Volumetric and Sedimentation Survey of EAGLE MOUNTAIN LAKE

October 2018 Survey

Texas Water Development Board

October 2019

Texas Water Development Board

Prepared for:

Tarrant Regional Water District

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Published and distributed by the

Texas Water Development Board

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Executive summary

In March 2018, the Texas Water Development Board (TWDB) entered into an agreement with the Tarrant Regional Water District to perform a volumetric and sedimentation survey of Eagle Mountain Lake (Tarrant and Wise counties, Texas). Surveying was performed using a multi-frequency (208 kHz, 50 kHz, and 12 kHz), sub-bottom profiling depth sounder. Sediment core samples were collected in select locations and correlated with sub-bottom acoustic profiles to estimate sediment accumulation thicknesses and sedimentation rates.

Eagle Mountain Dam and Eagle Mountain Lake are located on the West Fork Trinity River, in Tarrant County, less than 15 miles northwest of Downtown Fort Worth, Texas. The conservation pool elevation of Eagle Mountain Lake is 649.1 feet (NAVD88). The TWDB collected bathymetric data for Eagle Mountain Lake between August 14 and October 2, 2018, while daily average water surface elevations measured between 646.27 and 648.00 feet (NAVD88).

The 2018 TWDB volumetric survey indicates Eagle Mountain Lake has a total reservoir capacity of 185,087 acre-feet and encompasses 9,246 acres at conservation pool elevation (649.1 feet NAVD88). Previous capacity estimates include three U.S. Department of Agriculture estimates of 211,000 acre-feet, 205,175 acre-feet and 182,000 acre-feet in 1934, 1939, and 1952, respectively, a 1968 U.S. Army Corps of Engineers estimate of 190,460 acre-feet, a 1988 Freese and Nichols estimate of 178,440 acre-feet, and two TWDB surveys in 2001 and 2008. The 2001 and 2008 TWDB surveys were re-evaluated using current processing procedures resulting in updated capacity estimates of 184,157 acre-feet and 187,387 acre-feet, respectively.

The 2018 TWDB sedimentation survey indicates Eagle Mountain Lake has lost capacity at an average of 260 acre-feet per year since impoundment due to sedimentation below conservation pool elevation (649.1 feet NAVD88). **Long-term trends indicate that Eagle Mountain Lake loses capacity at an average of 274 acre-feet per year since impoundment due to sedimentation below conservation pool elevation (649.1 feet NAVD88).** The sedimentation survey indicates sediment accumulation is occurring throughout the reservoir. The TWDB recommends that a similar methodology be used to resurvey Eagle Mountain Lake in 10 years or after a major flood event.

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

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 March 2018, the TWDB entered into an agreement with the Tarrant Regional Water District, to perform a volumetric and sedimentation survey of Eagle Mountain Lake (Texas Water Development Board, 2018). This report provides an overview of the survey methods, analysis techniques, and associated results. Also included are the following contract deliverables: (1) a shaded relief plot of the reservoir bottom (Figure 4), (2) a bottom contour map (Figure 6), (3) an estimate of sediment accumulation and location (Figure 10), and (4) an elevation-area-capacity table of the reservoir acceptable to the Texas Commission on Environmental Quality (Appendices I and J).

Eagle Mountain Lake general information

Eagle Mountain Dam and Eagle Mountain Lake are located on the West Fork Trinity River, in Tarrant County, less than 15 miles northwest of Downtown Fort Worth, Texas (Figure 1). Eagle Mountain Lake is owned and operated by the Tarrant Regional Water District. Construction of the dam began on January 23, 1930, and the dam was completed on October 24, 1932. Deliberate impoundment of water began on February 28, 1934 (Texas Water Development Board, 1973). The reservoir was built primarily for water supply for Fort Worth and surrounding cities (Tarrant Regional Water District, 2019). Additional pertinent data about Eagle Mountain Dam and Eagle Mountain Lake can be found in Table 1.

Water rights for Eagle Mountain Lake have been appropriated to the Tarrant Regional Water District through Certificate of Adjudication No. 08-3809 and Amendments to Certificate of Adjudication Nos. 08-3809A, 08-3809B, and 08-3809C. The complete permits are on file in the Information Resources Division of the Texas Commission on Environmental Quality.

