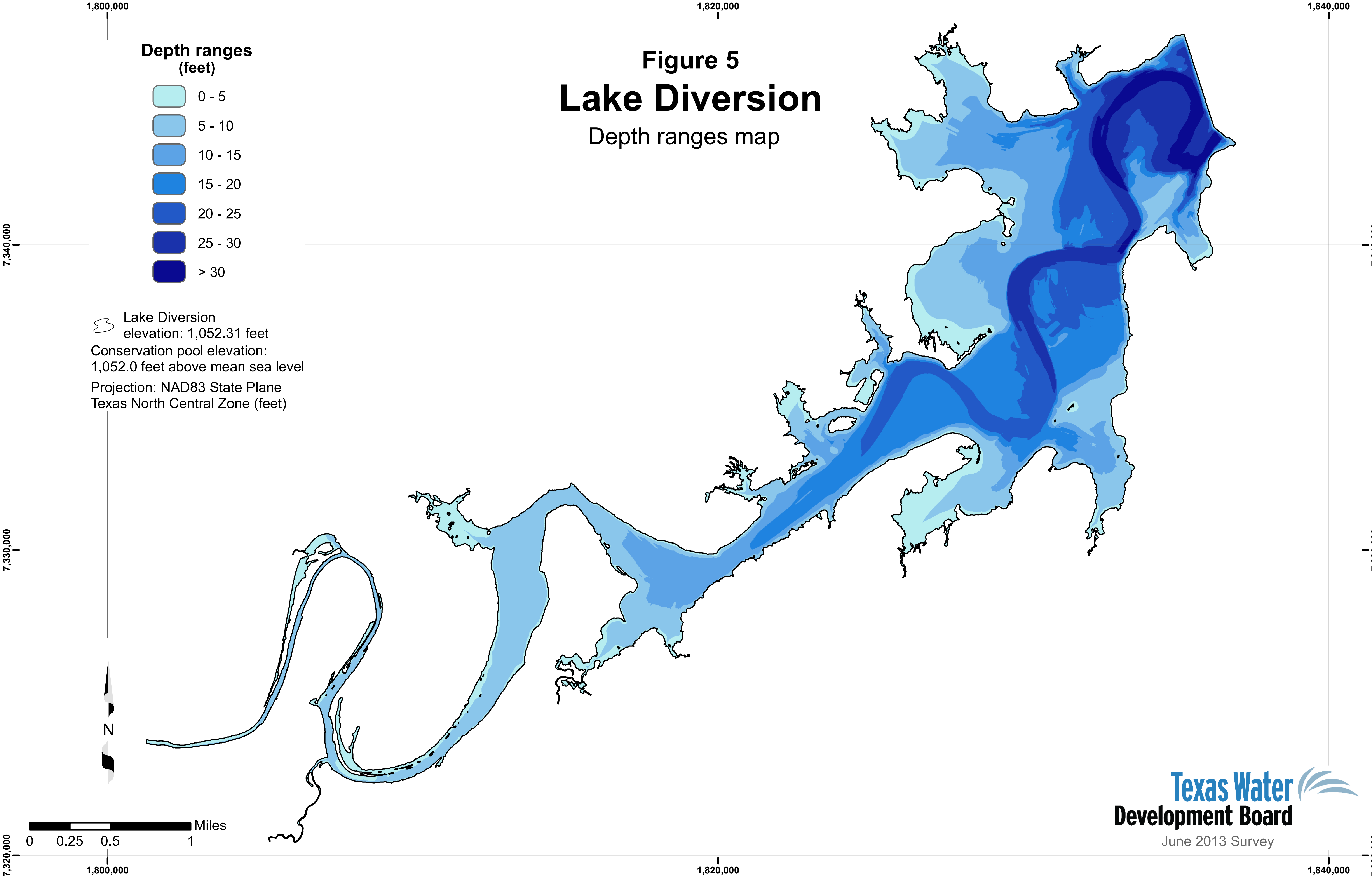


Figure 4
Lake Diversion
Elevation relief map
Elevations
(feet above mean sea level)
1,052 - 1,052.31
1,050 - 1,052
1,048 - 1,050
1,046 - 1,048
1,044 - 1,046
1,042 - 1,044
1,040 - 1,042
1,038 - 1,040
1,036 - 1,038
1,034 - 1,036
1,032 - 1,034
1,030 - 1,032
1,028 - 1,030
1,026 - 1,028
1,024 - 1,026
1,022.05 - 1,024
Lake Diversion
elevation: 1,052.31 feet
Conservation pool elevation:
1,052.0 feet above mean sea level
Projection: NAD83 State Plane
Texas North Central Zone (feet)
N
Miles
0
0.25
0.5
1
1,800,000
1,820,000
1,840,000
7,340,000
7,330,000
7,320,000
Texas Water
Development Board
June 2013 Survey

Figure 5
Lake Diversion
Depth ranges map



Texas Water Development Board
June 2013 Survey

Recommendations

To improve estimates of sediment accumulation rates, TWDB recommends resurveying Lake Diversion in approximately 10 years or after a major flood event. To further improve estimates of capacity loss, TWDB recommends a volumetric and sedimentation survey. Sedimentation surveys include additional analysis of the multi-frequency data for post-impoundment sediment by correlation with sediment core samples and a map identifying the spatial distribution of sediment throughout the reservoir.

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:

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Appendix A

Lake Diversion

RESERVOIR CAPACITY TABLE

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

June 2013 Survey
Conservation Pool Elevation 1,052.0 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
1,022	0	0	0	0	0	1	1	2	2	3
1,023	4	6	8	11	14	17	21	25	30	35
1,024	41	48	55	63	71	79	87	96	105	114
1,025	123	133	143	153	164	175	187	199	211	224
1,026	237	250	264	279	294	309	325	341	358	375
