Volumetric and Sedimentation Survey of WACO LAKE

November - December 2023 Survey

TEXAS WATER DEVELOPMENT BOARD

October 2024

Texas Water Development Board

Prepared for:

City of Waco, Texas

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Executive summary

In June 2023, the Texas Water Development Board (TWDB) entered into an agreement with the City of Waco, Texas, to perform a volumetric and sedimentation survey of Waco Lake (McLennan County, Texas). Surveying was performed using a multi-frequency (200 kHz, 50 kHz, and 12 kHz), sub-bottom profiling depth sounder. Sediment core samples were collected and correlated with sub-bottom acoustic profiles to estimate sediment accumulation thicknesses and sedimentation rates.

Waco Dam, impounding Waco Lake, is located on the Bosque River in McLennan County, within the city limits of Waco, Texas. The conservation pool elevation of Waco Lake is 462.0 feet above mean sea level (NGVD29). TWDB collected bathymetric data for Waco Lake on November 13-16, 2023, December 11-14, 2023, and December 18-19, 2023, while daily average water surface elevations measured 461.12 and 462.46 feet NGVD29.

The 2023 TWDB volumetric survey indicates Waco Lake has a total reservoir capacity of 189,116 acre-feet and encompasses 8,434 acres at conservation pool elevation (462.0 feet NGVD29). Previous capacity estimates at elevation 462.0 feet include a 1962 U.S. Army Corps of Engineers estimate of approximately 209,214 acre-feet and a 2011 TWDB estimate of 189,773 acre-feet. Differences in reservoir conditions as well as differences in the methodologies used among surveys can affect area and volume calculations. For this reason, the TWDB does not recommend comparing between volumetric surveys to determine loss of area or capacity. Information from past surveys is thus presented for informational purposes only.

The 2023 TWDB sedimentation survey measured 19,340 acre-feet of sediment. The sedimentation survey indicates sediment accumulation is greater in the South Bosque River branch of the reservoir than in the North Bosque River branch. Sediment accumulation is also greater near the dam on the South Bosque River side of the reservoir. The TWDB recommends that reservoirs be resurveyed approximately every 10 years or following a major event that results in increased sedimentation or scouring within 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. Texas Water Code Section 15.804 authorizes the TWDB to perform surveys to determine reservoir storage capacity, sedimentation levels, rates of sedimentation, and projected water supply availability.

In June 2023, the TWDB entered into an agreement with the City of Waco, Texas, to perform a volumetric and sedimentation survey of Waco Lake (McLennan County, Texas) (Texas Water Development Board, 2023). This report provides an overview of the survey methods, analysis techniques, and associated results. Also included are the following contract deliverables: (1) an elevation-area-capacity table of the reservoir acceptable to the Texas Commission on Environmental Quality (Appendices A, B, E, and F), (2) a bottom contour map (Figure 6), (3) a shaded relief plot of the reservoir bottom (Figure 4), and (4) an estimate of sediment accumulation and location (Figure 9).

Waco Lake general information

Waco Dam, impounding Waco Lake, is located on the Bosque River (Brazos River Basin) in McLennan County, within the city limits of Waco, Texas (Figure 1). Waco Dam and Waco Lake are owned and operated by the U.S. Army Corps of Engineers (USACE), Fort Worth District. Construction on Waco Dam began on June 13, 1958, and deliberate impoundment began on February 26, 1965. The dam was completed on June 24, 1965 (Texas Water Development Board, 1973). The reservoir was built primarily for water supply for the city of Waco and surrounding areas, and flood control in the Waco area (U.S. Army Corps of Engineers, 2024a). Additional pertinent data about Waco Dam and Waco Lake can be found in Table 1.

Water rights for Waco Lake have been appropriated to the City of Waco through Certificate of Adjudication and amendment numbers12-2315, 12-2315A, 12-2315B, 12-2315C, 12-2315D, 12-2315E and the Brazos River Authority through Permit to Appropriate State Water through permit numbers 5094 and 5094A (Texas Commission on Environmental Quality, 2023). The complete certificates and permits are on file at the Texas Commission on Environmental Quality (TCEQ).

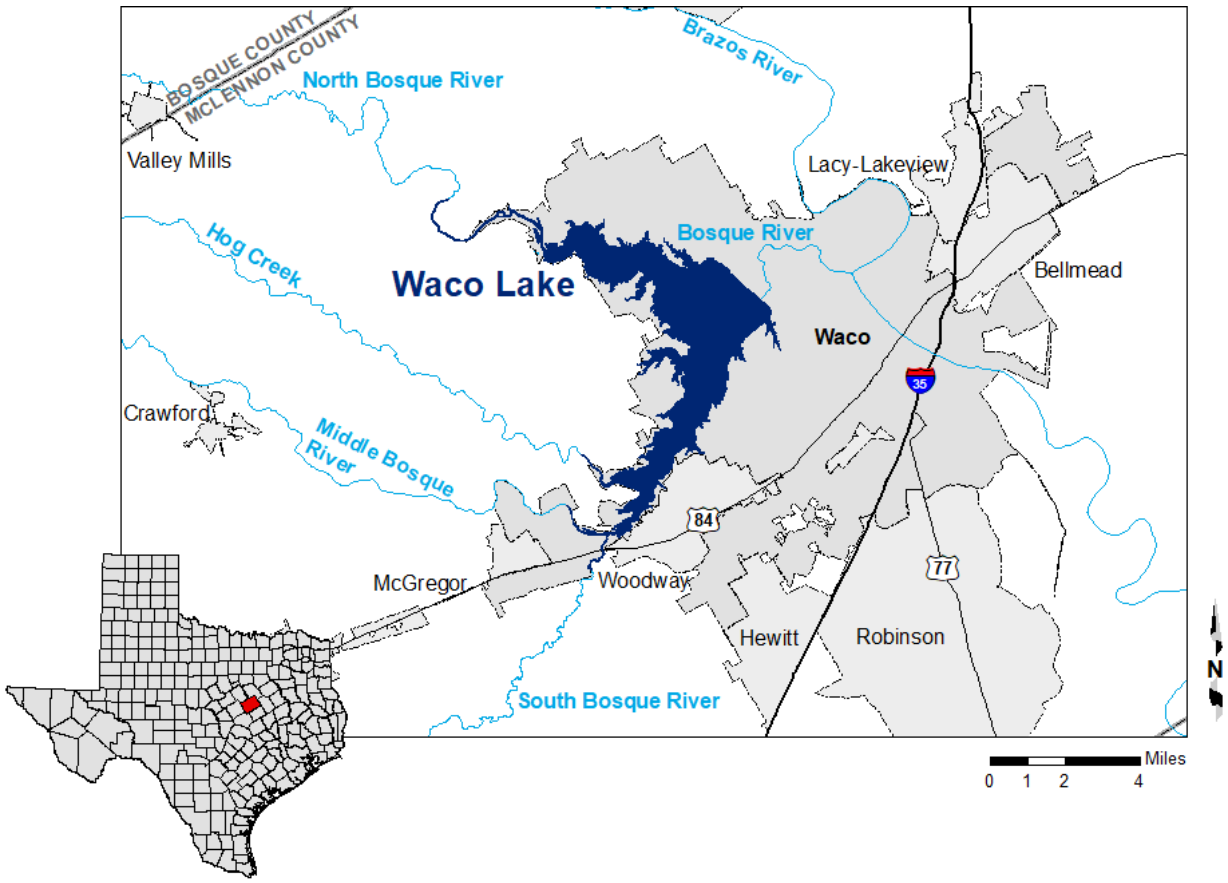


Figure 1. Location map.

Table 1. Pertinent Data for Waco Dam and Waco Lake

Owner(s)

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

Engineer (design)

U.S. Army Corps of Engineers

Location

On the Bosque River, Brazos River Basin, in McLennan County, contiguous to the city limits of Waco, Texas

Purpose

Municipal water supply storage for the City of Waco and surrounding areas, and flood control in the Waco area

Drainage Area	
Total Drainage Area	1,670 square miles
Dam	
Type	Earthfill with concrete spillway left bank
Total length (including spillway)	24,618 feet
Maximum height	140 feet
Top width (embankment)	20.0 feet
Top width (non overflow)	16.0 feet
Spillway	
Type	Ogee
Length (net)	560 feet
Crest elevation	465.0 feet NGVD29
Control	14 tainter gates, each 40 by 35 feet
Outlet Works	
Type	1 gate controlled conduit, 20-feet diameter
Invert elevation	400.0 feet NGVD29
Control	3 broome-type tractor sluice gates, each 6.67 feet by 20 feet

Reservoir Data

Feature	Elevation (feet NGVD29[a])	TWDB 2023 Capacity (acre-feet)	TWDB 2023 Area (acres)
Top of dam with parapet wall	514.6	1,037,611	25,686
PMF Design Water Surface	510.6	938,578	23,832
Top of Dam[b]	511.3	955,373	24,153
Maximum design water surface	505.0	812,269	21,312
Top of flood control pool and top of gates	500.0	710,763	19,358
Spillway crest	465.0	215,690	9,191
Top of conservation pool	462.0	189,116	8,434
Invert elevation/Dead pool elevation	400.0	226	34
Streambed	370.0	0	0
Conservation storage capacity[b]	—	188,890	—

Source: U.S. Army Corps of Engineers, 2024b.

a. National Geodetic Vertical Datum 1929 (NGVD29). The datum conversion from NGVD29 to NAVD88 (North American Vertical Datum 1988) is: NGVD29 + 0.22 feet = NAVD88

b. The Top of Dam was raised from 510.0 to 511.3 feet NGVD29 in April 2000.

c. Usable conservation storage equals total capacity at conservation pool elevation minus dead pool capacity. Dead pool refers to water that cannot be drained by gravity through the dam outlet works.

Volumetric and sedimentation survey of Waco Lake

Datum

Water surface elevations during the TWDB survey were obtained from the United States Geological Survey (USGS) gage USGS 08095550 *Waco Lk nr Waco, TX* (U.S. Geological Survey, 2024). These data were used to convert survey depths to elevations. The USGS gage records water surface elevations in feet relative to the North American Vertical Datum 1988 (NAVD88). However, elevations herein are reported in feet relative to the National Geodetic Vertical Datum 1929 (NGVD29). The conversion factor between NAVD88 and NGVD29 was obtained from the National Oceanic and Atmospheric Administration National Geodetic Survey's Coordinate Conversion and Transformation Tool (NCAT) (National Geodetic Survey, 2023) to a single reference point in the vicinity of the survey, the reservoir elevation gage: Latitude 31º34'46.59484" Longitude 97º11'52.01962" NAD83. NCAT was used to convert from Latitude 31º34'46" Longitude 97º11'51" North American Datum 1927, as reported by USGS. Elevations were converted from feet NAVD88 to feet NGVD29 by subtracting 0.220. This is the same conversion factor used by the USGS to compute temporary water surface elevations from NAVD88 to NGVD29. The horizontal datum used for this report is NAD83, and the horizontal coordinate system is State Plane Texas Central Zone (feet).

TWDB bathymetric and sedimentation data collection

The TWDB collected bathymetric data for Waco Lake on November 13-16, 2023, December 11-14, 2023, and December 18-19, 2023, while daily average water surface elevations measured between 461.12 and 462.46 feet NGVD29. For data collection, the TWDB used a Specialty Devices, Inc. (SDI), single-beam, multi-frequency (200 kHz, 50 kHz, and 12 kHz) sub-bottom profiling depth sounder integrated with differential global positioning system (DGPS) equipment. Data were collected along pre-planned survey lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 500 feet apart. Many of the same lines also were used by the TWDB for the *Volumetric and Sedimentation Survey of Waco Lake, May 2011 Survey* (Texas Water Development Board, 2012). 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. Each speed of sound profile, or velocity cast, is saved for further data processing. Figure 2 shows the data collection locations for the 2023 TWDB survey.

All sounding data were collected and reviewed before sediment core sampling sites were selected. Sediment core samples are collected throughout the reservoir to assist with interpretation of the sub-bottom acoustic profiles. After analyzing the sounding data, the TWDB selected 23 locations to collect sediment core samples (Figure 2). Sediment cores were collected March 25 through March 27, 2024, with a custom-coring boat and an SDI VibeCore system.

Sediment cores are collected in 3-inch diameter aluminum tubes. A sediment core extends from the current reservoir-bottom surface, through the accumulated sediment, and into the pre-impoundment surface. After the sample is retrieved, the core tube is cut to the level of the sediment core. The tube is capped, labeled, and either transported to TWDB headquarters for further analysis or analyzed onsite at the reservoir.

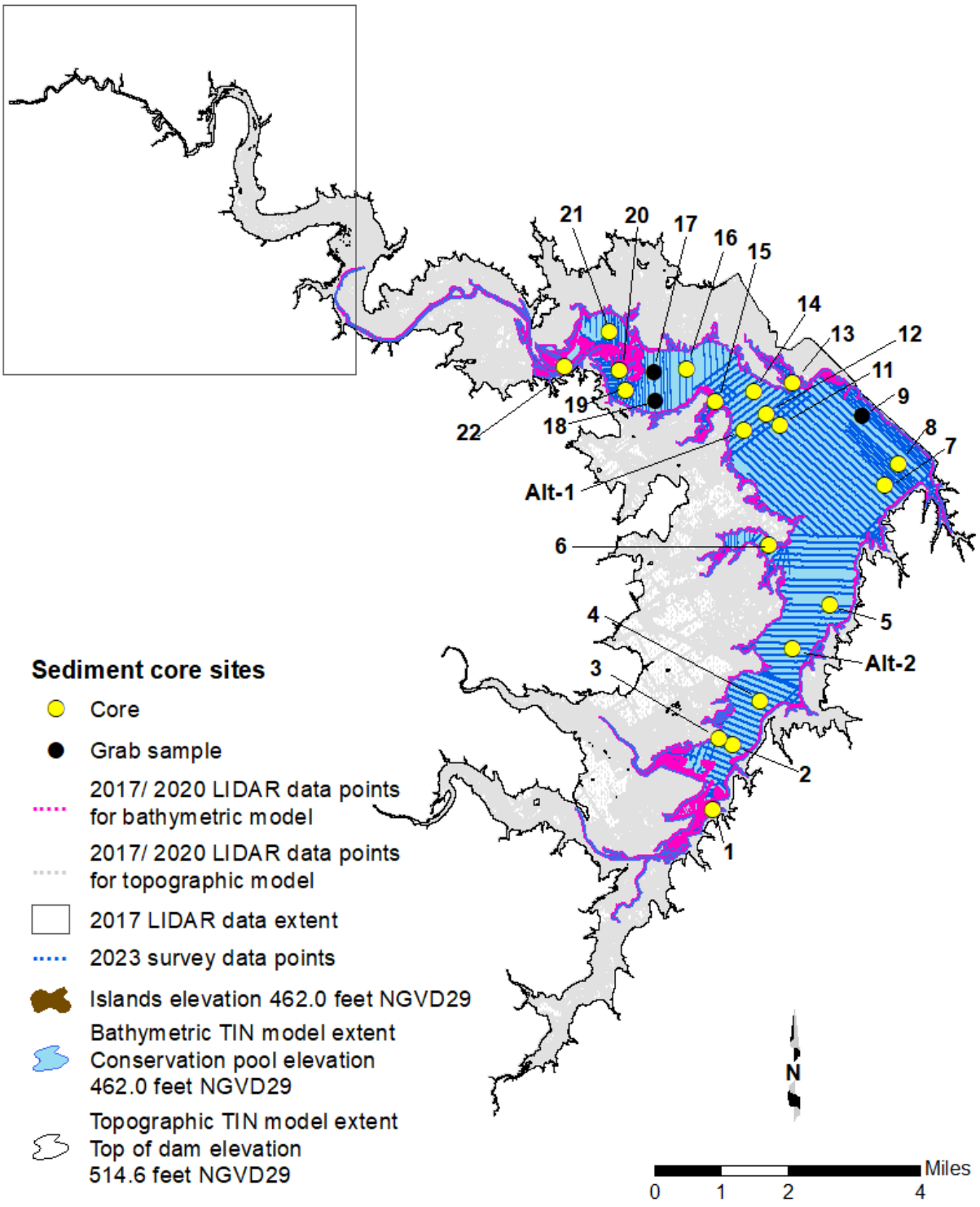


Figure 2. **2023 TWDB sounding data (*blue dots*), sediment coring locations (*yellow and black circles*), LIDAR data for bathymetric model (*pink dots*), and LIDAR data for topographic model (*gray dots*).**

Data processing

Model boundary

The bathymetric and topographic model boundaries of the reservoir were generated with Light Detection and Ranging (LIDAR) data available from the Texas Geographic Information Office (TxGIO), formerly known as the Texas Natural Resource Information System (TNRIS). These data were collected between January 12, 2020, and February 22, 2020, while the daily average water surface elevation of the reservoir measured between 456.51 and 460.31 feet NGVD29. Additional data collected on January 23, 2017, and January 25, 2017, while the daily average water surface elevation of the reservoir measured 462.77, 462.43, and 462.27 feet NGVD29, respectively, were used to fill in data gaps where 2020 data were unavailable. The LIDAR data files (.las) were imported into an LAS Dataset and the dataset was converted to a raster using a cell size of 1.0 meter by 1.0 meter. The horizontal datum of the LIDAR data is North American Datum 1983 (NAD83; meters) and the projection is Universal Transverse Mercator (UTM) Zone 14. The vertical datum is North American Vertical Datum 1988 (NAVD88; meters). A contour representing the conservation pool elevation of 140.884656 meters NAVD88, equivalent to 462.0 feet NGVD29 and a contour representing the top of the dam elevation of 156.911035 meters NAVD88, equivalent to 514.6 feet NGVD29 were extracted from the raster. The vertical datum transformation offset of 0.067 meters, was used to convert from meters NAVD88 to meters NGVD29 before converting to feet NGVD29. The vertical datum transformation offset for the conversion from NAVD88 to NGVD29 was determined by applying the National Oceanic and Atmospheric Administration National Geodetic Survey's Coordinate Conversion and Transformation Tool (NCAT) (National Geodetic Survey, 2023) to a single reference point in the vicinity of the survey, the reservoir elevation gage *USGS 08095550 Waco Lk nr Waco, TX Latitude 31°34'46" N, Longitude 97°11'51" W NAD27.* The topographic model contour was edited to close the contour across the dam and remove other artifacts.