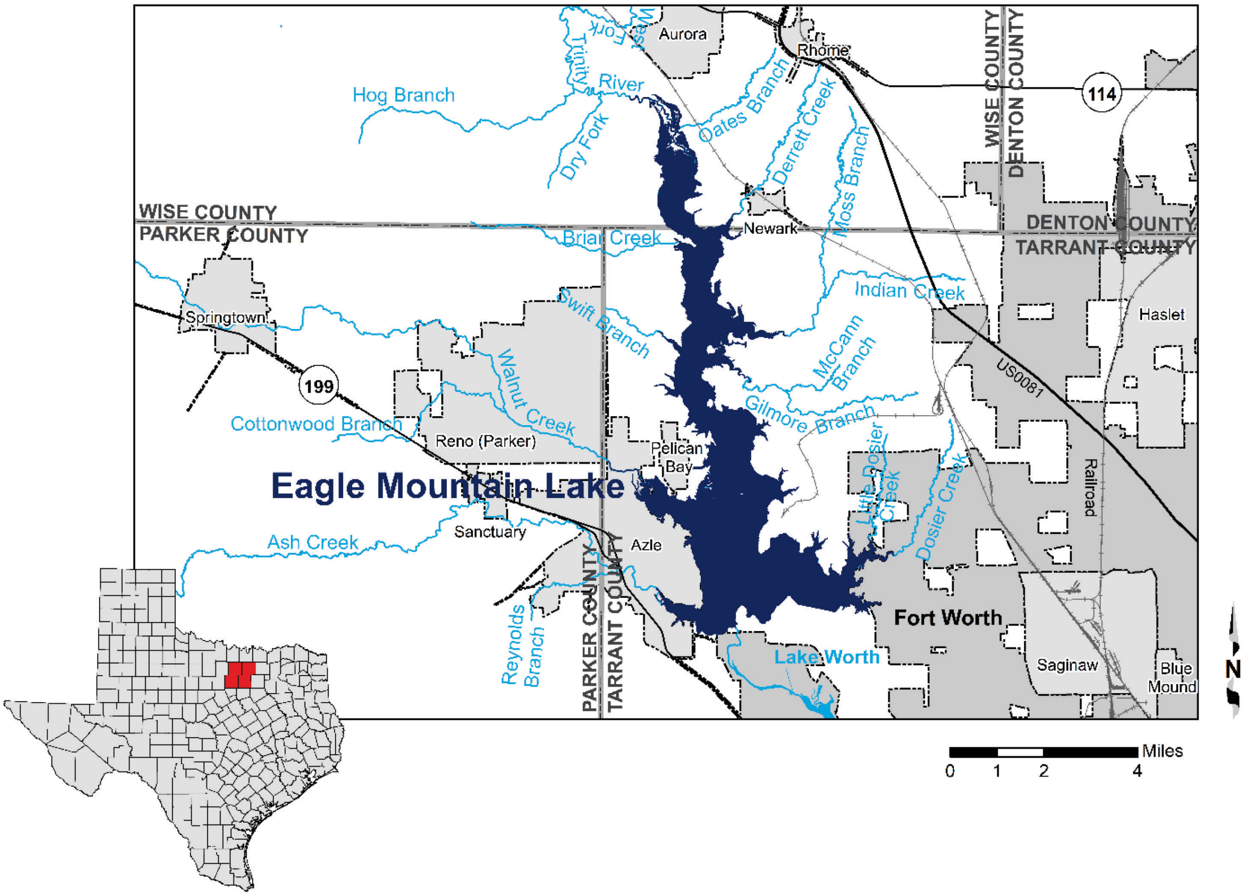

Figure 1. Location map of Eagle Mountain Lake.

Table 1. Pertinent Data for Eagle Mountain Dam and Eagle Mountain Lake

Owner	
Tarrant Regional Water District	
Engineer (Design)	
Hawley, Freese and Nichols (original)	
Freese, Nichols and Endress (1971 spillway)	
Location of Dam	
On the West Fork Trinity River in Tarrant County, less than 15 miles northwest of Downtown Fort Worth, Texas.	
Drainage Area	
1,970 square miles	
Dam	
Type	Two sections of earthfill and a concrete spillway separated by high ground of Eagle Mountain and Burgess Gap
Length	4,800 feet
Maximum height	85 feet
Top width	25 feet
Spillway (emergency)	
Location	At Burgess Gap, between dam and concrete spillway
Type	Natural ground
Length	1,300 feet
Crest elevation, top of fuse plug	676.0 feet NAVD88
Crest elevation, bottom of fuse plug	670.0 feet NAVD88
New Side Channel Spillway	
Location	Spillway levee section
Type	Concrete side channel ogee to forebay discharging through a 25-foot square conduit
Length	1,300 feet
Control	6 roller gates, each 11.25 feet by 22.0 feet
Crest elevation	637.0 feet NAVD88
Old Spillway	
Type	Concrete ogee with four bays, each 25 feet wide Three bays have vertical lift roller type gates
Crest elevation	649.1 feet NAVD88

Reservoir data (Based on 2018 TWDB survey)

Feature	**Elevation (feet** NAVD88[a]**)**	**Capacity (acre-feet)**	**Area (acres)**
Top of dam	682.0	N/A	N/A
Crest of emergency spillway	676.0	N/A	N/A
Base of emergency spillway	670.0	N/A	N/A
Crest of service spillway/ Top of conservation pool elevation	649.1	185,087	9,246
Invert of low flow outlet	599.9	0	0
Conservation storage capacity[b]	—	185,087	—

Source: (Texas Water Development Board, 1973)

[a] NAVD88 = North American Vertical Datum 1988

Note: On October 1, 2016, the U.S. Geological Survey changed the datum of water surface elevations from NGVD29 (National Geodetic Vertical Datum 1929) to NAVD88 (North American Vertical Datum 1988). (U.S. Geological Survey, 2019).

[b] 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 a dam's outlet works.

Volumetric and sedimentation survey of Eagle Mountain Lake

Datum

The vertical datum used during this survey is the North American Vertical Datum 1988 (NAVD88). This datum also is utilized by the United States Geological Survey (USGS) for the reservoir elevation gage *USGS 08045000 Eagle Mtn Res abv Ft Worth, TX* (U.S. Geological Survey, 2019). Elevations herein are reported in feet relative to the NAVD88 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 and sedimentation data collection

The TWDB collected bathymetric data for Eagle Mountain Lake between August 14 and October 2, 2018, while daily average water surface elevations measured between 646.27 and 648.00 feet (NAVD88). For data collection, the TWDB used a Specialty Devices, Inc. (SDI), single-beam, multi-frequency (208 kHz, 50 kHz, and 12 kHz) sub-bottom profiling depth sounder integrated with differential global positioning system (DGPS) equipment. Data was collected along pre-planned survey lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 500 feet apart. Many of the same survey lines also were used by the TWDB for the *Volumetric and Sedimentation Survey of Eagle Mountain Lake, February 2008 Survey* (Texas Water Development Board, 2008) and *Volumetric Survey of Eagle Mountain Lake, February 2001 Survey* (Texas Water Development Board, 2001). 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 2018 TWDB survey.

All sounding data was 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 12 locations to collect sediment core samples (Figure 2). Sediment cores were collected on November 13-14, 2018, with a custom-coring boat and an SDI VibeCore system.

Sediment cores are collected in 3-inch diameter aluminum tubes. Analysis of the acoustic data collected during the bathymetric survey assists in determining the depth of penetration the tube must be driven during sediment sampling. 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 and transported to TWDB headquarters for further analysis.