1,027	393	411	430	450	471	492	514	536	559	582
1,028	606	630	655	680	706	732	759	787	815	844
1,029	873	903	933	964	995	1,027	1,060	1,093	1,126	1,160
1,030	1,195	1,230	1,266	1,303	1,340	1,378	1,417	1,456	1,496	1,536
1,031	1,577	1,619	1,661	1,704	1,748	1,792	1,838	1,884	1,931	1,979
1,032	2,027	2,076	2,125	2,176	2,227	2,279	2,331	2,385	2,439	2,495
1,033	2,551	2,608	2,667	2,727	2,787	2,848	2,910	2,974	3,038	3,103
1,034	3,169	3,236	3,305	3,374	3,445	3,516	3,589	3,663	3,738	3,814
1,035	3,891	3,970	4,049	4,130	4,211	4,294	4,379	4,464	4,552	4,641
1,036	4,731	4,822	4,914	5,008	5,103	5,199	5,298	5,398	5,500	5,603
1,037	5,708	5,814	5,921	6,030	6,140	6,251	6,363	6,476	6,590	6,704
1,038	6,820	6,936	7,053	7,171	7,290	7,410	7,530	7,652	7,775	7,898
1,039	8,022	8,147	8,273	8,399	8,526	8,654	8,783	8,912	9,042	9,173
1,040	9,305	9,437	9,571	9,705	9,839	9,975	10,111	10,248	10,385	10,524
1,041	10,662	10,802	10,942	11,083	11,225	11,367	11,511	11,655	11,800	11,946
1,042	12,092	12,239	12,387	12,536	12,686	12,836	12,987	13,139	13,292	13,446
1,043	13,600	13,756	13,913	14,071	14,230	14,390	14,552	14,716	14,881	15,048
1,044	15,216	15,387	15,560	15,736	15,916	16,100	16,285	16,472	16,662	16,853
1,045	17,046	17,241	17,437	17,636	17,836	18,038	18,242	18,448	18,656	18,865
1,046	19,076	19,288	19,502	19,718	19,935	20,154	20,375	20,597	20,821	21,047
1,047	21,273	21,502	21,731	21,963	22,196	22,430	22,667	22,905	23,146	23,387
1,048	23,630	23,875	24,121	24,370	24,622	24,876	25,134	25,394	25,658	25,923
1,049	26,191	26,462	26,734	27,009	27,287	27,566	27,848	28,133	28,420	28,709
1,050	29,000	29,294	29,590	29,889	30,190	30,493	30,798	31,106	31,417	31,729
1,051	32,044	32,362	32,682	33,004	33,328	33,655	33,984	34,315	34,649	34,985
1,052	35,324	35,665	36,008	36,354						