The bathymetric model boundary was edited to match more recent conditions as reflected in aerial photographs taken more recently than the LIDAR data. The aerial photographs, also known as digital orthophoto quarter-quadrangle images (DOQQs), were obtained through the Texas Imagery Service. The Texas Geographic Information Office (TxGIO), formerly the Texas Natural Resources Information System (TNRIS), manages the Texas Imagery Service, allowing public organizations in the State of Texas to access high resolution imagery as a service using Environmental Systems Research Institute's ArcGIS software (Texas Geographic Information Office, 2023). DOQQs photographed on September 30, 2020, while the daily average water

surface elevation measured 461.87 feet NGVD29, were referenced to update the bathymetric model boundary by editing the LIDAR contour to more closely align with the land-water interface visible in the photographs.

LIDAR data points

To utilize the LIDAR data in the reservoir topographic model, the LIDAR data files (.las) were converted to a multipoint feature class in an Environmental Systems Research Institute's ArcGIS file geodatabase filtered to include only data classified as ground points. A topographical model of the data was generated. The ArcGIS tool Terrain to Points was used to extract points from the terrain, or topographical model of the reservoir. The terrain was created using the z-tolerance pyramid type. Points were extracted from the terrain at the z-tolerance level of 0.10 meters to model the bathymetric surface and 0.25 meters to model the topographic surface. New attribute fields were added to convert the elevations from meters NAVD88 to meters NGVD29, then feet NGVD29 for compatibility with the bathymetric survey data. Topographic LIDAR data were edited to use only points inside the 514.6-foot contour and outside the bathymetric model boundary. Bathymetric LIDAR data were edited to remove all points within the bathymetric footprint with an elevation greater than conservation pool. LIDAR data points inside the bathymetric model boundary were also verified against the survey data and the aerial photographs and the majority were found to be reasonable, however, any LIDAR data points that were not in agreement were deleted. Both feature classes were projected to NAD83 State Plane Texas Central Zone (feet).

Triangulated Irregular Network model

Following completion of data collection, the raw data files collected by the TWDB were edited to remove data anomalies. The current bottom surface of the reservoir is automatically determined by the data acquisition software. Hydropick software, developed by TWDB staff, was used to display, interpret, and edit the multi-frequency data by manually removing data anomalies in the current bottom surface and to manually edit the pre-impoundment surfaces. The speed of sound profiles, also known as velocity casts, were used to further refine the measured depths. For each location velocity casts are collected, the harmonic mean sound speed of all the casts is calculated. From this, depths collected using one average speed of sound are corrected with an overall optimum speed of sound for each specific depth (Specialty Devices, Inc., 2018).

All data were exported into a single file, including the current reservoir bottom surface, pre-impoundment surface, and sediment thickness at each sounding location. 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). The resulting point file was used in conjunction with sounding and boundary data to create volumetric and sediment Triangulated Irregular Network (TIN) models utilizing the 3D Analyst Extension of ArcGIS. The 3D Analyst algorithm uses Delaunay's criteria for triangulation to create a grid composed of triangles from non-uniformly spaced points, including the boundary vertices (Environmental Systems Research Institute, 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 bathymetry 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 artifacts may include artificially curved contour lines extending into the reservoir where the reservoir walls are steep or the reservoir is relatively narrow, intermittent representation of submerged stream channel connectivity, and oscillations of contour lines in between survey lines. These artifacts reduce the accuracy of the resulting volumetric and sediment TIN models in areas between actual survey data.

To improve the accuracy of bathymetric representation between survey lines, the TWDB developed various anisotropic spatial interpolation techniques. Generally, the directionality of interpolation at different locations of a reservoir can be determined from external data sources. A basic assumption is that the reservoir profile in the vicinity of a particular location has upstream and downstream similarity. In addition, the sinuosity and directionality of submerged stream channels can be determined by directly examining the survey data, or more robustly by examining scanned USGS 7.5-minute quadrangle maps (DRGs), hypsography files (the vector format of USGS 7.5-minute quadrangle map contours), and historical aerial photographs, when

available. Using the survey data, polygons are created to partition the reservoir into segments with centerlines defining the directionality of interpolation within each segment. Using the interpolation definition files and survey data, the current reservoir-bottom elevation, pre-impoundment elevation, and sediment thickness are calculated for each point in the high-resolution uniform grid of artificial survey points. The reservoir boundary, artificial survey points grid, and survey data points are used to create volumetric and sediment TIN models representing reservoir bathymetry and sediment accumulation throughout the reservoir. Specific details of this interpolation technique can be found in the HydroTools manual (McEwen and others, 2011a) and in McEwen and others (2011b).

In areas inaccessible to survey data collection, such as small coves and shallow upstream areas of the reservoir, linear interpolation is used for volumetric and sediment accumulation estimations (McEwen and others, 2011a). Although LIDAR was utilized, linear interpolation was necessary to accurately model features in the areas between survey data and LIDAR data. Linear interpolation results in improved elevation-capacity and elevation-area calculations.

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

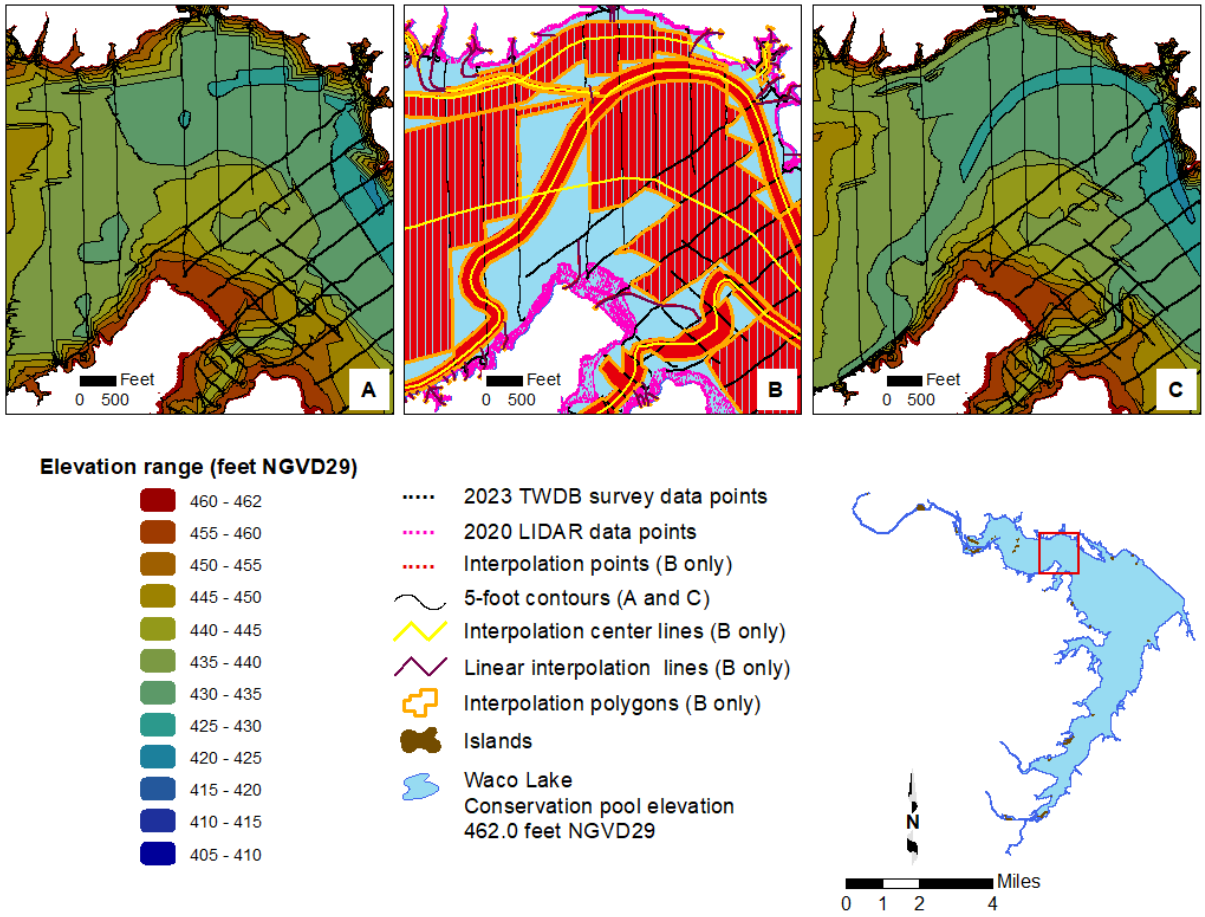


Figure 3. **Anisotropic spatial interpolation as applied to Waco Lake sounding data: A) bathymetric contours without interpolated points; B) sounding points (*black*), LIDAR data points (*pink*), and interpolated points (*red*); C) bathymetric contours with interpolated points.**

Area, volume, and contour calculation

Volumes and areas were computed for the entire reservoir at 0.1-foot intervals, from 376.1 to 462.0 feet for the bathymetric TIN model, and from 376.1 to 514.6 feet for the bathymetric and topographic TIN model. The bathymetric elevation-capacity table and bathymetric elevation-area table, based on the 2023 survey and analysis, are presented in Appendices A and B, respectively. The bathymetric capacity curve is presented in Appendix C, and the bathymetric area curve is presented in Appendix D. The topographic elevation-capacity table and topographic elevation-area table developed from the 2023 survey and analysis are presented in Appendices E and F, respectively. The topographic capacity curve is presented in Appendix G, and the topographic area curve is presented in Appendix H.

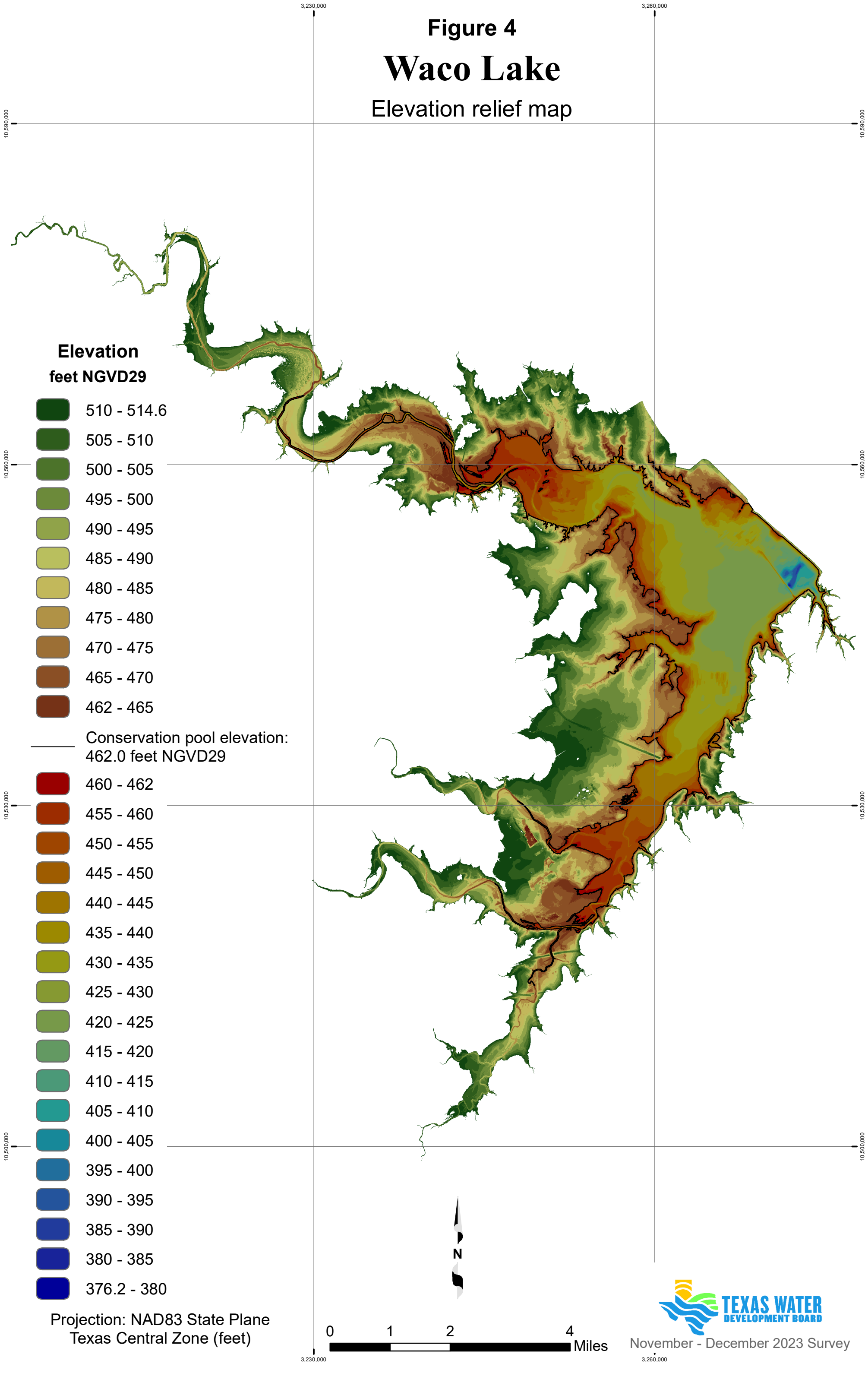
The topographic and bathymetric volumetric TIN models were converted to a raster representation using a cell size of 2 feet by 2 feet. The raster data then were used to produce three figures: (1) an elevation relief map representing the topography of the reservoir bottom

(Figure 4); (2) a depth range map showing depth ranges for Waco Lake (Figure 5); and (3) a 5-foot contour map (Figure 6).