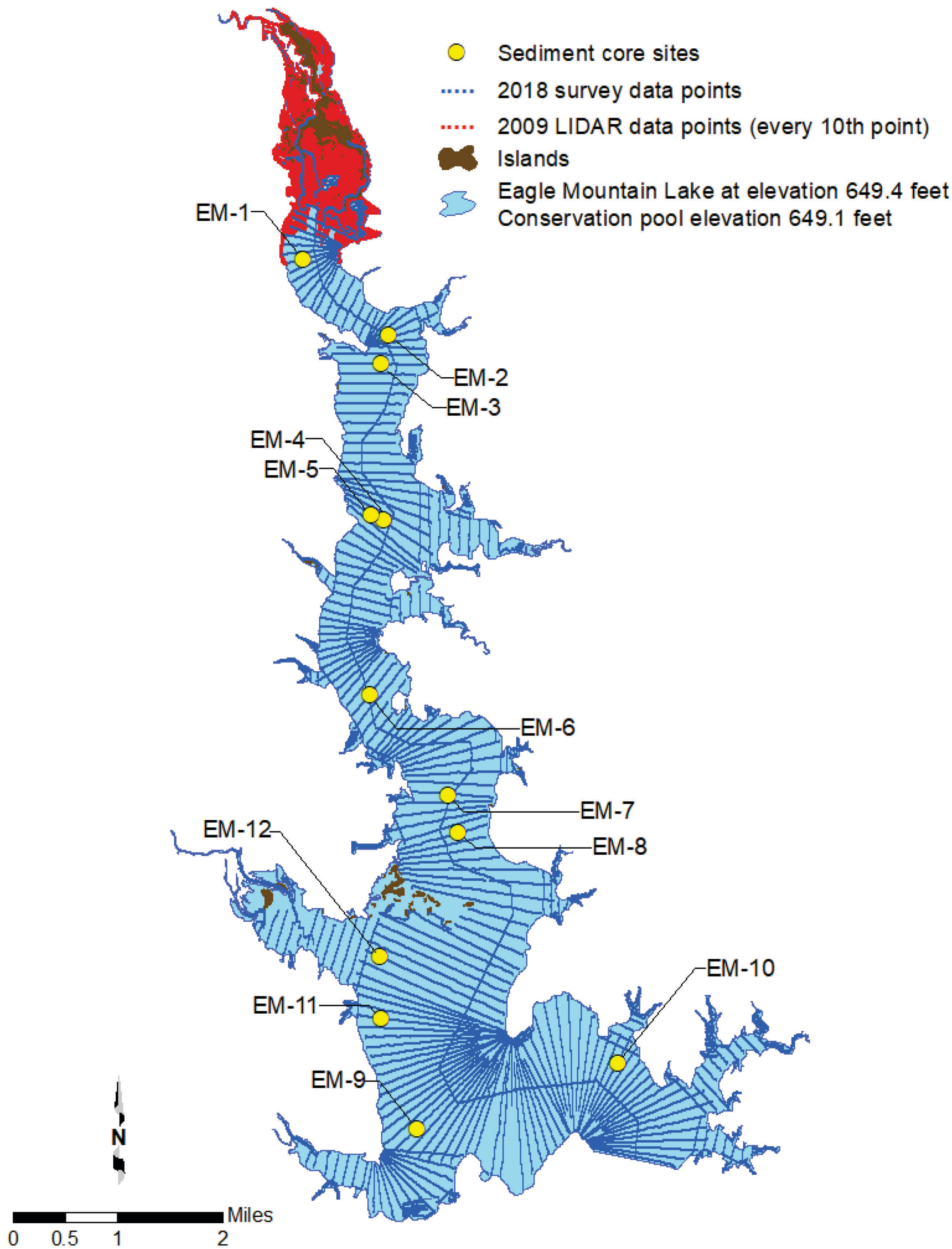

Figure 2. **2018 TWDB Eagle Mountain Lake survey data (*blue dots*), sediment coring locations (*yellow circles*), and 2009 LIDAR data (*red dots*).**

Data processing

Model boundary

The reservoir's model boundary was digitized from aerial photographs, also known as digital orthophoto quarter-quadrangle images (DOQQs), obtained through the Texas Imagery Service. The Texas Natural Resources Information System manages the Texas Imagery Service allowing public organizations in the State of Texas to access Google Imagery as a service using Environmental Systems Research Institute's ArcGIS software (Texas Natural Resources Information System, 2018a). The quarter-quadrangles containing Eagle Mountain Lake are Avondale (NW, SW), Azle (NE, SE), Boyd (SE), Lake Worth (NW), and Springtown (NE, SE). The DOQQs were photographed on January 26, 2017, while the daily average water surface elevation measured 649.44 feet (NAVD88). The DOQQs have a resolution of 6 inches (Texas Natural Resources Information System, 2018b). The model boundary was digitized at the land-water interface in the 2017 photographs and assigned an elevation of 649.4 feet.

The shoreline near the headwaters of the reservoir, within the Boyd (SE) quarter-quadrangle, is difficult to identify in the aerial photographs through dense vegetation. Therefore, the boundary near the headwaters was generated with Light Detection and Ranging (LIDAR) Data available from the Texas Natural Resource Information System. According to the associated metadata, the LIDAR data was collected on March 29, 2009, while the reservoir was at elevation 644.29 feet. The LIDAR data has a tested consolidated vertical accuracy of 0.084 meters at the 95th percentile in all land cover categories and a horizontal accuracy of 1 meter (Texas Natural Resources Information System, 2018b). LIDAR data with a classification equal to 2, or ground, was imported into an Environmental Systems Research Institute's ArcGIS file geodatabase from .las files. A topographical model of the data was generated and converted to a raster using a cell size of 1.0 meters by 1.0 meters. The horizontal datum of the LIDAR data is Universal Transverse Mercator (UTM) North American Datum 1983 (NAD83; meters) Zone 14, and the vertical datum is North American Vertical Datum 1988 (NAVD88; meters). To integrate the LIDAR boundary with the DOQQ boundary, a contour of 197.9371 meters NAVD88, equivalent to 649.4 feet NAVD88, was extracted from the raster. Horizontal coordinate transformations to NAD83 State Plane Texas North Central Zone (feet) coordinates were done using the ArcGIS Project tool. Additional editing of the 649.4-foot contour was necessary to remove other artifacts.

LIDAR data points

To model the headwaters area of the reservoir where shallow depths limited sounding data collection, lidar data was used to augment the data set. To incorporate the LIDAR data into the reservoir model the.las files were converted to text files with x, y, and z values. The LIDAR data was thinned using a stepwise progression in which every 10^{th} point was retained to reduce computational burden. LIDAR points outside the reservoir boundary were removed before adding to the model. LIDAR data was only used to model the headwaters area due to significant changes to the shoreline throughout the main body of the reservoir since LIDAR collection in 2009 (Figure 2). According to the associated metadata, the LIDAR data points have a nominal point spacing of 1.0 meter; therefore, using a thinned point dataset did not significantly affect the modeled topography of the coverage area. No further interpolation of the data in the areas of LIDAR coverage was necessary. After the points were clipped to within the boundary, the shapefile was projected to NAD83 State Plane Texas North Central Zone (feet). A new attribute field was added to convert the elevations from meters NAVD88 to feet NAVD88 for compatibility with the bathymetric survey data.

Triangulated Irregular Network model

Following completion of data collection, the raw data files collected by the TWDB were edited to remove data anomalies. The reservoir's current bottom surface is automatically determined by the data acquisition software. 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. The speed of sound profiles, also known as velocity casts, were used to further correct the measured depths. For each location velocity casts are collected, the harmonic mean sound speed of all the casts are 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). The TWDB developed an algorithm to automatically determine the pre-impoundment surface based on the intensity of the acoustic returns. Hydropick software, developed by TWDB staff, was used to calibrate the algorithm and manually edit the pre-impoundment surfaces in areas where the algorithm did not perform as expected. For further analysis, all data was 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). Finally, the point file resulting from spatial interpolation was used in conjunction with sounding and boundary data to create volumetric and sediment Triangulated Irregular Network (TIN) models utilizing the 3D Analyst Extension of ArcGIS. The 3D Analyst algorithm uses Delaunay's criteria for triangulation to create a grid composed of triangles from non-uniformly spaced points, including the boundary vertices (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 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 (known as digital raster graphics), 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 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, minor revisions of the interpolation definition files may be needed to account for differences in spatial coverage and boundary conditions between surveys. Using the interpolation definition files and survey data, the current reservoir-bottom elevation, pre-impoundment elevation, and sediment thickness are calculated for each point in the high-resolution uniform grid of artificial survey points. The reservoir boundary, artificial survey points grid, and survey data points are used to create volumetric and sediment TIN models representing 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).