Note: Capacities above elevation 1,048.7 feet calculated from interpolated areas

Appendix B

Lake Diversion

RESERVOIR AREA TABLE

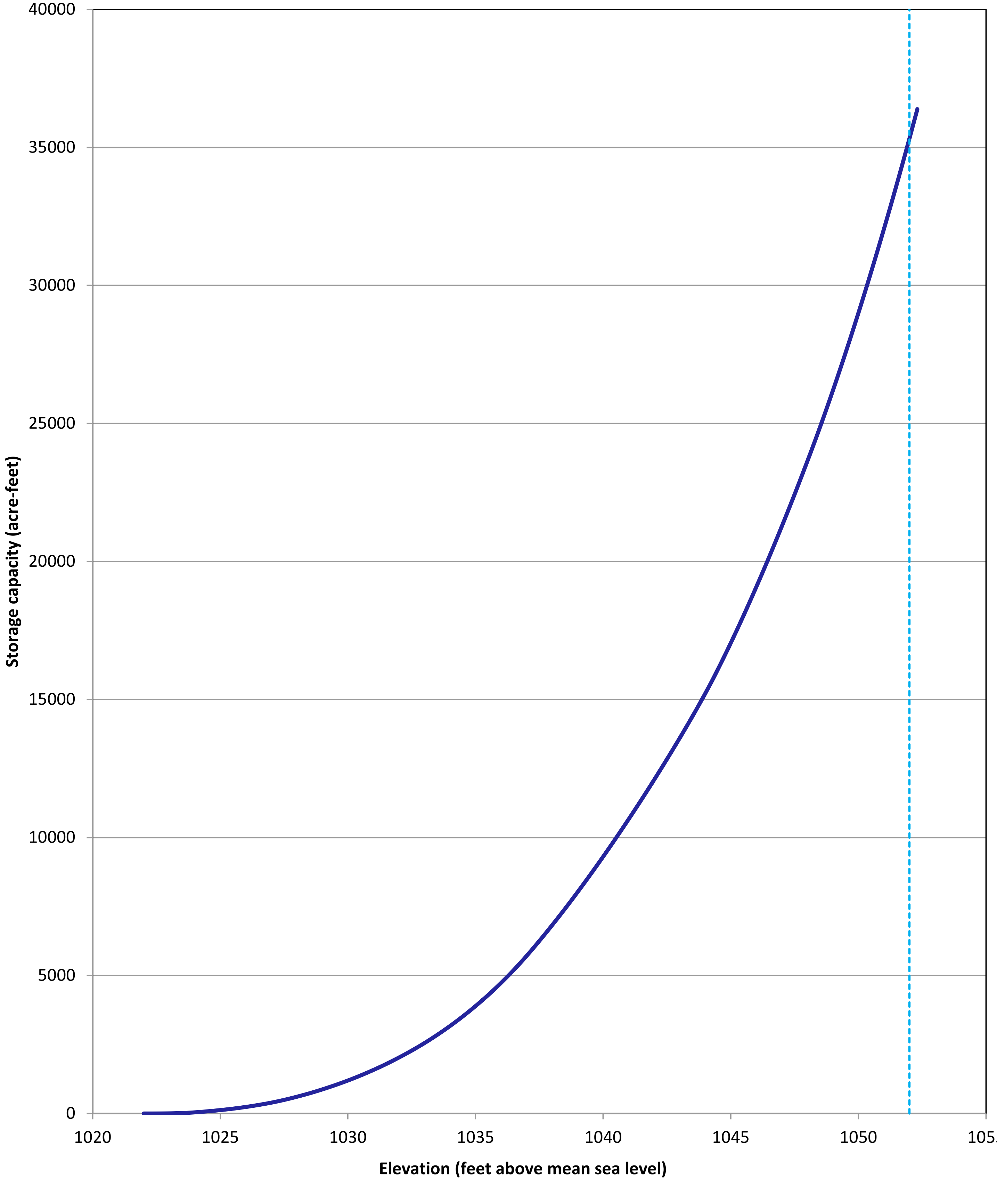
TEXAS WATER DEVELOPMENT BOARD — June 2013 Survey