Figure 4

Waco Lake

Elevation relief map



Projection: NAD83 State Plane
Texas Central Zone (feet)

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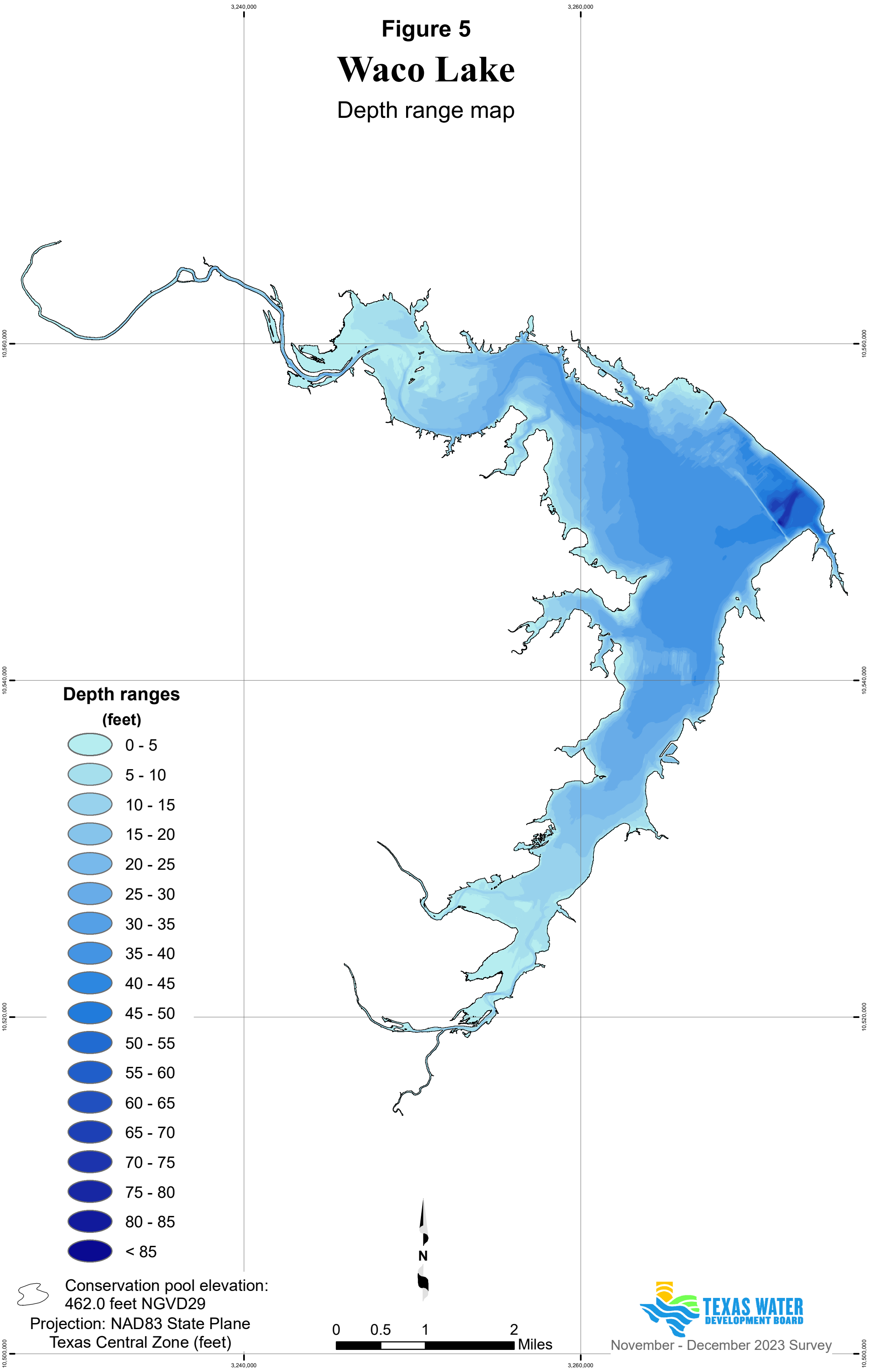
November - December 2023 Survey

Figure 5

Waco Lake

Depth range map



Analysis of sediment data from Waco Lake

Sedimentation in Waco Lake was determined by analyzing the acoustic signal returns of all three depth sounder frequencies using customized software called Hydropick. While the 200 kHz signal is used to determine the current bathymetric surface, the 200 kHz, 50 kHz, and 12 kHz are analyzed to determine the reservoir bathymetric surface at the time of initial impoundment, *i.e.*, pre-impoundment surface. Sediment core samples collected in the reservoir are correlated with the acoustic signals in each frequency to assist in identifying the pre-impoundment surface. The difference between the current surface bathymetry and the pre-impoundment surface bathymetry yields a sediment thickness value at each sounding location.

Sediment cores were analyzed onsite at Waco Lake and at TWDB headquarters in Austin. Each core was split longitudinally and analyzed to identify the location of the pre-impoundment surface. The pre-impoundment surface was identified within the sediment core using the following methods: (1) a visual examination of the sediment core for terrestrial materials, such as leaf litter, tree bark, twigs, intact roots, *etc.*, concentrations of which tend to occur on or just below the pre-impoundment surface; (2) recording changes in texture from well sorted, relatively fine-grained sediment to poorly sorted mixtures of coarse and fine-grained materials; and, (3) identifying variations in the physical properties of the sediment, particularly sediment water content and penetration resistance with depth (Van Metre and others, 2004). Total sediment core length, post impoundment sediment thickness, and pre-impoundment thickness were recorded. Physical characteristics of the sediment core, such as Munsell (2018) soil color, texture, relative water content, and presence of organic materials are presented in Table 2.

Table 2. Sediment core sample analysis data.

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample / post-impoundment sediment length (inches)	Sediment core description[b]		Munsell soil color
WACO-1	3256911.93	10523015.91	77.0 / 70.0	post-impoundment	0.0−2.0″ very high water content, fine silt, soupy, smooth	5Y 5/2 olive gray
					2.0–15.0″ moderate water content, silty clay, smooth, sticky, peanut butter like, uniform consistency and texture throughout	5Y 3/2 dark olive gray
					15.0–25.0″ moderate water content but less than previous layer, silty clay, sticky, peanut butter like, uniform consistency, more dense and malleable than previous layer, organic material present throughout (fibrous roots, terrestrial vegetation, twigs)	5Y 3/2 dark olive gray
					25.0–26.0″ moderate water content, band of organic material present (leaf litter, roots)	N/A
					26.0–28.0″ moderate water content but less than previous layer, silty clay, sticky, peanut butter like, uniform consistency, more dense and malleable than previous layer, organic material present throughout (fibrous roots, terrestrial vegetation, twigs)	5Y 3/2 dark olive gray
					28.0–29.0″ moderate water content, band of organic material present (leaf litter, roots)	N/A
					29.0–45.0″ moderate water content but less than previous layer, silty clay, sticky, similar to dried cake batter, malleable, density increases with depth	5Y 3/2 dark olive gray
					45.0–46.0″ moderate water content, band of organic material present (leaf litter, roots)	N/A
					46.0–48.0″ moderate water content but less than previous layer, silty clay, sticky, similar to dried cake batter, malleable, density increases with depth	5Y 3/2 dark olive gray
					48.0–55.0″ moderate water content, water content decreases with depth, silty clay, malleable, organic material present throughout (fibrous roots, grass, stems)	5Y 3/2 dark olive gray

a. Coordinates are based on NAD83 State Plane Texas Central System (feet).
b. Sediment core samples are measured in inches with zero representing the current bottom surface.

Table 2 (continued). Sediment core sample analysis data.

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample / post-impoundment sediment length (inches)	Sediment core description[b]		Munsell soil color
WACO-1 (continued)	3256911.93	10523015.91	77.0 / 70.0	post-impoundment	55.0–61.0″ low water content, silty clay, increased density, uniform consistency and texture throughout, organic material present throughout (fibrous roots, leaves, sticks)	5Y 3/2 dark olive gray
					61.0–70.0″ low water content, more dense than previous layer, silty clay smooth, malleable	5Y 2.5/1 black
				pre-impoundment	70.0–77.0″ low water content, silty clay, smooth, organic material present (leaf litter, terrestrial vegetation, streaks of charcoal)	5Y 2.5/1 black
WACO-2	3258468.33	10528244.22	47.0 / 44.0	post-impoundment	0.0–6.0″ high water content, silty clay with a fine layer of silt on top, smooth, peanut butter like, organic material present throughout (fibrous roots)	2.5Y 4/2 dark grayish brown
					6.0–17.0″ high to moderate water content, water content decreases with depth, silty clay, smooth, peanut butter like, density increases with depth, uniform consistency and texture, mottled coloration	2.5Y 3/1 very dark gray 2.5 Y 3/2 dark grayish brown
					17.0–36.0″ moderate water content, silty clay, smooth, sticky, peanut butter like, organic material present (sticks and twigs)	2.5Y 3/1 very dark gray
					36.0–44.0″ moderate water content, silty clay, smooth, uniform consistency and texture, density increases with depth	2.5Y 3/1 very dark gray
				pre-impoundment	44.0–47.0″ low water content, clay with loose bits of clay at top, malleable, dense, easily fractures	2.5Y 3/1 very dark gray
WACO-3	3257427.96	10528653.48	30.0 / 25.0	post-impoundment	0.0–1.0″ very high water content, silt, soupy, smooth	2.5Y 4/3 olive brown
					1.0–2.0″ high water content, silty clay, smooth, pudding like, organics present (twig)	2.5Y 3/1 very dark gray
					2.0–7.0″ high water content, silty clay, smooth, pudding like, uniform consistency and texture, less dense than previous layer	2.5Y 2.5/1 black
					7.0–25.0″ moderate water content, silty clay, smooth, uniform texture, density increases with depth	2.5Y 3/1 very dark gray

a. Coordinates are based on NAD83 State Plane Texas Central System (feet).
b. Sediment core samples are measured in inches with zero representing the current bottom surface.

Table 2 (continued). Sediment core sample analysis data.

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample / post-impoundment sediment length (inches)	Sediment core description[b]		Munsell soil color
WACO-3 (continued)	3257427.96	10528653.48	30.0 / 25.0	pre-impoundment	25.0–30.0″ low water content, clay with medium to coarse sized clay bits at top, malleable but easily crumbles, uniform consistency and texture,	2.5Y 4/1 dark gray
WACO-4	3260615.92	10531683.56	74.0 / 69.0	post-impoundment	0.0–15.0″ high water content, silty clay with a fine layer of silt on top, smooth, pudding like	2.5Y 2.5/1 black
					15.0–53.0″ high to moderate water content, water content decreases with depth, silty clay, uniform consistency and texture, density increases with depth, mottled coloration, organic material present throughout	2.5Y 2.5/1 black 2.5Y 3/1 very dark gray
					53.0–69.0″ moderate water content, silty clay, smooth, more dense than previous layer, density increases with depth	2.5Y 3/1 very dark gray
				pre-impoundment	69.0–74.0″ low water content, clay, malleable, easily crumbles	2.5Y 3/1 very dark gray
WACO-5	3266194.28	10539244.36	81.0 / 72.0	post-impoundment	0.0–1.0″ very high water content, fine silt, soupy	2.5Y 4/3 olive brown
					1.0–17.0″ high water content, silty clay, smooth, pudding like, uniform consistency and texture	5Y 2.5/1 black
					17.0–41.0″ high to moderate water content, water content decreases with depth, silty clay, smooth, sticky, peanut butter like, uniform consistency and texture, more dense than previous layer	2.5Y 3/1 very dark gray
					41.0–60.0″ moderate water content, silty clay with coarse to very coarse sized bits of clay at the bottom, uniform consistency and texture, more dense than previous layer	2.5Y 3/1 very dark gray
					60.0–72.0″ moderate to low water content, water content decreases with depth, silty clay with medium sized clay bits mixed throughout, malleable	2.5Y 3/1 very dark gray
				pre-impoundment	72.0–76.0″ low water content, clay, malleable but easily fractures, uniform consistency and texture, organic material present (fibrous roots)	2.5Y 2.5/1 black

a. Coordinates are based on NAD83 State Plane Texas Central System (feet).
b. Sediment core samples are measured in inches with zero representing the current bottom surface.

Table 2 (continued). Sediment core sample analysis data.

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample / post-impoundment sediment length (inches)	Sediment core description[b]		Munsell soil color
WACO-5 (continued)	3266194.28	10539244.36	81.0 / 72.0	pre-impoundment	76.0–81.0″ low water content, silty clay, uniform consistency and texture throughout, malleable	2.5Y 2.5/1 black
WACO-6	3261295.14	10544013.48	57.0 / 49.0	post-impoundment	0.0–1.0″ very high water content, fine silt, soupy	2.5Y 4/3 olive brown
					1.0–20.0″ high water content, silty clay, smooth, pudding like, uniform consistency and texture	2.5Y 2.5/1 black
					20.0–49.0″ high to moderate water content, water content decreases with depth, silty clay, smooth, peanut butter like, uniform texture, density increases with depth	2.5Y 3/1 very dark gray
				pre-impoundment	49.0–57.0″ low water content, clay with clay bits throughout, malleable, easily crumbles, density increases with depth, organic material present throughout (fibrous roots and terrestrial vegetation)	2.5Y 2.5/1 black
WACO-7	3270549.95	10548782.44	120.0 / 91.0	post-impoundment	0.0–34.0″ high water content, silty clay, smooth, pudding like, uniform consistency and texture	2.5Y 2.5/1 black
					34.0–73.0″ high to moderate water content, water content decreases with depth, silty clay, peanut butter like, density increases with depth	2.5Y 3/1 very dark gray
					73.0–91.0″ moderate water content, silty clay, not as sticky as previous layer, uniform consistency and texture throughout, malleable	2.5Y 3/1 very dark gray
				pre-impoundment	91.0–120.0″ moderate water content, silty clay, more dense than previous layer	2.5Y 3/1 very dark gray
WACO-8	3271604.27	10550494.09	122.0 / 122.0	post-impoundment	0.0–2.0″ very high water content, fine silt, soupy, smooth	2.5Y 3/4 olive brown
					2.0–17.0″ high water content, silty clay, smooth, pudding like, uniform consistency and texture throughout	2.5Y 3/1 very dark gray
					17.0–26.0″ high water content, silty clay, smooth, pudding like, uniform consistency and texture throughout, density increases with depth	2.5Y 4/1 dark gray

a. Coordinates are based on NAD83 State Plane Texas Central System (feet).

b. Sediment core samples are measured in inches with zero representing the current bottom surface.

Table 2 (continued). Sediment core sample analysis data.

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample / post-impoundment sediment length (inches)	Sediment core description[b]		Munsell soil color
WACO-8 (continued)	3271604.27	10550494.09	122.0 / 122.0	post-impoundment	26.0–72.0″ high to moderate water content, water content decreases with depth, silty clay, sticky, peanut butter like, uniform consistency and texture	2.5Y 4/1 dark gray with bands of black (2.5Y 2.5/1) at 27 and 29 inches
					72.0–122.0″ moderate water content, silty clay, uniform consistency and texture throughout, more dense than previous layer	2.5Y 4/1 dark gray
WACO-9	3268806.57	10554356.28	Grab[c]	post-impoundment	high water content, small amount of sandy silt with medium to very coarse size pebbles	N/A
WACO-11	3262184.45	10553563.42	41.0 / 34.0	post-impoundment	0.0–1.0″ very high water content, fine silt, soupy	2.5Y 4/3 olive brown
					1.0–12.0″ high water content, silty clay, smooth, pudding like, uniform consistency and texture throughout	2.5Y 2.5/1 black
					12.0–34.0″ high to moderate water content, water content decreases with depth, silty clay, sticky, peanut butter like, more dense than previous layer	2.5Y 3/1 very dark gray
				pre-impoundment	34.0–39.0″ low water content, sandy clay with high concentrations of sand at the top of the layer, loosely packed, small pebbles throughout	2.5Y 2.5/1 black
					39.0–41.0″ low water content, fine to very coarse pebbles throughout	2.5Y 2.5/1 black
WACO-12	3261103.95	10554445.35	17.0 / 8.0	post-impoundment	0.0–2.0″ very high water content, silt, soupy, smooth	2.5Y 4/2 dark grayish brown
					2.0–8.0″ high water content, silty clay, smooth, pudding like, uniform consistency and texture throughout	2.5Y 3/1 very dark gray
				pre-impoundment	8.0–17.0″ low water content, malleable, crumbles	2.5Y 2.5/1 black
WACO-13	3263196.54	10556950.34	25.0 / 25.0	post-impoundment	0.0–1.0″ high water content, fine silt, soupy	2.5Y 4/3 olive brown

a. Coordinates are based on NAD83 State Plane Texas Central System (feet).

b. Sediment core samples are measured in inches with zero representing the current bottom surface.

c. Grab samples were collected using a petite Ponar dredge sampler.

Table 2 (continued). Sediment core sample analysis data.