LIDAR data can provide a detailed topography in areas inaccessible to survey data collection, such as small coves and shallow upstream areas of the reservoir, however, significant changes to the shoreline occurred throughout the main body of the reservoir between LIDAR collection in 2009 and bathymetric data collection in 2018. These shoreline changes are evident in the aerial photographs taken in 2017. Therefore, linear interpolation was used for volumetric and sediment accumulation estimations. Linear interpolation follows a line linking the survey points file to the lake boundary file (McEwen *et al.* 2011a). Without linearly interpolated data, the TIN model builds flat triangles. A flat triangle is defined as a triangle where all three vertices are equal in elevation, generally the elevation of the reservoir boundary. Reducing flat triangles by applying linear interpolation improves the elevation-capacity and elevation-area calculations, although it is not always possible to remove all flat triangles.

Figure 3 illustrates typical results from application of the anisotropic interpolation and linear interpolation techniques to Eagle Mountain 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 (Appendix I) and elevation-area (Appendix J) tables.

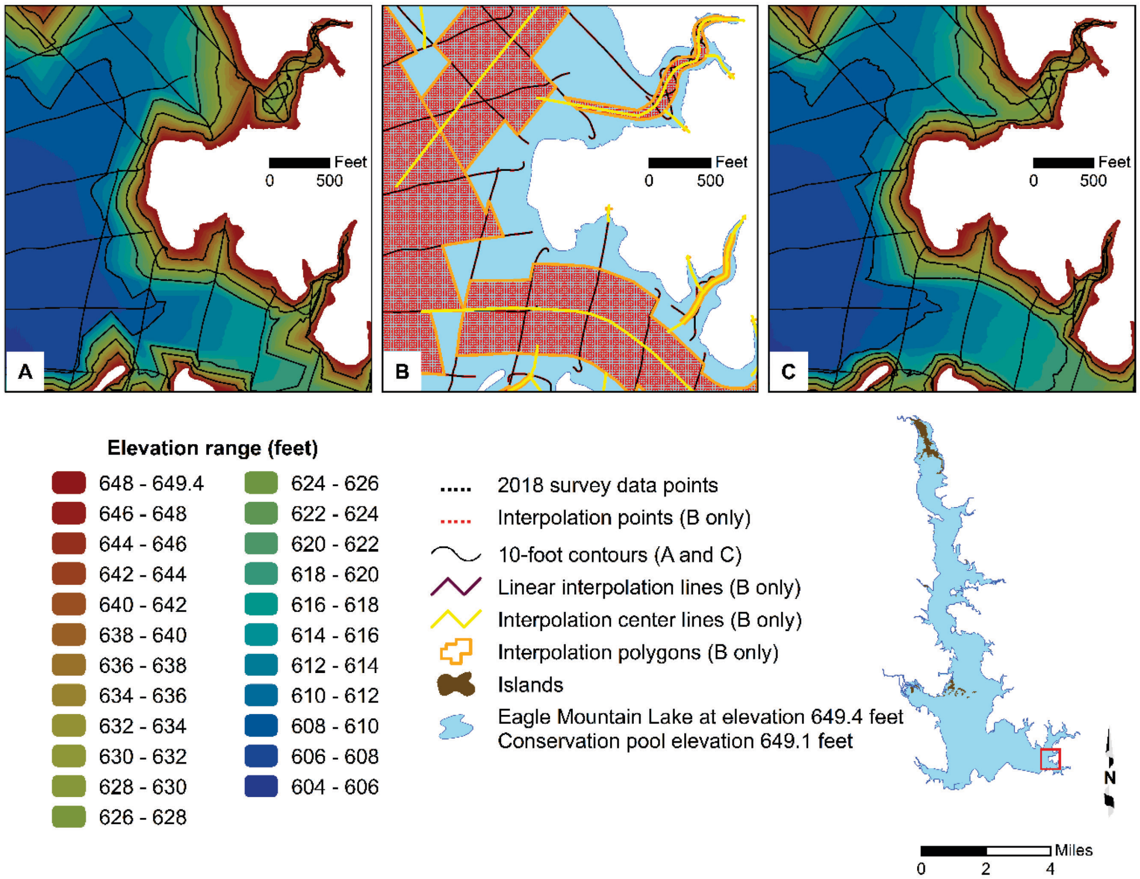

Figure 3. Anisotropic spatial interpolation and linear interpolation of Eagle Mountain Lake sounding data; A) bathymetric contours without interpolated points, B) sounding points (*black*) and interpolated points (*red*), C) bathymetric contours with interpolated points.

In 2016, TWDB conducted a re-assessment of surveys conducted prior to the development of current spatial interpolation techniques. As part of this re-assessment the TWDB applied anisotropic spatial interpolation to the 2001 Eagle Mountain survey. The original 2001 survey boundary (Texas Water Development Board, 2001) was revised at Eagle Mountain Marina near Castle, and a new TIN model was created using the revised boundary. Additionally, survey data points with anomalous elevations were removed from the new model. While linear interpolation was used to estimate the topography in areas without data, flat triangles led to anomalous area and volume calculations at the boundary elevation of 649.1 feet. The TWDB evaluated the availability and distribution of survey data and the shape of the elevation-area curve and determined the highest contour accurately modeled by survey data was 647.0 feet. Therefore, areas between 647.0 feet and 649.1 feet were linearly interpolated between the computed values, and volumes above 647.0 feet were calculated based on the corrected areas (Texas Water Development Board, 2016). The re-calculated 2001 elevation-capacity table and elevation-area table are presented in Appendices A and B, respectively. The re-calculated capacity curve is presented in Appendix C, and the area curve is presented in Appendix D.

Cross-sectional comparison of the 2018, 2008, and 2001 TWDB current bottom surfaces revealed several discrepancies within the 2008 bottom surface. Upon further investigation, discrepancies between overlapping data in the 2008 survey suggested an error occurred during the original processing of the data. Available field notes suggested a possible draft error. Using the cross-sectional comparisons of the three surveys, draft corrections were estimated and applied to the final 2008 survey data set. The original 2008 model boundary, digitized from aerial photographs taken between August 3, 2004, and August 4, 2004, while the daily average water surface elevations measured between 648.74 feet and 648.68 feet, was modified to include the 2009 LIDAR shoreline in the upper reaches within the Boyd (SE) quarter-quadrangle. Using the same interpolation definition file used for the 2018 survey, with minor edits to account for differences in data coverage and boundary conditions, anisotropic spatial interpolation was applied to the 2008 data to provide a new best estimate of the total reservoir capacity. Many contour segments digitized from aerial photographs taken on July 30, 2006, and August 19, 2006, while the water surface elevation measured 643.81 feet, and 2009 LIDAR points were also used in the new model.