AREA IN ACRES — Conservation Pool Elevation1,052.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

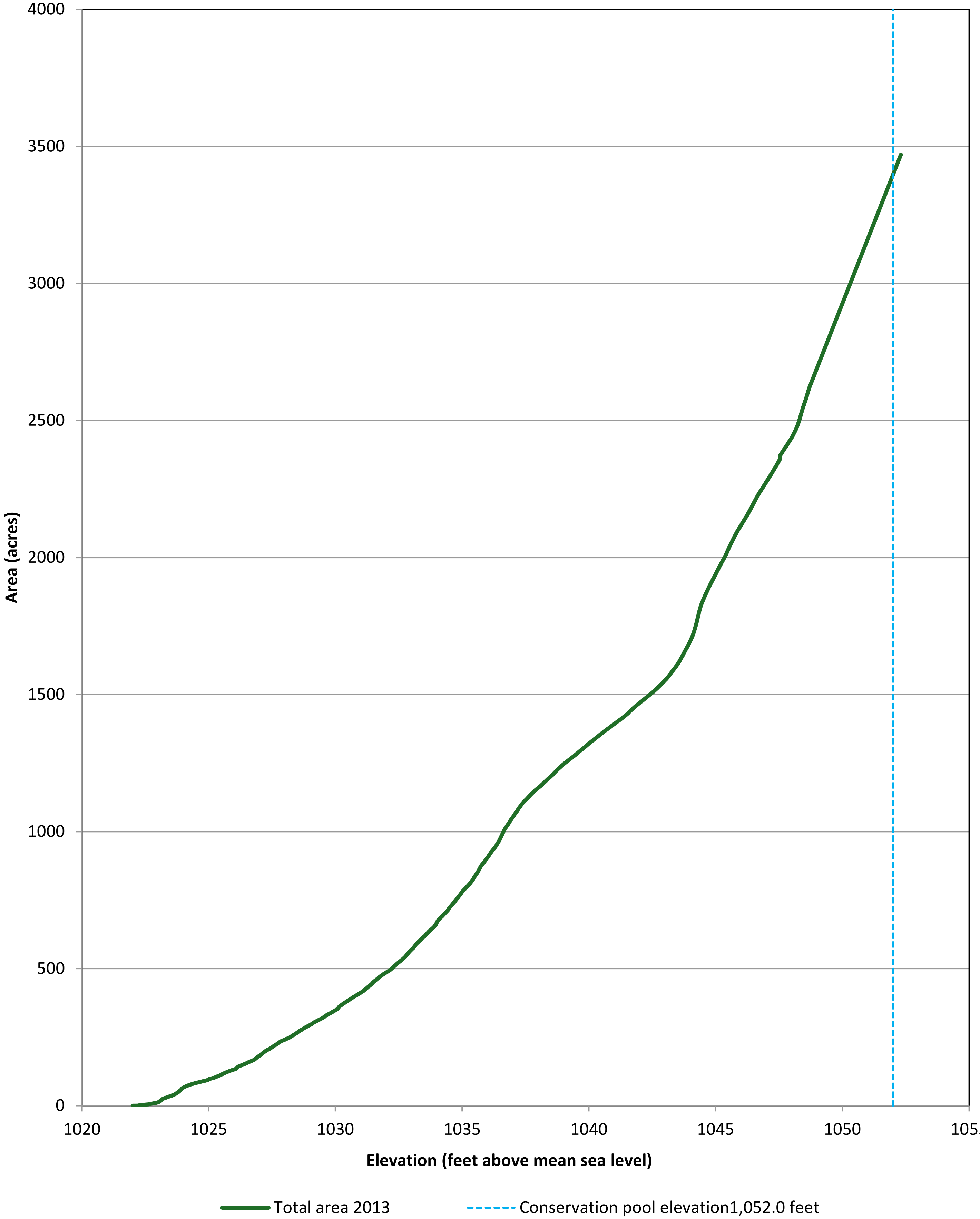
ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1,022	0	0	0	2	3	4	5	6	8	10
1,023	12	18	25	29	32	35	38	44	50	57
1,024	66	71	74	78	80	83	85	88	90	92
1,025	96	99	102	105	109	113	118	122	126	129
1,026	132	137	144	148	151	155	160	164	168	176
1,027	182	189	196	203	207	213	220	226	232	237
1,028	241	245	249	255	261	267	273	279	285	290
1,029	294	300	306	311	315	321	328	333	337	343
1,030	348	355	365	371	377	383	390	396	401	407
1,031	412	418	426	434	442	451	459	466	474	480
1,032	486	492	498	507	515	523	531	539	548	559
1,033	569	579	591	600	609	617	627	636	645	654
1,034	668	681	690	700	709	722	733	744	755	767
1,035	780	790	800	810	821	837	850	867	881	893
1,036	905	919	932	943	957	974	994	1,011	1,025	1,040
1,037	1,053	1,067	1,080	1,093	1,105	1,115	1,124	1,134	1,143	1,152
1,038	1,159	1,167	1,176	1,184	1,193	1,202	1,210	1,220	1,229	1,238
1,039	1,246	1,253	1,261	1,268	1,275	1,282	1,290	1,298	1,305	1,313