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample / post-impoundment sediment length (inches)	Sediment core description[b]		Munsell soil color
WACO-13 (continued)	3263196.54	10556950.34	25.0 / 25.0	post-impoundment	1.0–13.0″ high water content, silty clay, soupy, smooth	2.5Y 2.5/1 black
					13.0–25.0″ moderate water content, silty clay, smooth, peanut butter like, more dense than previous layer	2.5Y 3/1 very dark gray
WACO-14	3260101.99	10556189.47	115.0 / 96.0	post-impoundment	0.0–5.0″ very high water content, fine silt, soupy, smooth, uniform consistency and texture	2.5Y 4/3 olive brown
					5.0–57.0″ high to moderate water content, water content decreases with depth, silty clay, smooth, peanut butter like, uniform consistency and texture throughout, organic material present at 57 inches	2.5Y 3/1 very dark gray
					57.0–90.0″ moderate to water content, water content decreases with depth, silty clay, malleable, organic material present (fibrous roots)	2.5Y 3/1 very dark gray
					90.0–96.0″ moderate water content, clay sand, malleable	2.5Y 4/1 gray
				pre-impoundment	96.0–112.5″ moderate to low water content, water content decreases with depth, clay, malleable, organic material present (fibrous roots)	2.5Y 3/1 very dark gray
					112.5–113.0″ low water content, coarse grain sand	2.5Y 4/1 gray
					113–115.0″ low water content, clay, malleable, organic material present (fibrous roots, leaf litter)	2.5Y 3/1 very dark gray
WACO-15	3257099.10	10555402.57	16.5 / 16.5	post-impoundment	0.0–15.0″ very high to high water content, water content decreases with depth, silty clay with a fine layer of silt on top, smooth, pudding like, uniform consistency and texture	2.5Y 3/1 very dark gray
					15.0–16.0″ high water content, medium size pebbles and a cobble	2.5Y 3/1 very dark gray
					16.0–16.5″ high water content, fine size pebbles	2.5Y 3/1 very dark gray

a. Coordinates are based on NAD83 State Plane Texas Central System (feet).

b. Sediment core samples are measured in inches with zero representing the current bottom surface.

Table 2 (continued). Sediment core sample analysis data.

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample / post-impoundment sediment length (inches)	Sediment core description[b]		Munsell soil color
WACO-16	3254801.71	10557989.65	12.0 / 12.0	post-impoundment	0.0–1.0″ very high water content, fine silt, soupy, smooth, uniform consistency and texture	2.5Y 3/3 dark olive brown
					1.0–12.0″ high water content, silty clay, medium size bits of clay at the bottom, organic material present (bark)	2.5Y 3/1 very dark gray
WACO-17	3252279.25	10557826.02	Grab[c]	post-impoundment	high water content, sandy clay with a layer of fine silt on top, organic material present (charcoal, bark, and small woody debris)	5Y 4/2 olive gray
WACO-18	3252350.03	10555561.50	Grab[c]	post-impoundment	high water content, silty clay with a layer of fine silt on top, smooth, pudding like, organic material present (fibrous roots, leaf litter)	5Y 4/2 olive gray
WACO-19	3249940.88	10556355.29	108.0 / 89.0	post-impoundment	0.0–25.0″ very high to moderate water content, water content decreases with depth, silty clay with a layer of fine silt on top, smooth, peanut butter like, organic material present at 17 inches (small woody debris)	2.5Y 3/2 very dark grayish brown
					25.0–32.0″ moderate water content, sandy clay, organic material present throughout (fibrous and dendritic roots, small woody debris, leaf litter)	2.5Y 3/1 very dark gray
					32.0–85.0″ moderate to low water content, water content decreases with depth, silty clay, sticky, uniform consistency and texture throughout, malleable, density increases with depth, organic material present between 63-65 inches (fibrous roots)	2.5Y 3/1 very dark gray
					85.0–89.0″ low water content, sand, dense, uniform consistency and texture	2.5Y 4/2 dark grayish brown
				pre-impoundment	89.0–108.0″ low water content, clay, malleable, dense, organic material present (leaf litter)	2.5Y 3/2 very dark grayish brown
WACO-20	3249462.26	10557909.98	72.0 / 69.0	post-impoundment	0.0–3.0″ very high water content, fine silt, soupy, smooth, uniform consistency and texture	2.5Y 4/3 olive brown
					3.0–18.0″ low water content, fine grain sand, dense, uniform consistency and texture	2.5Y 5/2 grayish brown

a. Coordinates are based on NAD83 State Plane Texas Central System (feet).

b. Sediment core samples are measured in inches with zero representing the current bottom surface.

c. Grab samples were collected using a petite Ponar dredge sampler.

Table 2 (continued). Sediment core sample analysis data.

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample / post-impoundment sediment length (inches)	Sediment core description[b]		Munsell soil color
WACO-20 (continued)	3249462.26	10557909.98	72.0 / 69.0	post-impoundment	18.0–67.0″ low water content, silty clay, fudge like consistency, organic material present (fibrous roots)	2.5Y 3/1 very dark gray
					67.0–69.0″ low water content, band of organic material present (leaf litter)	2.5Y 2.5/1 black
				pre-impoundment	69.0–72.0″ low water content, clay, malleable	2.5Y 3/1 very dark gray
WACO-21	3248660.43	10560951.06	28.0 / 28.0	post-impoundment	0.0–4.0″ high water content, silty clay with a layer of fine silt on top, smooth, uniform consistency and texture	2.5Y 4/2 dark grayish brown
					4.0–6.0″ moderate water content, fine sand	2.5Y4/4 olive brown
					6.0–28.0″ moderate water content, silty clay, smooth, uniform consistency and texture	2.5Y 3/1 very dark gray
WACO-22	3245137.58	10558189.94	41.0 / 41.0	post-impoundment	0.0–1.0″ very high water content, silt, soupy, smooth	2.5Y 4/2 dark grayish brown
					1.0–19.0″ high water content, silty clay, smooth, pudding like, uniform consistency and texture	2.5Y 4/2 dark grayish brown
					19.0–35.0″ moderate water content, silty clay, peanut butter like, organic material present from 19-26 inches (fibrous roots)	2.5Y 3/1 very dark gray
				pre-impoundment	35.0–41.0″ moderate water content, silty clay, sticky, peanut butter like, mottled coloration, organic material present (fibrous roots, terrestrial vegetation)	2.5Y 4/2 dark grayish brown 2.5Y 2.5/1 black
WACO-ALT 1	3259367.40	10553148.92	4.0 / 1.0	post-impoundment	0.0–1.0″ very high water content, fine silt	2.5Y 4/3 olive brown
				pre-impoundment	1.0–4.0″ low water content, clay, malleable, playdough like, dense	2.5Y 2.5/1 black

a. Coordinates are based on NAD83 State Plane Texas Central System (feet).

b. Sediment core samples are measured in inches with zero representing the current bottom surface.

Table 2 (continued). Sediment core sample analysis data.

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample / post-impoundment sediment length (inches)	Sediment core description[b]		Munsell soil color
WACO-ALT 2	3263222.91	10535776.55	103.0 / 100.0	post-impoundment	0.0–2.0″ very high water content, fine silt	2.5Y 3/2 brown
					2.0–100.0″ high to moderate water content, water content decreases with depth, silty clay, uniform consistency and texture, density increases with depth	2.5Y 3/1 very dark gray
				pre-impoundment	100.0–103.0″ high to moderate water content, clay with bits of clay present, medium to very coarse pebbles throughout	2.5Y 3/1 very dark gray

a. Coordinates are based on NAD83 State Plane Texas Central System (feet).

b. Sediment core samples are measured in inches with zero representing the current bottom surface.

Several criteria determine sediment core locations. Locations are dispersed throughout the reservoir, are selected to represent the various acoustic signatures seen in the data and are chosen to represent various depths and topographical features such as the submerged river channels, floodplains, shallow slopes, and deep basins. The pre-impoundment surface is identified by matching each sediment core with the acoustic signal returns. This information then serves as a guide for identifying the pre-impoundment surface along cross-sections where sediment core samples were not collected.

A photograph of sediment core WACO-11 (for location, refer to Figure 2) is shown in Figure 7. The base, or deepest part of the sample, is denoted by the blue line. The pre-impoundment boundary (yellow line closest to the base) was evident within this sediment core sample at 34 inches and identified by the change in color, texture, moisture, porosity, and structure. Identification of the pre-impoundment surface for each sediment core followed a similar procedure.

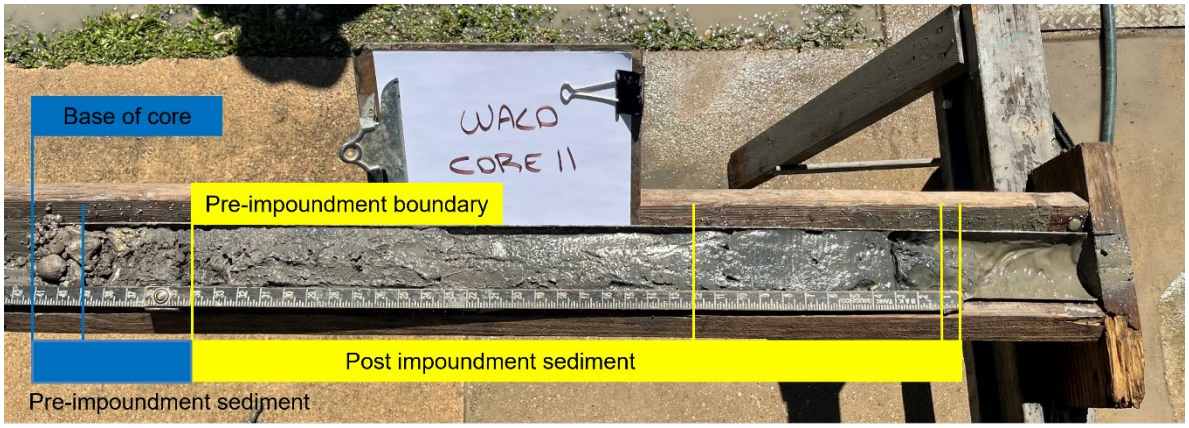


Figure 7. **Sediment core WACO-11. Post-impoundment sediment layers occur in the top 34 inches of this sediment core (identified by the yellow box). Pre-impoundment sediment layers were identified and are defined by the blue box.**

Figure 8 illustrates the relationships between acoustic signal returns and the depositional layering seen in sediment cores. In this example, sediment core WACO-11 is shown correlated with each frequency: 200 kHz, 50 kHz, and 12 kHz. The current bathymetric surface is determined based on signal returns from the 200 kHz transducer as represented by the top red line in Figure 8. The pre-impoundment surface is identified by comparing boundaries observed in the 200 kHz, 50 kHz, and 12 kHz signals to the location of the pre-impoundment surface of the sediment core sample. Many layers of sediment may be identified during analysis based on changes in observed characteristics such as water content, organic matter content, and sediment particle size, and each layer is classified as

either post-impoundment or pre-impoundment. Yellow boxes represent post-impoundment sediments identified in the sediment core. Blue boxes indicate pre-impoundment sediments. In this example, the pre-impoundment boundary in sediment core WACO-11 most closely aligned with the different layers picked up by the 50 kHz acoustic returns (Figure 8 B).

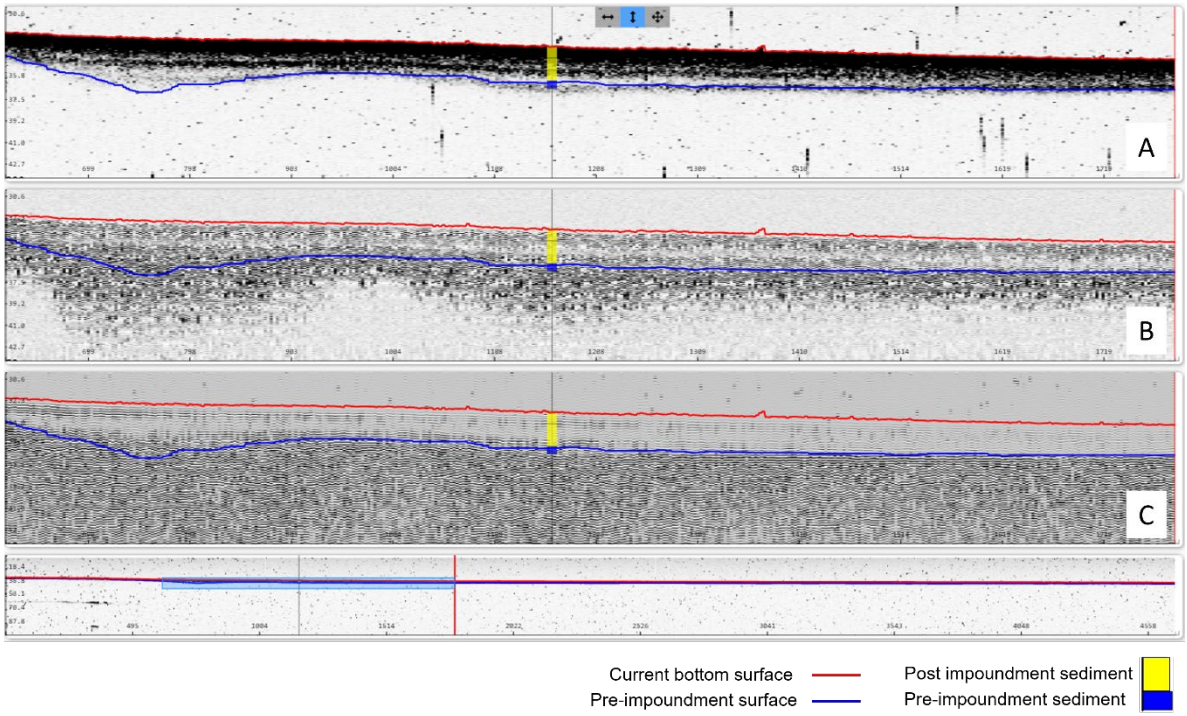


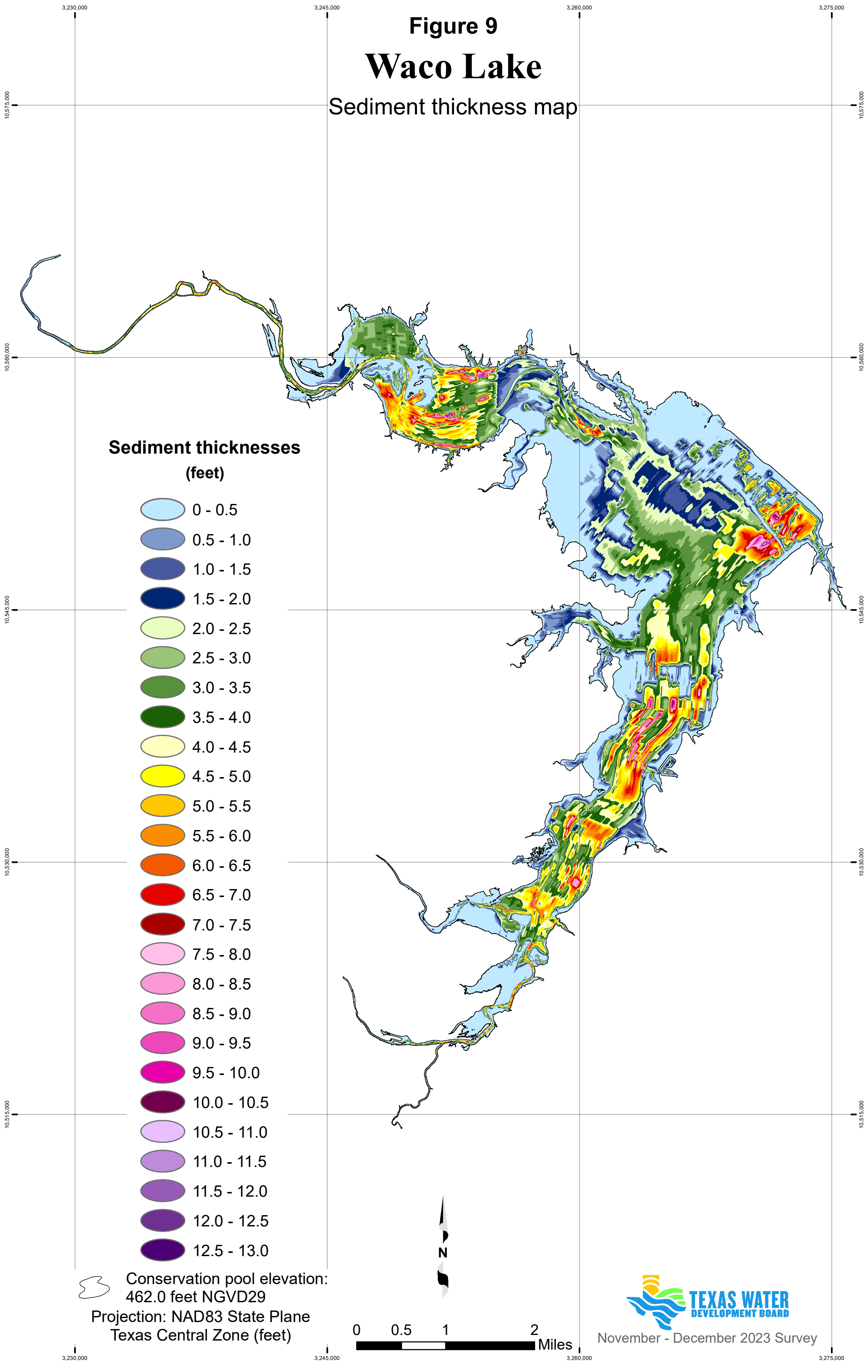
Figure 8. **Sediment core sample WACO-11 compared with acoustic signal returns: A) 200 kHz frequency, B) 50 kHz frequency, and C) 12 kHz frequency.**

After the pre-impoundment surface for all cross-sections is identified, a pre-impoundment TIN model and a sediment thickness TIN model are created. Pre-impoundment elevations and sediment thicknesses are interpolated between surveyed cross-sections using HydroTools with the same interpolation definition file used for bathymetric interpolation. For the purposes of TIN model creation, the TWDB assumed the sediment thickness for each LIDAR point and the reservoir boundary was zero feet (defined as the 462.0-foot elevation contour). The sediment thickness TIN model was converted to a raster representation using a cell size of 2 feet by 2 feet and was used to produce a sediment thickness map (Figure 9). Elevation-capacity and elevation-area tables were computed from the pre-impoundment TIN model for the purpose of calculating the total volume of accumulated sediment.