While linear interpolation was used to estimate the topography in areas without data, flat triangles at contour elevation 643.81 feet led to anomalous area and volume calculations at elevations immediately above and below the contour. The TWDB evaluated the availability and distribution of survey data and the shape of the elevation-area curve to determine cubic spline interpolation of the areas between 641.0 and 643.85 feet, and 643.85 and 645.0 feet would best estimate the areas between these elevations. Volumes above 641.0 feet were calculated based on the corrected areas. The re-calculated 2008 elevation-capacity table and elevation-area table are presented in Appendices E and F, respectively. The re-calculated capacity curve is presented in Appendix G, and the area curve is presented in Appendix H.

Area, volume, and contour calculation

Using ArcInfo software and the volumetric TIN model, volumes and areas were computed for the entire reservoir at 0.1-foot intervals, from 599.0 to 649.4 feet. The elevation-capacity table and elevation-area table, based on the 2018 survey and analysis, are presented in Appendices I and J, respectively. The capacity curve is presented in Appendix K, and the area curve is presented in Appendix L.

The volumetric TIN model was converted to a raster representation using a cell size of 2 feet by 2 feet. The raster data then was 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 shaded depth ranges for Eagle Mountain Lake (Figure 5); and, (3) a 2-foot contour map (Figure 6).