1,040	1,321	1,329	1,336	1,343	1,350	1,358	1,365	1,372	1,379	1,386
1,041	1,392	1,399	1,406	1,413	1,420	1,428	1,437	1,446	1,454	1,462
1,042	1,469	1,477	1,484	1,492	1,499	1,507	1,515	1,524	1,533	1,542
1,043	1,552	1,562	1,573	1,586	1,598	1,611	1,626	1,642	1,660	1,677
1,044	1,696	1,717	1,746	1,783	1,819	1,843	1,865	1,885	1,903	1,921
1,045	1,939	1,957	1,975	1,992	2,009	2,030	2,050	2,068	2,086	2,102
1,046	2,117	2,132	2,148	2,164	2,180	2,198	2,216	2,232	2,247	2,261
1,047	2,276	2,290	2,305	2,321	2,336	2,353	2,380	2,394	2,408	2,423
1,048	2,437	2,455	2,475	2,501	2,533	2,562	2,590	2,621	2,644	2,668
1,049	2,691	2,715	2,738	2,762	2,785	2,809	2,832	2,856	2,880	2,903
1,050	2,927	2,950	2,974	2,997	3,021	3,044	3,068	3,091	3,115	3,138
1,051	3,162	3,185	3,209	3,233	3,256	3,280	3,303	3,327	3,350	3,374
1,052	3,397	3,421	3,444	3,468						

Note: Areas above elevation 1,048.7 feet interpolated



Lake Diversion
June 2013 Survey
Prepared by: TWDB

Appendix C: Capacity curve



Lake Diversion
June 2013 Survey
Prepared by: TWDB

Appendix D: Area curve

Figure 6

Contours
(feet above mean sea level)