Figure 9

Waco Lake

Sediment thickness map



Survey results

Volumetric survey

The 2023 TWDB volumetric survey indicates Waco Lake has a total reservoir capacity of 189,116 acre-feet and encompasses 8,434 acres at conservation pool elevation (462.0 feet NGVD29). Current area and capacity estimates are presented along with previous estimates of area and capacity at conservation pool elevation in Table 3. Because differences in reservoir conditions as well as differences in the methodologies used among surveys can affect area and volume calculations, the TWDB does not recommend comparing between volumetric surveys to determine loss of area or capacity. Information from past surveys is thus presented for informational purposes only.

Table 3. Current and previous survey capacity and surface area estimates.

Survey	Surface Area (acres)	Total Capacity (acre-feet)	Conservation Pool Elevation[a]	Source
Original Design[b]	8,639	209,214	462.0	U.S. Army Corps of Engineers, 1975
U.S. Army Corps of Engineers 1970	8,436	203,586	462.0	U.S. Army Corps of Engineers, 1975
TWDB 2011	8,190	189,773	462.0	Texas Water Development Board, 2012
TWDB 2023	8,434	189,116	462.0	

a. Feet above mean sea level, National Geodetic Vertical Datum 1929 (NGVD29).
b. Area and capacity values calculated by linearly interpolating between values presented in Reservoir Data table at elevations 455.0 and 465.0 feet (U.S. Army Corps of Engineers, 1975).

Sedimentation survey

The 2023 TWDB sedimentation survey measured 19,340 acre-feet of sediment. The sedimentation survey indicates sediment accumulation is greater in the South Bosque River branch of the reservoir than in the North Bosque River branch. Sediment accumulation is also greater near the dam on the South Bosque River side of the reservoir.

Waco Lake is prone to periods of high inflow as well as periods of drought as seen in the water surface elevation records (Texas Water Development Board, 2023). The fluctuation in water levels makes it difficult to identify the pre-impoundment layer in the acoustic returns and can lead to an under or overestimate of sediment in these areas. Low water levels lead to the desiccation of any exposed sediment. For example, prior to this survey the reservoir levels began falling below conservation pool elevation in September of 2021, reaching a low daily average of 450.11 feet NGVD29 on October 23, 2023, before

returning to near full in less than a week (Texas Water Development Board, 2024). Upon inundation and re-saturation, exposed sediment will not return to its original high level of water content (Dunbar and Allen, 2003). Drying of sediment in exposed areas create hard surfaces that cannot be penetrated with gravity coring techniques, and compressive stresses on the sediments may also increase sediment density, inhibiting the measurement of the original, pre-impoundment surface. Density stratification in the sediment layers can also scatter and attenuate acoustic return signals of the multi-frequency depth sounder (U.S. Army Corps of Engineers, 2013). This is evident in the acoustic returns near sediment core sites 17, 19, and 20, where layers of sand or sandy soil were identified.

Comparison of capacity estimates of Waco Lake derived using differing methodologies are provided in Table 4 for sedimentation rate calculation. The 2023 TWDB sedimentation survey indicates Waco Lake has lost capacity at an average of 333 acre-feet per year since impoundment due to sedimentation below conservation pool elevation (462.0 feet NGVD29). Any changes to the hydrologic system that contributes runoff to the reservoir, including changes in vegetative cover, land use, or frequency and intensity of rainfall events, can impact the local rate of sedimentation. Because methodological and technological changes from one survey to the next yield inconsistencies in estimates of capacity loss rates, long term capacity calculations, computed by plotting all capacity estimates and calculating a linear regression line, reduces the effect of individual survey error. As illustrated in Figure 10, long-term trends indicate Waco Lake loses capacity at an average of 335 acre-feet per year since impoundment due to sedimentation below conservation pool elevation (462.0 feet NGVD29).

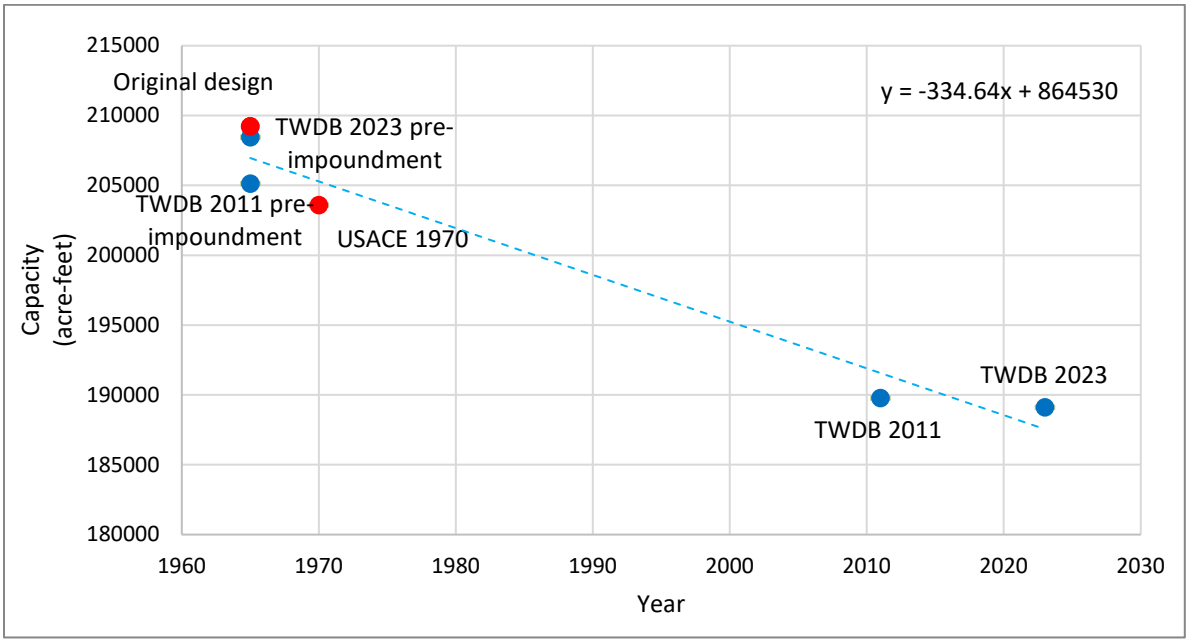


Figure 10. **Plot of current and previous capacity estimates (acre-feet). Capacity estimates for each TWDB survey plotted as blue dots and other surveys as red dots. The blue trend line illustrates the total average loss of capacity through 2023.**

Table 4. Average annual capacity loss comparisons.

Previous surveys	U.S. Army Corps of Engineers 1962	U.S. Army Corps of Engineers 1970	TWDB 2011	TWDB pre-impoundment estimate based on 2023 survey
Total capacity (acre-feet) at top of conservation pool elevation 462.0 feet NGVD29[a]	209,214	203,586	189,773	208,456
	versus 189,116 acre-feet (TWDB 2023)			
Volume difference (acre-feet)	20,098	14,470	657	19,340
Percent change	9.6	7.1	0.3	9.3
Number of years[b]	58	53	12	58
Capacity loss rate (acre-feet/year)	347	273	55	333
Capacity loss rate (acre-feet/square mile of drainage area of 1,670 square miles/year	0.21	0.16	0.03	0.20

a. Feet above mean sea level, National Geodetic Vertical Datum 1929 (NGVD29).

b. Note: Waco Dam was completed on June 24, 1965, and deliberate impoundment began on February 26, 1965.

Recommendations

Sedimentation processes tend to be slow, with changes accumulating over the time frame of years—unless in the event of a major flood, for example. For these reasons, we recommend reservoir sedimentation surveys be conducted every 10 years or after a major event. Closely monitoring changes in the reservoir provides information needed to plan for a secure water supply for the future.

TWDB contact information

For more information about the TWDB Hydrographic Survey Program, visit www.twdb.texas.gov/surfacewater/surveys. Any questions regarding the TWDB Hydrographic Survey Program or this report may be addressed to: Hydrosurvey@twdb.texas.gov.

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Appendix A

Waco Lake

RESERVOIR BATHYMETRIC CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — December 2023 Survey

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 462.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION (Feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
376	0	0	0	0	0	0	0	0	0	0
377	0	0	0	0	0	0	0	0	0	0
378	0	0	0	0	0	0	0	0	0	0
379	0	0	0	0	0	0	0	0	0	0
380	0	0	0	0	0	0	0	0	0	0
381	0	0	0	0	0	0	0	1	1	1
382	1	1	1	1	1	1	1	1	1	1
383	1	1	1	1	1	1	1	1	2	2
384	2	2	2	2	2	2	2	2	2	2
385	3	3	3	3	3	3	3	3	3	3
386	4	4	4	4	4	4	4	4	4	4
387	5	5	5	5	5	5	5	5	6	6
388	6	6	6	6	6	7	7	7	7	7
389	7	8	8	8	8	9	9	10	10	10
390	11	11	12	12	13	14	14	15	16	16
391	17	18	19	20	21	22	23	24	26	27
392	28	29	31	32	34	35	37	38	40	41
393	43	44	46	48	49	51	53	54	56	58
394	60	61	63	65	67	69	71	73	75	77
395	79	82	84	86	89	91	94	96	99	101
396	104	106	109	112	114	117	120	123	125	128
397	131	134	137	140	143	146	148	151	154	157
398	161	164	167	170	173	176	179	182	186	189
399	192	195	199	202	205	209	212	215	219	222
400	226	229	232	236	239	243	247	250	254	257
401	261	265	268	272	276	279	283	287	290	294
402	298	302	306	310	313	317	321	325	329	333
403	337	341	345	349	353	357	361	366	370	374
404	378	382	387	391	395	399	404	408	413	417
405	421	426	430	435	439	444	449	453	458	463
406	467	472	477	482	487	492	497	502	507	512
407	517	522	528	533	538	544	549	555	560	566
408	572	578	584	590	596	602	609	616	623	630
409	638	645	653	661	669	677	686	694	703	712
410	721	730	740	750	760	770	781	792	803	815
411	826	838	850	862	874	886	898	911	923	936
412	949	962	975	988	1,001	1,014	1,028	1,041	1,055	1,069
413	1,083	1,096	1,110	1,124	1,139	1,153	1,167	1,181	1,196	1,210
414	1,225	1,240	1,255	1,269	1,284	1,299	1,314	1,329	1,345	1,360
415	1,376	1,391	1,407	1,422	1,438	1,454	1,470	1,487	1,503	1,519
416	1,536	1,553	1,570	1,587	1,604	1,621	1,639	1,657	1,674	1,692
417	1,710	1,728	1,746	1,765	1,783	1,801	1,820	1,839	1,857	1,876
418	1,895	1,914	1,933	1,953	1,972	1,992	2,012	2,032	2,052	2,072
419	2,093	2,113	2,134	2,155	2,177	2,198	2,220	2,242	2,264	2,287
420	2,309	2,333	2,356	2,380	2,404	2,428	2,453	2,478	2,504	2,530
421	2,557	2,584	2,612	2,641	2,670	2,701	2,732	2,765	2,798	2,833
422	2,868	2,905	2,944	2,984	3,026	3,071	3,118	3,167	3,218	3,272
423	3,328	3,387	3,450	3,516	3,587	3,660	3,737	3,818	3,903	3,992
424	4,085	4,182	4,284	4,390	4,500	4,615	4,734	4,857	4,984	5,114
425	5,248	5,385	5,526	5,669	5,815	5,965	6,119	6,277	6,438	6,603
426	6,773	6,945	7,121	7,301	7,485	7,673	7,863	8,057	8,252	8,449
427	8,649	8,849	9,052	9,256	9,462	9,669	9,878	10,088	10,300	10,513
428	10,728	10,943	11,161	11,380	11,601	11,823	12,047	12,272	12,498	12,726
429	12,954	13,185	13,416	13,649	13,884	14,120	14,358	14,598	14,840	15,083
430	15,329	15,577	15,827	16,080	16,335	16,593	16,854	17,119	17,387	17,659

Appendix A (Continued)

Waco Lake

RESERVOIR BATHYMETRIC CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — December 2023 Survey

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 462.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION (Feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
431	17,933	18,210	18,490	18,772	19,058	19,346	19,636	19,930	20,227	20,526
432	20,827	21,131	21,438	21,748	22,061	22,376	22,693	23,012	23,334	23,657
433	23,983	24,311	24,641	24,973	25,307	25,643	25,981	26,321	26,662	27,006
434	27,352	27,699	28,048	28,399	28,753	29,107	29,464	29,823	30,183	30,545
435	30,908	31,273	31,640	32,008	32,378	32,749	33,122	33,497	33,873	34,250
436	34,629	35,010	35,392	35,776	36,162	36,549	36,937	37,327	37,719	38,112
437	38,506	38,901	39,298	39,697	40,097	40,498	40,901	41,305	41,711	42,118
438	42,527	42,937	43,349	43,763	44,178	44,594	45,012	45,431	45,852	46,274
439	46,697	47,122	47,548	47,976	48,405	48,836	49,268	49,701	50,135	50,571
440	51,008	51,447	51,887	52,328	52,772	53,217	53,663	54,112	54,562	55,013
441	55,467	55,923	56,380	56,839	57,299	57,761	58,225	58,690	59,157	59,626
442	60,096	60,568	61,042	61,517	61,994	62,472	62,953	63,435	63,918	64,403
443	64,890	65,379	65,869	66,362	66,856	67,352	67,849	68,349	68,850	69,353
444	69,858	70,364	70,872	71,381	71,892	72,405	72,919	73,434	73,951	74,469
445	74,989	75,510	76,033	76,556	77,082	77,608	78,137	78,666	79,198	79,730
446	80,264	80,799	81,335	81,873	82,412	82,953	83,494	84,037	84,582	85,127
447	85,675	86,223	86,773	87,324	87,878	88,432	88,989	89,547	90,107	90,668
448	91,231	91,796	92,362	92,930	93,500	94,071	94,643	95,217	95,793	96,371
449	96,950	97,531	98,113	98,698	99,284	99,872	100,462	101,055	101,649	102,245
450	102,843	103,442	104,044	104,648	105,253	105,860	106,470	107,081	107,694	108,309
451	108,926	109,545	110,166	110,789	111,414	112,042	112,672	113,304	113,937	114,573
452	115,210	115,850	116,491	117,135	117,780	118,427	119,076	119,728	120,381	121,036
453	121,693	122,351	123,012	123,674	124,339	125,004	125,672	126,341	127,012	127,685
454	128,360	129,036	129,713	130,393	131,074	131,756	132,440	133,126	133,813	134,503
455	135,194	135,887	136,581	137,277	137,975	138,674	139,375	140,078	140,782	141,489
456	142,197	142,906	143,618	144,332	145,048	145,766	146,487	147,210	147,937	148,667
457	149,400	150,135	150,873	151,613	152,356	153,101	153,850	154,601	155,355	156,112
458	156,871	157,633	158,397	159,164	159,933	160,704	161,479	162,256	163,037	163,819
459	164,605	165,392	166,182	166,974	167,769	168,566	169,365	170,166	170,969	171,774
460	172,582	173,392	174,203	175,017	175,833	176,650	177,469	178,291	179,114	179,938
461	180,764	181,592	182,421	183,252	184,085	184,919	185,755	186,593	187,432	188,274
462	189,116									