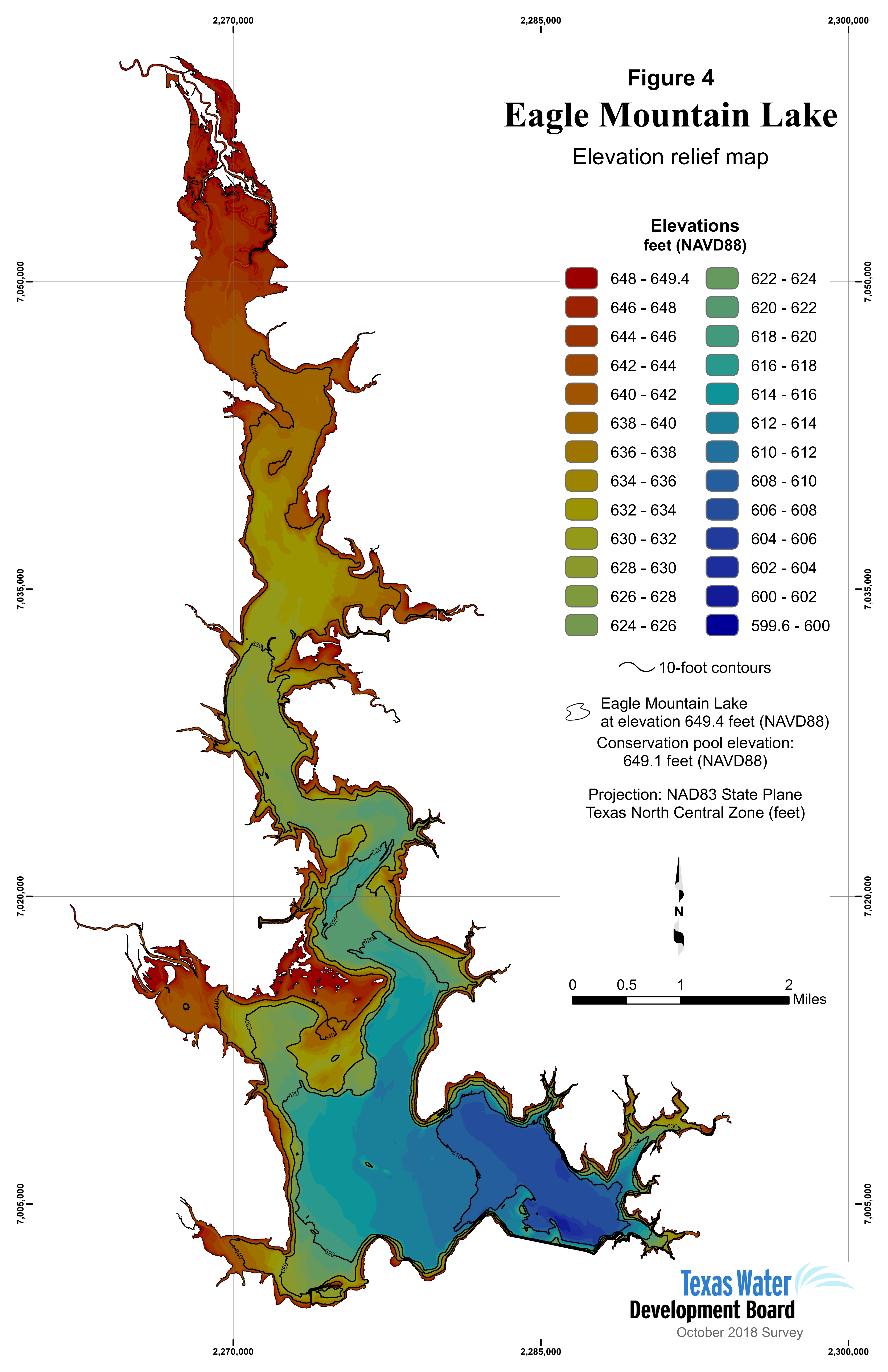

Figure 4

Eagle Mountain Lake

Elevation relief map

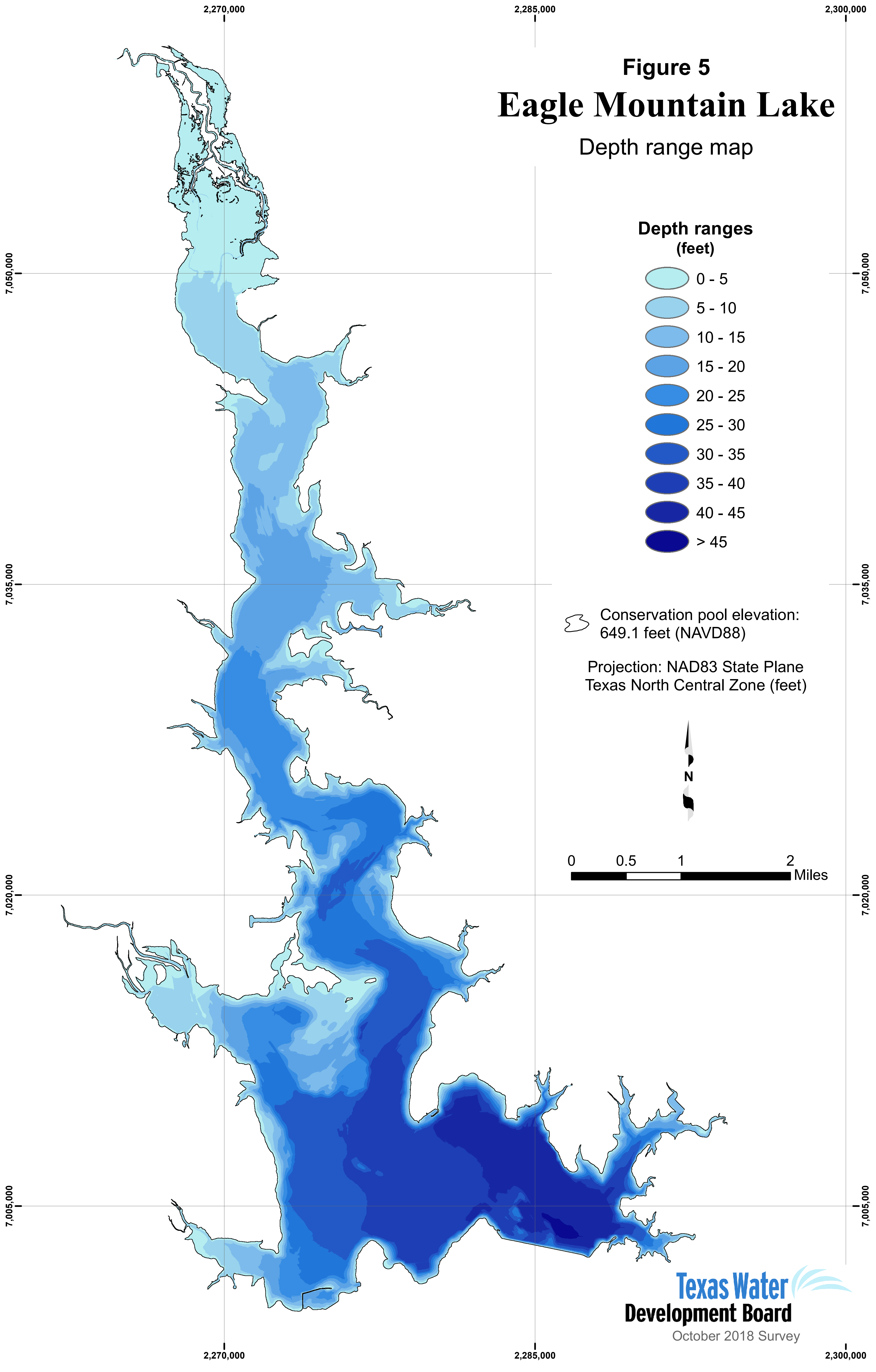
Figure 5
Eagle Mountain Lake
Depth range map
Depth ranges (feet)
0 - 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 45
> 45
Conservation pool elevation: 649.1 feet (NAVD88)
Projection: NAD83 State Plane Texas North Central Zone (feet)
N
0
0.5
1
2
Miles
2,270,000
2,285,000
2,300,000
7,050,000
7,035,000
7,020,000
7,005,000
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Analysis of sediment data from Eagle Mountain Lake

Sedimentation in Eagle Mountain Lake was determined by analyzing the acoustic signal returns of all three depth sounder frequencies using customized software called Hydropick. While the 208 kHz signal is used to determine the current bathymetric surface, the 208 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 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 soil color, texture, relative water content, and presence of organic materials were recorded (Table 2).

Table 2. Sediment core sample analysis data for Eagle Mountain Lake.

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample/ post-impoundment sediment	Sediment core description		Munsell soil color
EM-1	2268757.86	7048372.28	32.0"/ 2.5"	post-impoundment	0.0–2.5" high water content, chunky/globby texture, uniform color/consistency throughout	10YR 3/2 very dark grayish brown
				pre-impoundment	2.5–32.0" mostly clay, malleable (holds shape), water content decreases with depth, uniform color/texture throughout	10YR 4/1 dark gray
EM-2	2273041.34	7044543.89	78.5"/ 57.0"	post-impoundment	0.0–57.0" pudding like, color/texture consistent throughout, minimal organic material at 22.0 inches, decreasing water content with depth	10YR 2/1 black
				pre-impoundment	57.0–64.0" gritty texture, high water content, sticky (similar to peanut butter), uniform consistency	10YR 3/1 very dark gray
					64.0–78.5" all clay, dense and compact, holds shape, uniform color/consistency	10YR 4/1 dark gray
EM-3	2272682.53	7043091.67	18.5"/ 2.0"	post-impoundment	0.0–2.0" very sandy (gritty) silt, small pieces of shell/rock, uniform color throughout, loosely packed	2.5YR 4/2 dark grayish brown
				pre-impoundment	2.0–18.5" dense, very low water content, malleable, gritty, uniform color/texture throughout	2.5YR 4/6 red
EM-4	2272775.19	7035221.07	72.0"/ 53.0"	post-impoundment	0.0–2.0" pudding like, silty, smooth, very high water content, uniform color/texture	10YR 3/1 very dark gray
					2.0–35.0" smooth pudding like, uniform color/texture throughout, loosely packed material, high water content (less than previous layer)	10YR 3/1 very dark gray
					35.0–43.0" loosely packed, moderate water content, pudding like with thick grains of clay	10YR 2/1 black
					43.0–53.0" very smooth, sticky, moderate water content, will not hold shape, uniform color/texture throughout	10YR 3/1 very dark gray
				pre-impoundment	53.0–72.0" predominately clay, small bits of organic matter (roots), water content decreasing with depth	10YR 3/1 very dark gray

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

Table 2. Sediment core sample analysis data for Eagle Mountain Lake (continued).