1050
1045
1040
1035
1030
1025

Lake Diversion
elevation: 1,052.31 feet
Islands

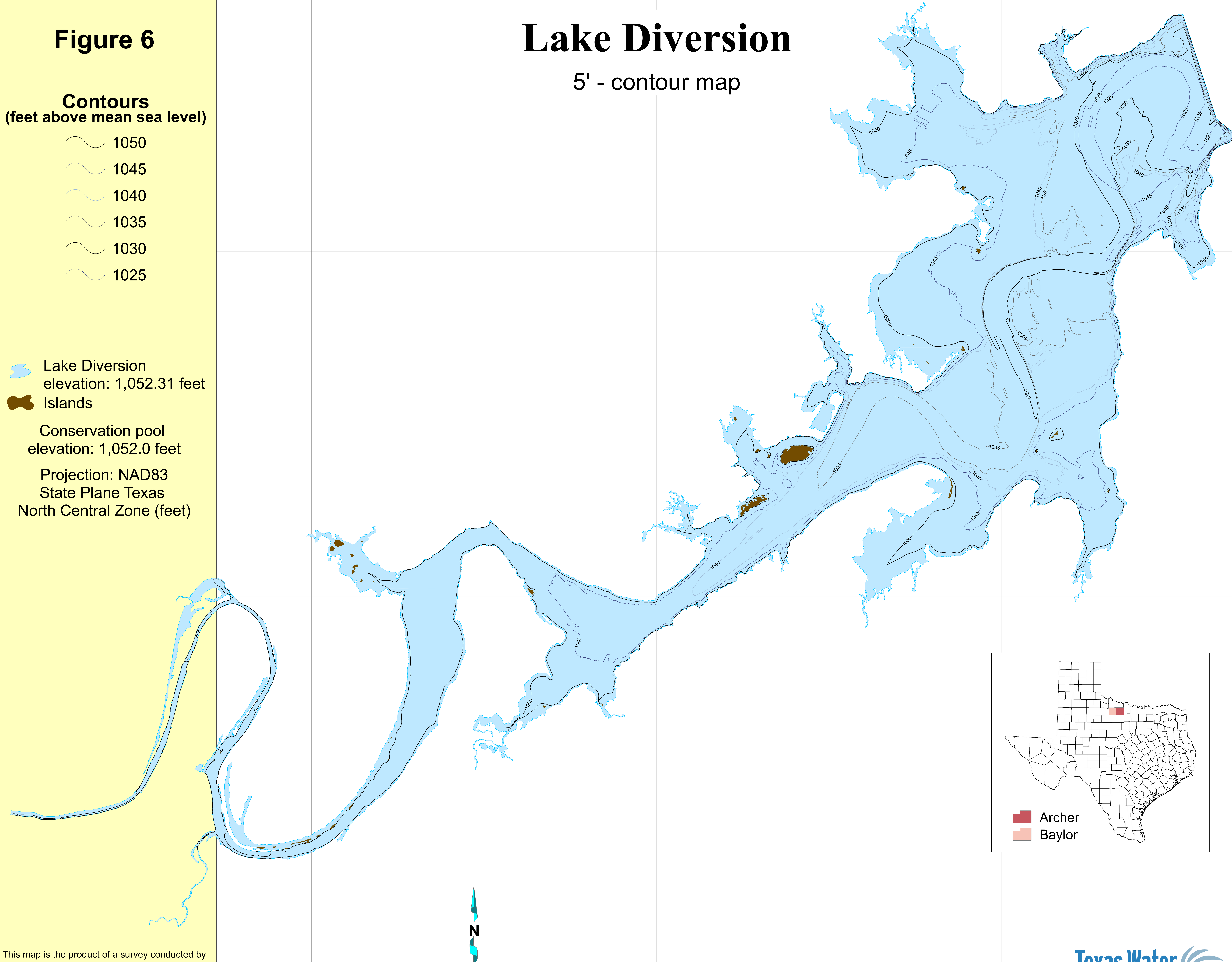
Conservation pool
elevation: 1,052.0 feet

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

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 Diversion. The Texas Water Development Board makes no representations nor assumes any liability.

Lake Diversion

5' - contour map



Texas Water Development Board
June 2013 Survey