Appendix B

Waco Lake

RESERVOIR BATHYMETRIC AREA TABLE

TEXAS WATER DEVELOPMENT BOARD — December 2023 Survey

AREA IN ACRES — Conservation Pool Elevation 462.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION (Feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
376	0	0	0	0	0	0	0	0	0	0
377	0	0	0	0	0	0	0	0	0	0
378	0	0	0	0	0	0	0	0	0	0
379	0	0	0	0	0	0	0	0	0	0
380	0	0	0	0	0	0	0	0	0	0
381	0	0	0	0	0	0	0	0	0	0
382	0	0	0	0	0	0	0	0	1	1
383	1	1	1	1	1	1	1	1	1	1
384	1	1	1	1	1	1	1	1	1	1
385	1	1	1	1	1	1	1	1	1	1
386	1	1	1	1	1	1	1	1	1	1
387	1	1	1	1	1	1	1	1	1	1
388	1	1	1	1	1	1	2	2	2	2
389	2	2	3	3	3	4	4	4	4	5
390	5	5	5	5	6	6	7	7	8	8
391	9	9	10	10	11	11	11	12	12	12
392	13	13	14	14	14	15	15	15	15	16
393	16	16	16	17	17	17	17	17	18	18
394	18	18	18	19	19	19	20	21	21	22
395	22	23	23	24	24	25	25	25	25	26
396	26	26	27	27	27	27	28	28	28	28
397	28	29	29	29	29	30	30	30	30	30
398	31	31	31	31	31	31	32	32	32	32
399	32	33	33	33	33	34	34	34	34	34
400	34	35	35	35	35	35	36	36	36	36
401	36	36	37	37	37	37	37	38	38	38
402	38	38	38	39	39	39	39	39	40	40
403	40	40	40	41	41	41	41	41	42	42
404	42	42	43	43	43	43	43	44	44	44
405	45	45	45	45	46	46	46	47	47	47
406	48	48	49	49	49	50	50	50	51	51
407	52	52	53	53	54	54	55	56	56	57
408	58	59	60	62	64	66	68	70	72	74
409	75	77	78	80	81	82	84	85	88	90
410	93	95	98	100	103	106	108	111	113	115
411	116	118	119	120	121	122	124	125	126	127
412	129	130	131	132	133	134	135	136	137	137
413	138	139	140	141	142	143	143	144	145	146
414	146	147	148	149	150	150	151	152	153	154
415	155	156	157	158	159	161	162	163	165	166
416	167	169	170	171	173	174	175	177	178	179
417	180	181	182	183	184	185	186	187	188	189
418	190	191	193	194	196	197	199	200	202	204
419	206	208	210	212	214	217	219	221	223	226
420	229	233	236	239	242	246	250	254	259	265
421	270	275	283	292	301	310	319	329	339	350
422	362	377	394	413	436	459	480	501	524	549
423	576	607	644	684	720	753	789	828	870	912
424	953	994	1,038	1,081	1,125	1,168	1,209	1,249	1,287	1,324
425	1,356	1,386	1,417	1,449	1,483	1,519	1,557	1,593	1,631	1,674
426	1,711	1,745	1,778	1,817	1,859	1,894	1,921	1,944	1,964	1,983
427	2,000	2,017	2,034	2,049	2,065	2,080	2,095	2,110	2,124	2,138
428	2,153	2,167	2,183	2,200	2,215	2,229	2,243	2,256	2,269	2,282
429	2,296	2,310	2,324	2,338	2,353	2,369	2,390	2,409	2,426	2,448
430	2,468	2,489	2,512	2,537	2,565	2,598	2,629	2,667	2,698	2,728

Appendix B (Continued)

Waco Lake

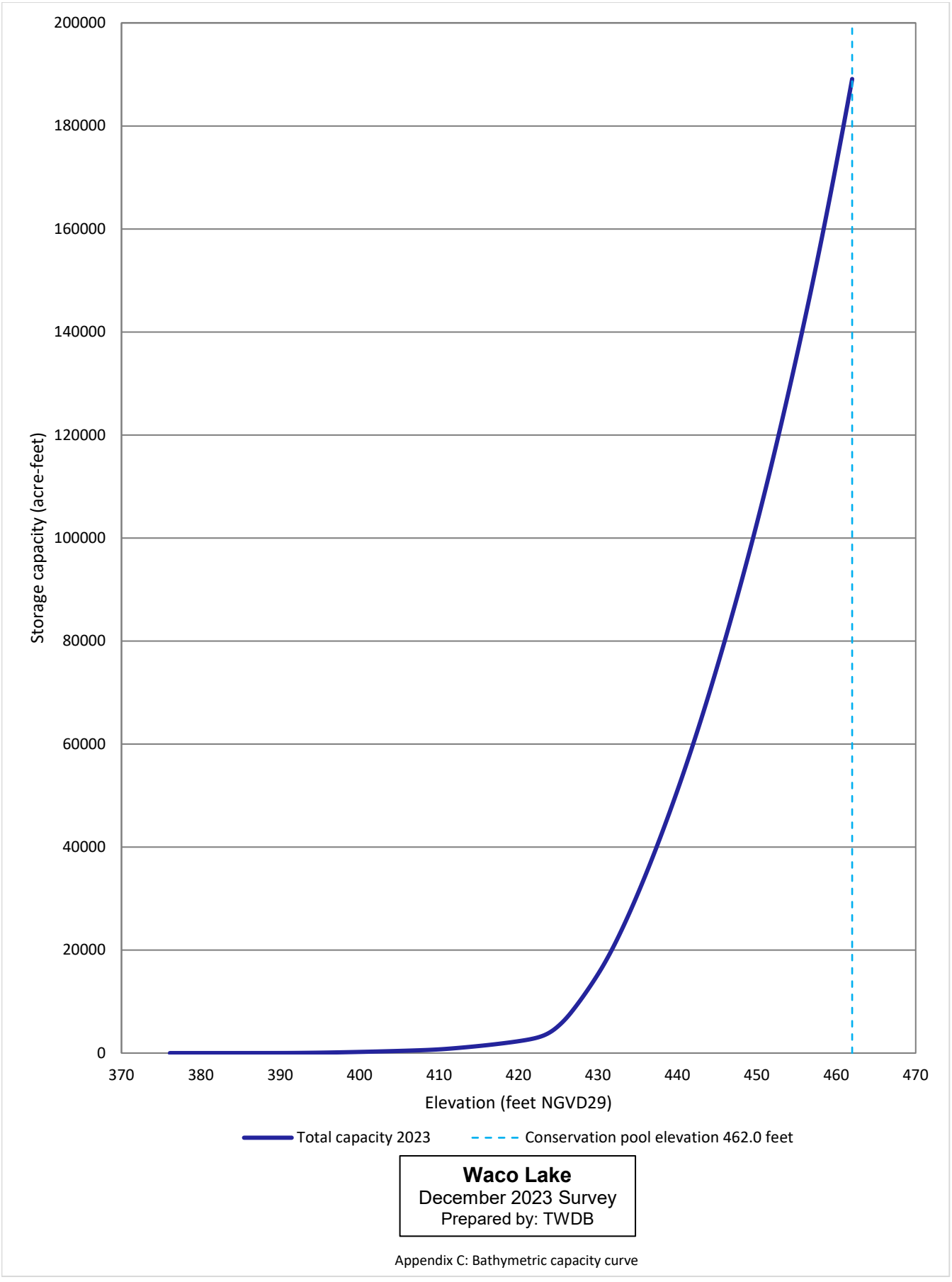
RESERVOIR BATHYMETRIC AREA TABLE

TEXAS WATER DEVELOPMENT BOARD — December 2023 Survey

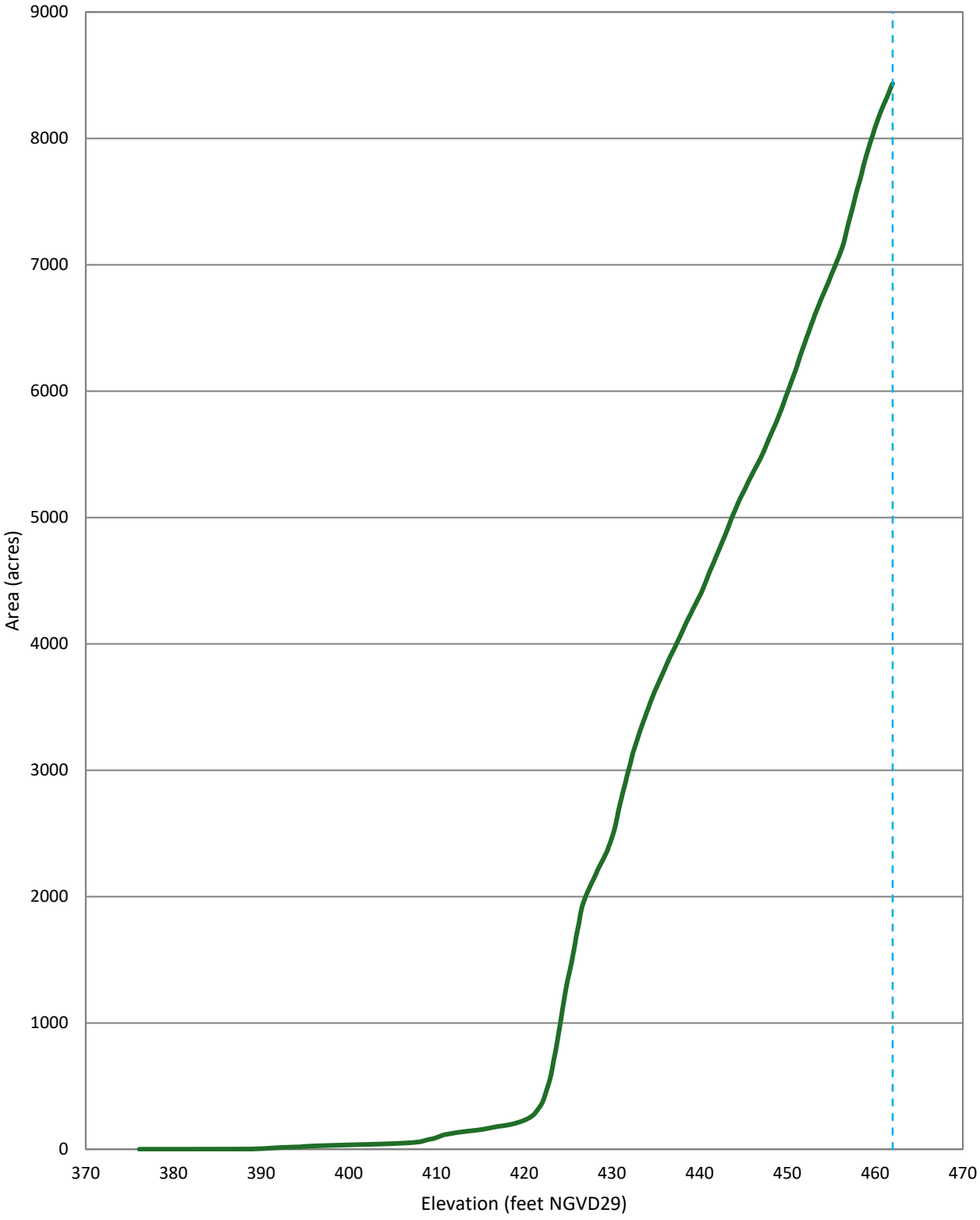
AREA IN ACRES — Conservation Pool Elevation 462.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION (Feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
431	2,756	2,784	2,813	2,840	2,867	2,894	2,922	2,951	2,978	3,003
432	3,029	3,055	3,083	3,113	3,140	3,161	3,182	3,204	3,225	3,246
433	3,268	3,290	3,311	3,331	3,350	3,369	3,388	3,407	3,426	3,446
434	3,465	3,483	3,501	3,522	3,541	3,558	3,576	3,593	3,611	3,628
435	3,644	3,659	3,674	3,690	3,705	3,721	3,736	3,752	3,767	3,783
436	3,799	3,815	3,831	3,847	3,863	3,879	3,893	3,907	3,921	3,936
437	3,949	3,963	3,977	3,992	4,007	4,021	4,035	4,050	4,064	4,080
438	4,095	4,111	4,127	4,142	4,157	4,172	4,187	4,200	4,213	4,227
439	4,241	4,255	4,271	4,285	4,298	4,311	4,325	4,339	4,352	4,365
440	4,379	4,392	4,407	4,423	4,441	4,458	4,475	4,492	4,510	4,527
441	4,547	4,565	4,581	4,597	4,613	4,628	4,644	4,661	4,678	4,695
442	4,711	4,727	4,745	4,761	4,777	4,795	4,811	4,827	4,844	4,860
443	4,878	4,896	4,912	4,931	4,950	4,969	4,988	5,005	5,021	5,037
444	5,053	5,069	5,086	5,103	5,118	5,134	5,148	5,163	5,176	5,190
445	5,203	5,217	5,231	5,246	5,260	5,276	5,290	5,304	5,317	5,331
446	5,344	5,358	5,372	5,385	5,398	5,411	5,424	5,437	5,450	5,464
447	5,478	5,492	5,507	5,523	5,539	5,556	5,574	5,590	5,607	5,623
448	5,639	5,655	5,671	5,687	5,702	5,718	5,733	5,749	5,766	5,783
449	5,800	5,818	5,836	5,854	5,872	5,891	5,911	5,931	5,951	5,970
450	5,988	6,007	6,026	6,045	6,065	6,084	6,103	6,121	6,140	6,159
451	6,178	6,199	6,220	6,244	6,266	6,287	6,307	6,327	6,346	6,364
452	6,385	6,406	6,425	6,444	6,463	6,482	6,502	6,522	6,540	6,558
453	6,578	6,598	6,616	6,633	6,650	6,667	6,684	6,703	6,720	6,737
454	6,752	6,768	6,785	6,801	6,817	6,833	6,849	6,866	6,883	6,902
455	6,919	6,936	6,952	6,969	6,985	7,002	7,019	7,037	7,054	7,071
456	7,090	7,108	7,126	7,146	7,169	7,195	7,223	7,253	7,283	7,312
457	7,339	7,365	7,391	7,416	7,442	7,469	7,497	7,527	7,555	7,581
458	7,606	7,629	7,653	7,678	7,704	7,730	7,762	7,789	7,815	7,840
459	7,864	7,888	7,911	7,934	7,956	7,978	8,000	8,021	8,042	8,067
460	8,087	8,107	8,127	8,146	8,165	8,184	8,203	8,221	8,238	8,254
461	8,270	8,286	8,301	8,317	8,334	8,351	8,368	8,386	8,404	8,419
462	8,434									



Appendix C: Bathymetric capacity curve



Waco Lake
December 2023 Survey
Prepared by: TWDB

Appendix D: Bathymetric area curve

Appendix E

Waco Lake

RESERVOIR BATHYMETRIC AND TOPOGRAPHIC CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — December 2023 Survey

CAPACITY IN ACRE-FEET — Conservation pool elevation 462.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT — Top of dam elevation 514.6 feet NGVD29