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample/ post-impoundment sediment		Sediment core description	Munsell soil color
EM-5	2272192.57	7035514.80	34.5"/ 10"	post-impoundment	0–1.0" very high water content, smooth with grittiness, color consistent throughout	10YR 3/1 very dark gray
					0–10.0" high water content, clay present	10YR 3/1 black
				pre-impoundment	10.0–34.5" high water content decreasing to moderate at bottom, organic material present (woody debris), clay material present, sticky (similar to peanut butter)	10YR 2/1 black
EM-6	2272100.74	7026394.82	45.5"/N/A	post-impoundment	0.0–2.0" very high water content, smooth, uniform color/texture throughout, soupy consistency	10YR 3/1 very dark gray
					2.0–39.0" high water content, pudding like, smooth, uniform color/texture throughout	10YR 2/1 black
					39.0–45.5" high water content, uniform color/texture throughout, more dense than previous layers, pudding like, will somewhat hold shape	10YR 3/1 very dark gray
EM-7	2276040.19	7021372.62	27.25"/19.0"	post-impoundment	0.0–19.0" high water content, organic matter at 16 inches, smooth, uniform color/texture throughout, pudding like	2.5Y 3/3 dark olive brown
				pre-impoundment	19.0–27.25" very low water content, dense clay material, organic material present (roots, woody debris), water decreases throughout layer, uniform color/texture throughout	2.5Y 3/2
EM-8	2276534.47	7019459.50	35.5"/12.0"	post-impoundment	0.0–3.0" very high water content, soupy, uniform color/texture throughout, organic material present	10YR 3/2 very dark grayish brown
					3.0–12.0" high water content, soupy, uniform color/texture throughout, organic material present	10YR 3/2 very dark grayish brown
				pre-impoundment	12.0–35.5" moderate water content (decreasing throughout layer), organic material present (woody debris, roots), compacted sand	10YR 3/2 very dark grayish brown (top), 10YR 4/3 brown (bottom)

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

Table 2. Sediment core sample analysis data for Eagle Mountain Lake (continued).

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample/ post-impoundment sediment	Sediment core description		Munsell soil color
EM-9	2274482.95	7004556.66	87.75"/45.0"	post-impoundment	0.0–9.0" very high water content, soupy, smooth, uniform color/texture throughout	10YR 2/1 black
					9.0–45.0" high water content, pudding like, smooth texture, uniform color/texture throughout	10YR 2/1 black
				pre-impoundment	45.0–55.0" high water content (48.0"–55.0") decreasing to very low, uniform color/texture throughout, clay present, malleable, sticking	no color recorded
					55.0–87.75" high water content decreasing to very low, uniform color/texture throughout, clay present, malleable, sticking	no color recorded
EM-10	2284598.41	7007837.50	116.0"/94.0"	post-impoundment	0.0–29.0" high water content, pudding like, uniform color/texture throughout	10YR 3/1 very dark gray
					29.0–94.0" high water content, pudding like, more dense than previous layer, smooth, uniform color/texture throughout	10YR 3/1 very dark gray
				pre-impoundment	94.0–116.0" moderate water content decreasing to low, organic material present at top and bottom of layer, predominately clay, malleable, sediment at top of layer is sticky	10YR 2/1 black
EM-11	2272651.69	7010111.55	109.0"/52.0"	post-impoundment	0.0–39.0" high water content, pudding like, smooth, uniform color/texture throughout	10YR 3/1 very dark gray
					39.0–52.0 high water content, silt/sand mix, milkshake consistency, organic material (roots) present at bottom of layer, uniform color/texture throughout	10YR 3/2 very dark grayish brown
				pre-impoundment	52.0–94.0" low water content decreasing with depth, very dense, organic material present at top and middle (66.0") of layer, predominately compacted sand	10YR 5/3 brown
					94.0–109.0" very low water content, predominately clay, malleable, dense, organic material found throughout, uniform color/texture throughout	10YR 2/1 black

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

Table 2. Sediment core sample analysis data for Eagle Mountain Lake (continued).

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample/ post-impoundment sediment	Sediment core description		Munsell soil color
EM-12	2272640.39	7013199.46	116.0"/63.0"	post-impoundment	0.0–18.0" high water content, pudding like, smooth, organic material present (woody debris, roots)	10YR 3/1 very dark gray
					18.0–63.0" high water content (less than previous layer), smooth clumps of clay present throughout, pudding like, uniform color/texture throughout, more dense, sticky, organic material (rocks) present	10YR 3/1 very dark gray
				pre-impoundment	63.0–76.0" moderate water content, organic material present at top of layer, high concentration of clay, sticky, more dense than previous layer, sand mixed throughout (gritty), uniform color/texture throughout	10YR 2/1 black
					76.0–101.0" low water content, sand/clay mix, predominately sand, organic material present (roots), dense	10YR 3/1 very dark gray
					101.0–116.0" low to no water content, predominately clay, malleable, holds shape, organic material present (woody debris, roots), uniform color/texture throughout	10YR 2/1 black

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

A photograph of sediment core EM-9 (for location, refer to Figure 2) is shown in Figure 7 and is representative of sediment cores sampled from Eagle Mountain Lake. The base of the sample is denoted by the blue line. The pre-impoundment boundary (right most yellow line) was evident within this sediment core sample at 45.0 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.

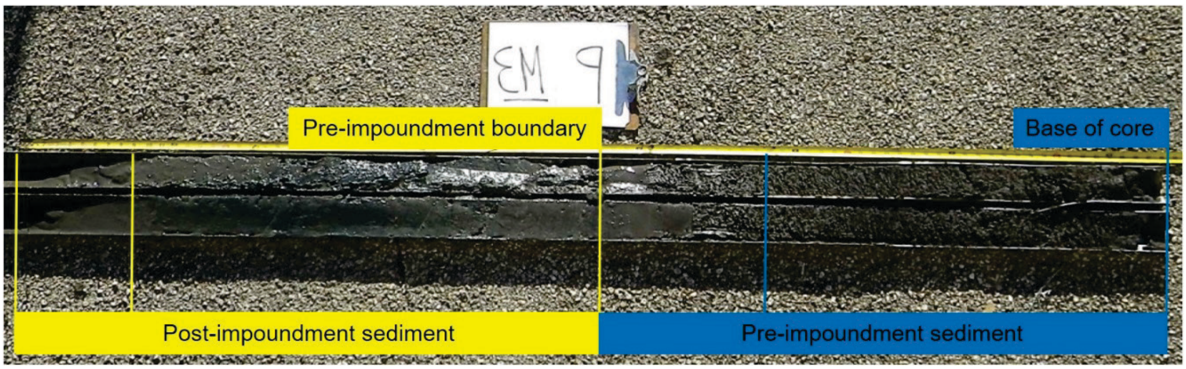

Figure 7. Sediment core EM-9 from Eagle Mountain Lake. Post-impoundment sediment layers occur in the top 45.0 inches of this sediment core (identified by the yellow box). Pre-impoundment sediment layers were identified and are defined by the blue box.

Figure 8 compares sediment core sample EM-9 with the acoustic signals as seen in Hydropick for each frequency: 208 kHz, 50 kHz, and 12 kHz. The current bathymetric surface is automatically determined based on signal returns from the 208 kHz transducer as represented by the top red line in Figure 8. The pre-impoundment surface is identified by comparing boundaries observed in the 208 kHz, 50 kHz, and 12 kHz signals to the location of the pre-impoundment surface of the sediment core sample. Many layers of sediment were 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. The boundary of each layer of sediment identified in the sediment core sample during analysis (Table 2) is represented in Figures 8 and 9 by a yellow or blue box. A yellow box represents post-impoundment sediments. A blue box indicates pre-impoundment sediments that were identified.