ELEVATION (Feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
376	0	0	0	0	0	0	0	0	0	0
377	0	0	0	0	0	0	0	0	0	0
378	0	0	0	0	0	0	0	0	0	0
379	0	0	0	0	0	0	0	0	0	0
380	0	0	0	0	0	0	0	0	0	0
381	0	0	0	0	0	0	0	1	1	1
382	1	1	1	1	1	1	1	1	1	1
383	1	1	1	1	1	1	1	1	2	2
384	2	2	2	2	2	2	2	2	2	2
385	3	3	3	3	3	3	3	3	3	3
386	4	4	4	4	4	4	4	4	4	4
387	5	5	5	5	5	5	5	5	6	6
388	6	6	6	6	6	7	7	7	7	7
389	7	8	8	8	8	9	9	10	10	10
390	11	11	12	12	13	14	14	15	16	16
391	17	18	19	20	21	22	23	24	26	27
392	28	29	31	32	34	35	37	38	40	41
393	43	44	46	48	49	51	53	54	56	58
394	60	61	63	65	67	69	71	73	75	77
395	79	82	84	86	89	91	94	96	99	101
396	104	106	109	112	114	117	120	123	125	128
397	131	134	137	140	143	146	148	151	154	157
398	161	164	167	170	173	176	179	182	186	189
399	192	195	199	202	205	209	212	215	219	222
400	226	229	232	236	239	243	247	250	254	257
401	261	265	268	272	276	279	283	287	290	294
402	298	302	306	310	313	317	321	325	329	333
403	337	341	345	349	353	357	361	366	370	374
404	378	382	387	391	395	399	404	408	413	417
405	421	426	430	435	439	444	449	453	458	463
406	467	472	477	482	487	492	497	502	507	512
407	517	522	528	533	538	544	549	555	560	566
408	572	578	584	590	596	602	609	616	623	630
409	638	645	653	661	669	677	686	694	703	712
410	721	730	740	750	760	770	781	792	803	815
411	826	838	850	862	874	886	898	911	923	936
412	949	962	975	988	1,001	1,014	1,028	1,041	1,055	1,069
413	1,083	1,096	1,110	1,124	1,139	1,153	1,167	1,181	1,196	1,210
414	1,225	1,240	1,255	1,269	1,284	1,299	1,314	1,329	1,345	1,360
415	1,376	1,391	1,407	1,422	1,438	1,454	1,470	1,487	1,503	1,519
416	1,536	1,553	1,570	1,587	1,604	1,621	1,639	1,657	1,674	1,692
417	1,710	1,728	1,746	1,765	1,783	1,801	1,820	1,839	1,857	1,876
418	1,895	1,914	1,933	1,953	1,972	1,992	2,012	2,032	2,052	2,072
419	2,093	2,113	2,134	2,155	2,177	2,198	2,220	2,242	2,264	2,287
420	2,309	2,333	2,356	2,380	2,404	2,428	2,453	2,478	2,504	2,530
421	2,557	2,584	2,612	2,641	2,670	2,701	2,732	2,765	2,798	2,833
422	2,868	2,905	2,944	2,984	3,026	3,071	3,118	3,167	3,218	3,272
423	3,328	3,387	3,450	3,516	3,587	3,660	3,737	3,818	3,903	3,992
424	4,085	4,182	4,284	4,390	4,500	4,615	4,734	4,857	4,984	5,114
425	5,248	5,385	5,526	5,669	5,815	5,965	6,119	6,277	6,438	6,603
426	6,773	6,945	7,121	7,301	7,485	7,673	7,863	8,057	8,252	8,449
427	8,649	8,849	9,052	9,256	9,462	9,669	9,878	10,088	10,300	10,513
428	10,728	10,943	11,161	11,380	11,601	11,823	12,047	12,272	12,498	12,726
429	12,954	13,185	13,416	13,649	13,884	14,120	14,358	14,598	14,840	15,083
430	15,329	15,577	15,827	16,080	16,335	16,593	16,854	17,119	17,387	17,659

Appendix E (Continued)

Waco Lake

RESERVOIR BATHYMETRIC AND TOPOGRAPHIC CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — December 2023 Survey

CAPACITY IN ACRE-FEET — Conservation pool elevation 462.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT — Top of dam elevation 514.6 feet NGVD29

ELEVATION (Feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
431	17,933	18,210	18,490	18,772	19,058	19,346	19,636	19,930	20,227	20,526
432	20,827	21,131	21,438	21,748	22,061	22,376	22,693	23,012	23,334	23,657
433	23,983	24,311	24,641	24,973	25,307	25,643	25,981	26,321	26,662	27,006
434	27,352	27,699	28,048	28,399	28,753	29,107	29,464	29,823	30,183	30,545
435	30,908	31,273	31,640	32,008	32,378	32,749	33,122	33,497	33,873	34,250
436	34,629	35,010	35,392	35,776	36,162	36,549	36,937	37,327	37,719	38,112
437	38,506	38,901	39,298	39,697	40,097	40,498	40,901	41,305	41,711	42,118
438	42,527	42,937	43,349	43,763	44,178	44,594	45,012	45,431	45,852	46,274
439	46,697	47,122	47,548	47,976	48,405	48,836	49,268	49,701	50,135	50,571
440	51,008	51,447	51,887	52,328	52,772	53,217	53,663	54,112	54,562	55,013
441	55,467	55,923	56,380	56,839	57,299	57,761	58,225	58,690	59,157	59,626
442	60,096	60,568	61,042	61,517	61,994	62,472	62,953	63,435	63,918	64,403
443	64,890	65,379	65,869	66,362	66,856	67,352	67,849	68,349	68,850	69,353
444	69,858	70,364	70,872	71,381	71,892	72,405	72,919	73,434	73,951	74,469
445	74,989	75,510	76,033	76,556	77,082	77,608	78,137	78,666	79,198	79,730
446	80,264	80,799	81,335	81,873	82,412	82,953	83,494	84,037	84,582	85,127
447	85,675	86,223	86,773	87,324	87,878	88,432	88,989	89,547	90,107	90,668
448	91,231	91,796	92,362	92,930	93,500	94,071	94,643	95,217	95,793	96,371
449	96,950	97,531	98,113	98,698	99,284	99,872	100,462	101,055	101,649	102,245
450	102,843	103,442	104,044	104,648	105,253	105,860	106,470	107,081	107,694	108,309
451	108,926	109,545	110,166	110,789	111,414	112,042	112,672	113,304	113,937	114,573
452	115,210	115,850	116,491	117,135	117,780	118,427	119,077	119,728	120,381	121,036
453	121,693	122,351	123,012	123,675	124,339	125,005	125,672	126,342	127,013	127,686
454	128,361	129,037	129,714	130,394	131,075	131,757	132,442	133,128	133,815	134,505
455	135,196	135,889	136,583	137,280	137,977	138,677	139,378	140,081	140,786	141,492
456	142,201	142,911	143,623	144,336	145,052	145,771	146,492	147,216	147,943	148,673
457	149,406	150,141	150,880	151,620	152,363	153,109	153,858	154,610	155,364	156,122
458	156,882	157,644	158,409	159,176	159,946	160,718	161,494	162,272	163,053	163,837
459	164,624	165,412	166,204	166,997	167,793	168,591	169,392	170,194	170,999	171,806
460	172,616	173,428	174,241	175,057	175,875	176,695	177,517	178,341	179,167	179,994
461	180,824	181,655	182,488	183,322	184,159	184,997	185,837	186,680	187,524	188,371
462	189,220	190,070	190,922	191,776	192,632	193,490	194,350	195,213	196,077	196,944
463	197,813	198,684	199,557	200,433	201,311	202,191	203,074	203,958	204,846	205,736
464	206,628	207,523	208,420	209,320	210,222	211,127	212,034	212,944	213,857	214,772
465	215,690	216,610	217,533	218,459	219,387	220,318	221,252	222,189	223,128	224,069
466	225,014	225,961	226,911	227,863	228,818	229,776	230,737	231,701	232,667	233,636
467	234,608	235,583	236,561	237,541	238,525	239,511	240,499	241,491	242,485	243,482
468	244,482	245,485	246,490	247,498	248,510	249,523	250,540	251,560	252,582	253,608
469	254,636	255,667	256,702	257,739	258,779	259,823	260,870	261,920	262,974	264,030
470	265,091	266,155	267,222	268,292	269,365	270,442	271,521	272,604	273,689	274,778
471	275,870	276,964	278,062	279,163	280,267	281,374	282,484	283,597	284,713	285,833
472	286,955	288,080	289,209	290,340	291,475	292,612	293,752	294,895	296,040	297,188
473	298,339	299,493	300,649	301,807	302,969	304,133	305,300	306,470	307,642	308,817
474	309,995	311,176	312,359	313,546	314,735	315,928	317,123	318,322	319,523	320,728
475	321,935	323,146	324,359	325,576	326,795	328,017	329,242	330,470	331,700	332,933
476	334,169	335,408	336,649	337,893	339,139	340,389	341,641	342,896	344,153	345,414
477	346,677	347,943	349,212	350,483	351,758	353,036	354,316	355,599	356,886	358,174
478	359,466	360,760	362,057	363,357	364,659	365,964	367,271	368,581	369,894	371,209
479	372,527	373,848	375,171	376,497	377,825	379,157	380,491	381,827	383,166	384,508
480	385,853	387,201	388,551	389,904	391,259	392,618	393,979	395,343	396,709	398,078
481	399,451	400,825	402,203	403,583	404,966	406,351	407,739	409,130	410,524	411,920
482	413,318	414,719	416,123	417,529	418,939	420,350	421,765	423,182	424,602	426,024
483	427,449	428,877	430,307	431,739	433,175	434,612	436,053	437,496	438,941	440,389
484	441,840	443,293	444,749	446,207	447,668	449,132	450,599	452,068	453,541	455,016
485	456,494	457,975	459,458	460,944	462,433	463,924	465,419	466,915	468,415	469,918

Appendix E (Continued)

Waco Lake

RESERVOIR BATHYMETRIC AND TOPOGRAPHIC CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — December 2023 Survey

CAPACITY IN ACRE-FEET — Conservation pool elevation 462.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT — Top of dam elevation 514.6 feet NGVD29

ELEVATION (Feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
486	471,424	472,932	474,443	475,957	477,473	478,992	480,514	482,039	483,566	485,096
487	486,628	488,163	489,701	491,242	492,785	494,330	495,879	497,430	498,983	500,540
488	502,099	503,660	505,225	506,792	508,361	509,934	511,509	513,087	514,667	516,251
489	517,837	519,425	521,017	522,611	524,208	525,808	527,410	529,016	530,624	532,235
490	533,849	535,466	537,085	538,707	540,333	541,961	543,591	545,225	546,862	548,501
491	550,143	551,788	553,436	555,087	556,741	558,398	560,058	561,721	563,387	565,056
492	566,727	568,401	570,079	571,759	573,441	575,127	576,816	578,507	580,202	581,899
493	583,599	585,303	587,009	588,718	590,431	592,146	593,865	595,587	597,312	599,040
494	600,772	602,506	604,244	605,985	607,730	609,477	611,228	612,982	614,740	616,501
495	618,265	620,032	621,803	623,577	625,354	627,134	628,918	630,706	632,496	634,291
496	636,088	637,889	639,693	641,501	643,311	645,126	646,943	648,764	650,588	652,416
497	654,246	656,080	657,918	659,759	661,603	663,451	665,302	667,156	669,014	670,876
498	672,741	674,610	676,482	678,357	680,236	682,118	684,004	685,893	687,785	689,681
499	691,580	693,483	695,389	697,298	699,211	701,128	703,048	704,971	706,898	708,829
500	710,763	712,700	714,641	716,586	718,534	720,486	722,441	724,400	726,363	728,329
501	730,298	732,272	734,248	736,229	738,213	740,201	742,193	744,188	746,188	748,191
502	750,198	752,209	754,224	756,242	758,265	760,292	762,323	764,358	766,396	768,439
503	770,485	772,535	774,590	776,648	778,710	780,776	782,846	784,920	786,998	789,081
504	791,168	793,259	795,354	797,453	799,557	801,665	803,778	805,894	808,015	810,140
505	812,269	814,402	816,540	818,682	820,828	822,978	825,133	827,293	829,456	831,624
506	833,796	835,972	838,153	840,338	842,527	844,721	846,919	849,121	851,327	853,538
507	855,753	857,973	860,198	862,426	864,660	866,898	869,140	871,387	873,639	875,895
508	878,156	880,422	882,693	884,968	887,249	889,533	891,823	894,117	896,417	898,721
509	901,029	903,342	905,660	907,981	910,308	912,639	914,974	917,314	919,659	922,008
510	924,361	926,719	929,082	931,449	933,821	936,198	938,578	940,964	943,354	945,748
511	948,148	950,551	952,960	955,373	957,790	960,213	962,640	965,071	967,508	969,949
512	972,396	974,847	977,302	979,762	982,227	984,697	987,171	989,650	992,134	994,623
513	997,116	999,614	1,002,117	1,004,625	1,007,136	1,009,652	1,012,173	1,014,698	1,017,227	1,019,760
514	1,022,298	1,024,839	1,027,385	1,029,935	1,032,490	1,035,048	1,037,611			

Appendix F

Waco Lake

RESERVOIR BATHYMETRIC AND TOPOGRAPHIC AREA TABLE

TEXAS WATER DEVELOPMENT BOARD
AREA IN ACRES
ELEVATION INCREMENT IS ONE TENTH FOOT

December 2023 Survey
Conservation pool elevation 462.0 feet NGVD29
Top of dam elevation 514.6 feet NGVD29

ELEVATION (Feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
376	0	0	0	0	0	0	0	0	0	0
377	0	0	0	0	0	0	0	0	0	0
378	0	0	0	0	0	0	0	0	0	0
379	0	0	0	0	0	0	0	0	0	0
380	0	0	0	0	0	0	0	0	0	0
381	0	0	0	0	0	0	0	0	0	0
382	0	0	0	0	0	0	0	0	1	1
383	1	1	1	1	1	1	1	1	1	1
384	1	1	1	1	1	1	1	1	1	1
385	1	1	1	1	1	1	1	1	1	1
386	1	1	1	1	1	1	1	1	1	1
387	1	1	1	1	1	1	1	1	1	1
388	1	1	1	1	1	1	2	2	2	2
389	2	2	3	3	3	4	4	4	4	5
390	5	5	5	5	6	6	7	7	8	8
391	9	9	10	10	11	11	11	12	12	12
392	13	13	14	14	14	15	15	15	15	16
393	16	16	16	17	17	17	17	17	18	18
394	18	18	18	19	19	19	20	21	21	22
395	22	23	23	24	24	25	25	25	25	26
396	26	26	27	27	27	27	28	28	28	28
397	28	29	29	29	29	30	30	30	30	30
398	31	31	31	31	31	31	32	32	32	32
399	32	33	33	33	33	34	34	34	34	34
400	34	35	35	35	35	35	36	36	36	36
401	36	36	37	37	37	37	37	38	38	38
402	38	38	38	39	39	39	39	39	40	40
403	40	40	40	41	41	41	41	41	42	42
404	42	42	43	43	43	43	43	44	44	44
405	45	45	45	45	46	46	46	47	47	47
406	48	48	49	49	49	50	50	50	51	51
407	52	52	53	53	54	54	55	56	56	57
408	58	59	60	62	64	66	68	70	72	74
409	75	77	78	80	81	82	84	85	88	90
410	93	95	98	100	103	106	108	111	113	115
411	116	118	119	120	121	122	124	125	126	127
412	129	130	131	132	133	134	135	136	137	137
413	138	139	140	141	142	143	143	144	145	146
414	146	147	148	149	150	150	151	152	153	154
415	155	156	157	158	159	161	162	163	165	166
416	167	169	170	171	173	174	175	177	178	179
417	180	181	182	183	184	185	186	187	188	189
418	190	191	193	194	196	197	199	200	202	204
419	206	208	210	212	214	217	219	221	223	226
420	229	233	236	239	242	246	250	254	259	265
421	270	275	283	292	301	310	319	329	339	350
422	362	377	394	413	436	459	480	501	524	549
423	576	607	644	684	720	753	789	828	870	912
424	953	994	1,038	1,081	1,125	1,168	1,209	1,249	1,287	1,324
425	1,356	1,386	1,417	1,449	1,483	1,519	1,557	1,593	1,631	1,674
426	1,711	1,745	1,778	1,817	1,859	1,894	1,921	1,944	1,964	1,983
427	2,000	2,017	2,034	2,049	2,065	2,080	2,095	2,110	2,124	2,138
428	2,153	2,167	2,183	2,200	2,215	2,229	2,243	2,256	2,269	2,282
429	2,296	2,310	2,324	2,338	2,353	2,369	2,390	2,409	2,426	2,448
430	2,468	2,489	2,512	2,537	2,565	2,598	2,629	2,667	2,698	2,728

Appendix F (Continued)

Waco Lake

RESERVOIR BATHYMETRIC AND TOPOGRAPHIC AREA TABLE

TEXAS WATER DEVELOPMENT BOARD — December 2023 Survey

AREA IN ACRES — Conservation pool elevation 462.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT — Top of dam elevation 514.6 feet NGVD29

ELEVATION (Feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
431	2,756	2,784	2,813	2,840	2,867	2,894	2,922	2,951	2,978	3,003
432	3,029	3,055	3,083	3,113	3,140	3,161	3,182	3,204	3,225	3,246
433	3,268	3,290	3,311	3,331	3,350	3,369	3,388	3,407	3,426	3,446
434	3,465	3,483	3,501	3,522	3,541	3,558	3,576	3,593	3,611	3,628
435	3,644	3,659	3,674	3,690	3,705	3,721	3,736	3,752	3,767	3,783
436	3,799	3,815	3,831	3,847	3,863	3,879	3,893	3,907	3,921	3,936
437	3,949	3,963	3,977	3,992	4,007	4,021	4,035	4,050	4,064	4,080
438	4,095	4,111	4,127	4,142	4,157	4,172	4,187	4,200	4,213	4,227
439	4,241	4,255	4,271	4,285	4,298	4,311	4,325	4,339	4,352	4,365
440	4,379	4,392	4,407	4,423	4,441	4,458	4,475	4,492	4,510	4,527
441	4,547	4,565	4,581	4,597	4,613	4,628	4,644	4,661	4,678	4,695
442	4,711	4,727	4,745	4,761	4,777	4,795	4,811	4,827	4,844	4,860
443	4,878	4,896	4,912	4,931	4,950	4,969	4,988	5,005	5,021	5,037
444	5,053	5,069	5,086	5,103	5,118	5,134	5,148	5,163	5,176	5,190
445	5,203	5,217	5,231	5,246	5,260	5,276	5,290	5,304	5,317	5,331
446	5,344	5,358	5,372	5,385	5,398	5,411	5,424	5,437	5,450	5,464
447	5,478	5,492	5,507	5,523	5,539	5,556	5,574	5,590	5,607	5,623
448	5,639	5,655	5,671	5,687	5,702	5,718	5,733	5,749	5,766	5,783
449	5,800	5,818	5,836	5,854	5,872	5,891	5,911	5,931	5,951	5,970
450	5,988	6,007	6,026	6,045	6,065	6,084	6,103	6,121	6,140	6,159
451	6,178	6,199	6,220	6,244	6,266	6,287	6,307	6,327	6,346	6,364
452	6,385	6,406	6,425	6,444	6,463	6,482	6,502	6,522	6,540	6,558
453	6,578	6,598	6,616	6,633	6,651	6,668	6,685	6,704	6,721	6,738
454	6,753	6,769	6,786	6,802	6,818	6,834	6,851	6,868	6,885	6,903
455	6,921	6,937	6,954	6,970	6,987	7,004	7,021	7,039	7,056	7,073
456	7,092	7,110	7,129	7,149	7,171	7,197	7,225	7,256	7,285	7,314
457	7,342	7,368	7,394	7,420	7,446	7,473	7,502	7,532	7,560	7,587
458	7,612	7,636	7,660	7,685	7,711	7,738	7,770	7,799	7,825	7,851
459	7,876	7,900	7,923	7,947	7,970	7,993	8,015	8,037	8,059	8,085
460	8,106	8,128	8,148	8,169	8,189	8,209	8,230	8,249	8,267	8,285
461	8,302	8,320	8,337	8,355	8,373	8,393	8,413	8,436	8,458	8,479
462	8,496	8,512	8,529	8,548	8,569	8,591	8,613	8,634	8,656	8,678
463	8,700	8,723	8,745	8,767	8,790	8,813	8,837	8,861	8,886	8,911
464	8,936	8,960	8,985	9,010	9,035	9,061	9,087	9,114	9,140	9,166
465	9,191	9,217	9,243	9,269	9,296	9,324	9,352	9,378	9,405	9,431
466	9,458	9,484	9,511	9,538	9,565	9,593	9,621	9,651	9,679	9,707
467	9,735	9,763	9,791	9,818	9,846	9,874	9,901	9,929	9,957	9,984
468	10,012	10,040	10,068	10,097	10,125	10,153	10,182	10,210	10,239	10,268
469	10,298	10,328	10,359	10,389	10,421	10,452	10,485	10,518	10,552	10,586
470	10,621	10,654	10,686	10,718	10,749	10,780	10,811	10,841	10,871	10,901
471	10,931	10,962	10,992	11,024	11,055	11,086	11,117	11,148	11,178	11,209
472	11,239	11,269	11,299	11,329	11,358	11,386	11,414	11,442	11,468	11,495
473	11,521	11,548	11,575	11,601	11,628	11,655	11,682	11,710	11,737	11,765
474	11,794	11,822	11,851	11,880	11,910	11,940	11,970	12,000	12,030	12,061
475	12,091	12,120	12,149	12,178	12,207	12,236	12,264	12,291	12,318	12,345
476	12,372	12,398	12,425	12,452	12,480	12,507	12,535	12,562	12,590	12,618
477	12,646	12,674	12,703	12,732	12,761	12,790	12,819	12,847	12,875	12,902
478	12,929	12,956	12,983	13,009	13,035	13,061	13,087	13,114	13,140	13,166
479	13,193	13,219	13,246	13,273	13,299	13,326	13,352	13,379	13,406	13,433
480	13,460	13,488	13,516	13,543	13,570	13,597	13,624	13,652	13,680	13,707
481	13,734	13,761	13,788	13,815	13,841	13,868	13,895	13,921	13,947	13,973
482	13,999	14,025	14,051	14,077	14,104	14,132	14,158	14,184	14,211	14,237
483	14,263	14,288	14,314	14,340	14,365	14,391	14,416	14,441	14,467	14,493
484	14,519	14,545	14,572	14,598	14,625	14,652	14,680	14,710	14,738	14,766
485	14,793	14,820	14,847	14,874	14,901	14,928	14,956	14,984	15,013	15,042

Appendix F (Continued)

Waco Lake

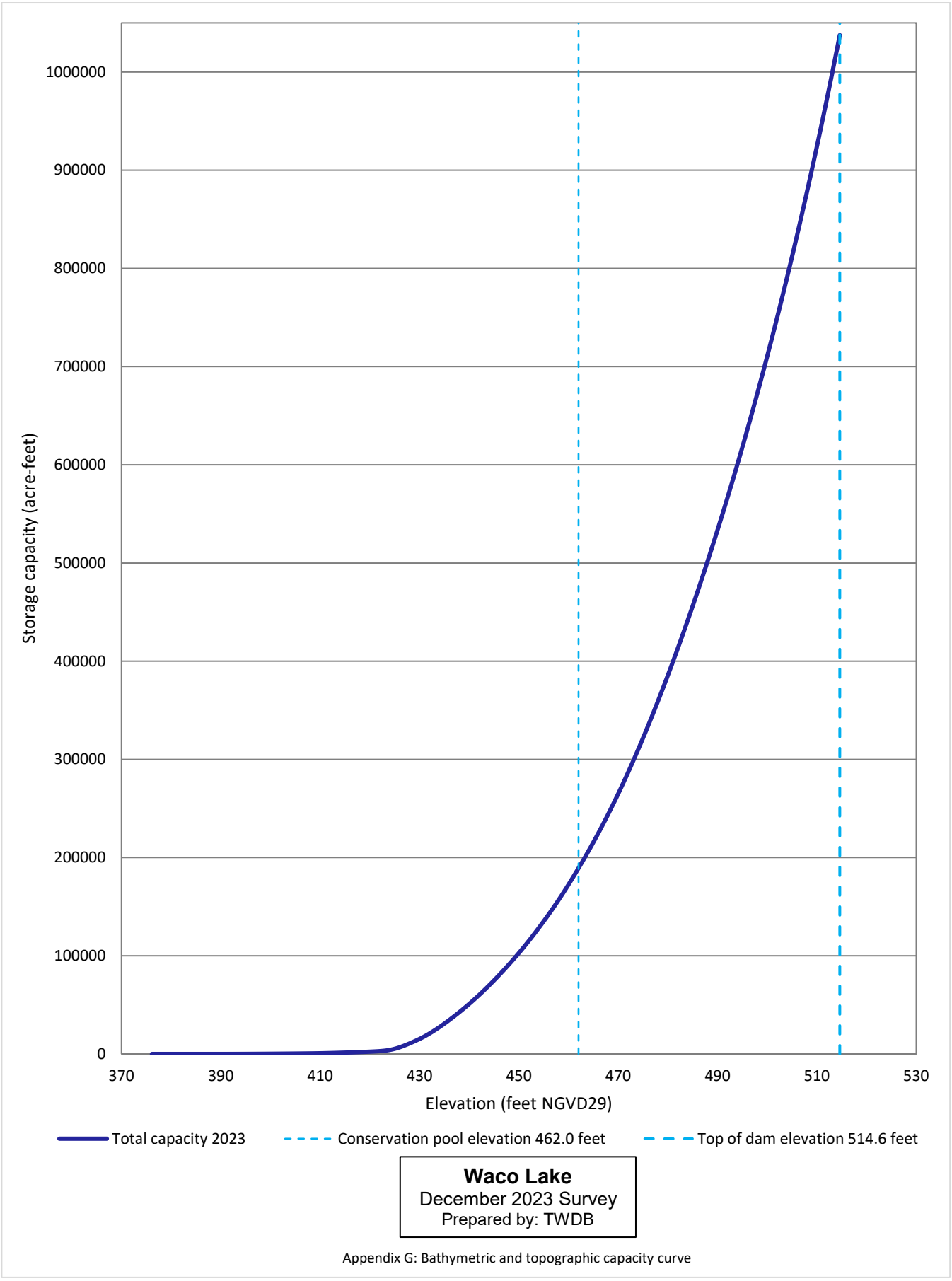
RESERVOIR BATHYMETRIC AND TOPOGRAPHIC AREA TABLE

TEXAS WATER DEVELOPMENT BOARD — December 2023 Survey

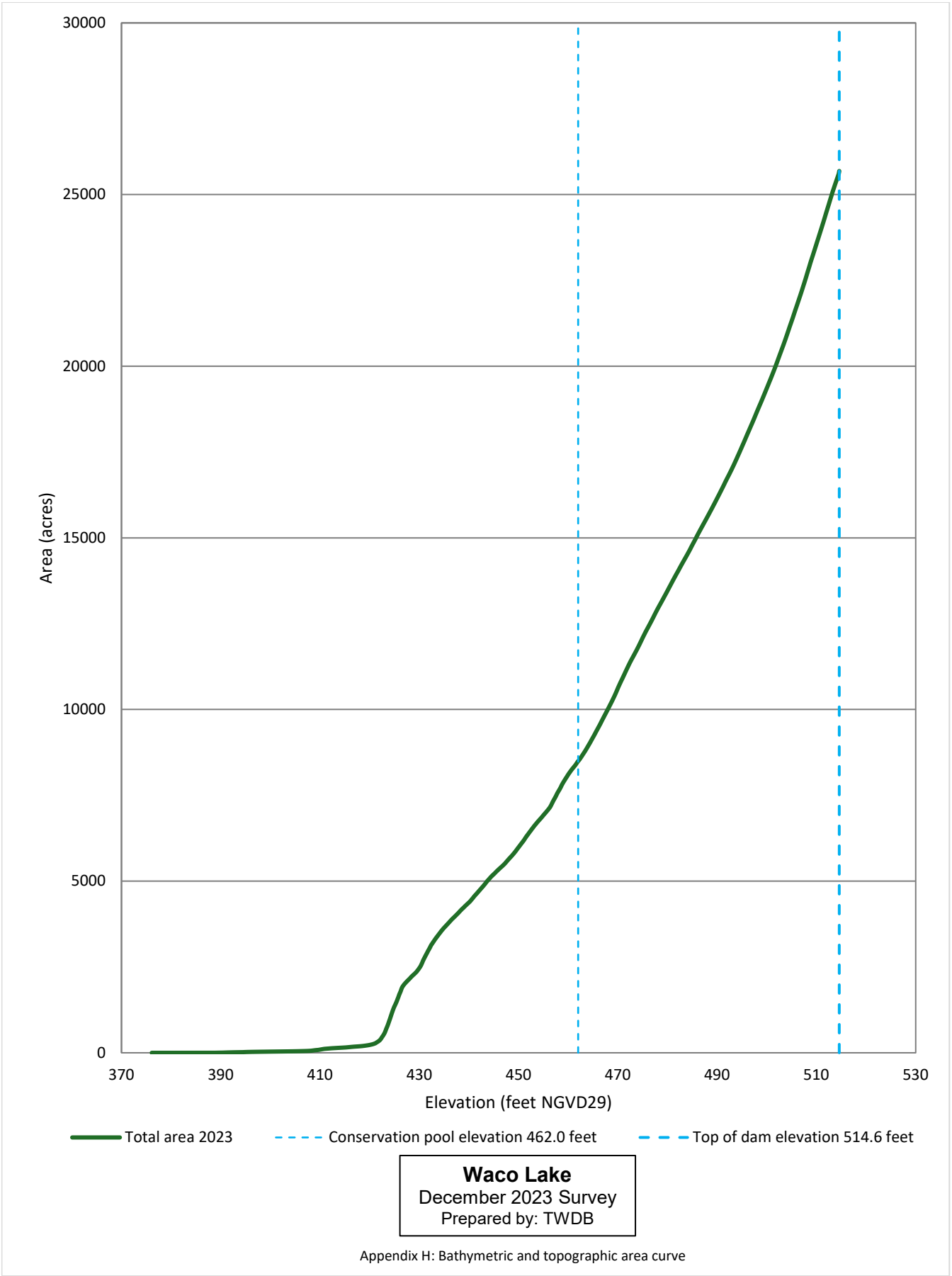
AREA IN ACRES — Conservation pool elevation 462.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT — Top of dam elevation 514.6 feet NGVD29

ELEVATION (Feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
486	15,069	15,097	15,124	15,151	15,178	15,205	15,232	15,259	15,285	15,312
487	15,338	15,365	15,391	15,417	15,444	15,470	15,497	15,523	15,550	15,576
488	15,603	15,630	15,657	15,684	15,711	15,738	15,765	15,792	15,819	15,846
489	15,874	15,901	15,929	15,957	15,984	16,012	16,040	16,068	16,096	16,125
490	16,153	16,181	16,209	16,237	16,265	16,294	16,322	16,351	16,380	16,408
491	16,437	16,466	16,495	16,524	16,554	16,584	16,615	16,644	16,673	16,701
492	16,729	16,757	16,786	16,814	16,842	16,871	16,900	16,929	16,959	16,988
493	17,018	17,048	17,079	17,109	17,140	17,172	17,203	17,235	17,266	17,298
494	17,331	17,363	17,395	17,427	17,460	17,492	17,525	17,558	17,591	17,624
495	17,657	17,690	17,723	17,756	17,789	17,822	17,856	17,890	17,924	17,958
496	17,992	18,026	18,059	18,092	18,125	18,158	18,191	18,225	18,258	18,292
497	18,325	18,358	18,391	18,425	18,459	18,493	18,528	18,565	18,600	18,634
498	18,669	18,703	18,738	18,772	18,806	18,839	18,873	18,906	18,940	18,974
499	19,008	19,042	19,077	19,112	19,147	19,182	19,217	19,253	19,288	19,323
500	19,358	19,393	19,429	19,465	19,501	19,536	19,571	19,606	19,642	19,678
501	19,714	19,751	19,788	19,824	19,861	19,898	19,936	19,974	20,012	20,051
502	20,089	20,129	20,169	20,209	20,248	20,288	20,328	20,366	20,406	20,445
503	20,484	20,523	20,561	20,600	20,640	20,681	20,722	20,763	20,804	20,846
504	20,888	20,931	20,973	21,016	21,059	21,103	21,146	21,187	21,229	21,271
505	21,312	21,354	21,396	21,439	21,483	21,527	21,571	21,614	21,657	21,700
506	21,742	21,785	21,828	21,871	21,914	21,957	22,000	22,043	22,087	22,131
507	22,175	22,220	22,266	22,311	22,356	22,402	22,447	22,493	22,540	22,587
508	22,635	22,684	22,732	22,779	22,825	22,872	22,919	22,968	23,017	23,063
509	23,108	23,152	23,196	23,240	23,286	23,331	23,377	23,422	23,467	23,513
510	23,559	23,605	23,650	23,695	23,741	23,786	23,832	23,877	23,923	23,968
511	24,014	24,060	24,107	24,153	24,199	24,246	24,293	24,341	24,390	24,439
512	24,486	24,533	24,579	24,626	24,673	24,720	24,766	24,816	24,863	24,910
513	24,956	25,004	25,052	25,096	25,140	25,183	25,226	25,269	25,312	25,355
514	25,397	25,439	25,480	25,522	25,564	25,607	25,686			



Appendix G: Bathymetric and topographic capacity curve



Appendix H: Bathymetric and topographic area curve

Figure 6

Waco Lake

5' - contour map

CONTOURS
(feet NGVD29)

460
455
450
445
440
435
430
425
420
415
410
405
400
395
390
385
380

Islands

Waco Lake
Conservation pool
elevation 462.0 feet

Projection: NAD83 State Plane
Texas Central Zone (feet)

McLennan 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 Waco Lake. The Texas Water Development Board makes no representations nor assumes any liability.

3,240,000
3,255,000
3,270,000
10,555,000
10,540,000
10,525,000

N

0 1 2 Miles

TEXAS WATER DEVELOPMENT BOARD

November - December 2023 Survey