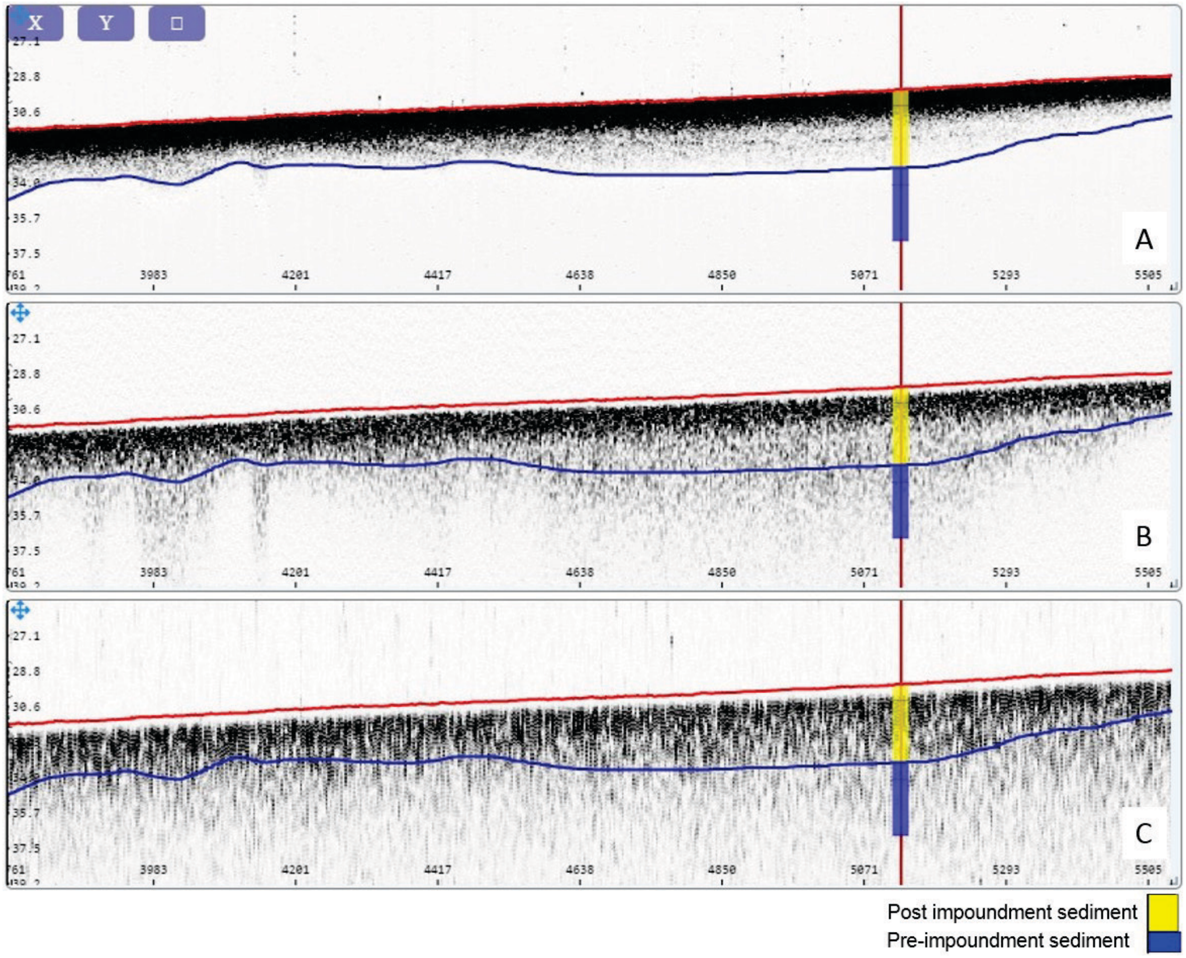

Figure 8. Comparison of sediment core EM-9 with acoustic signal returns. A) 208 kHz frequency, B) 50 kHz frequency, and C) 12 kHz frequency. The current surface in red and pre-impoundment surface in blue.

In this case, the boundary in the 208 kHz signal most closely matched the pre-impoundment interface of the sediment core sample; therefore, the 208 kHz signal was used to locate the pre-impoundment surface (blue line in the top panel in Figure 8). Figure 9 shows sediment core sample EM-9 correlated with the 208 kHz frequency of the nearest surveyed cross-section. The pre-impoundment surface is first identified along cross-sections for which sediment core samples have been collected. This information then is used as a guide for identifying the pre-impoundment surface along cross-sections where sediment core samples were not collected.

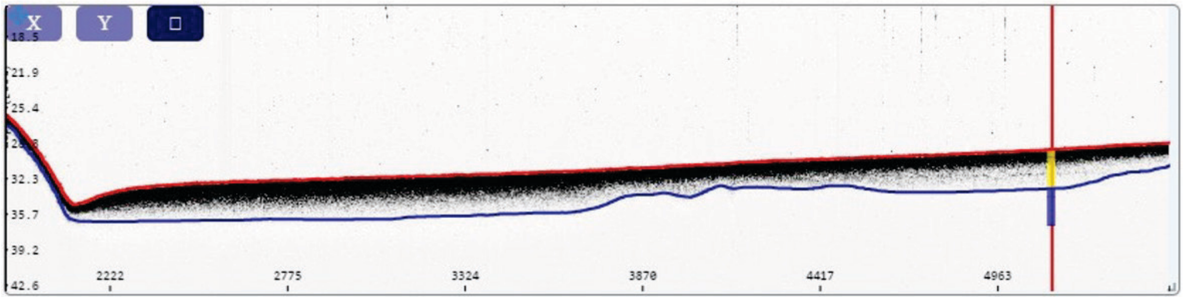

Figure 9. Cross-section of data collected during survey, displayed in Hydropick (208 kHz frequency), correlated with sediment core sample EM-9 and showing the current surface in red and pre-impoundment surface in blue.

The pre-impoundment surface was automatically generated in Hydropick using Otsu's thresholding algorithm of classifying greyscale intensity images into binary (black and white) images based on maximum inter-class variance. The acoustic return images of a selected frequency from each survey line were processed using this technique and the pre-impoundment surface was identified as the bottom black/white interface (where black is the sediment layer) of the resulting binary image (D. Pothina, written commun., 2014). The pre-impoundment surface then is verified and edited manually as needed.

Identification of the pre-impoundment surface can be challenging. Eagle Mountain Lake has periodically experienced low water levels leading to the desiccation of any exposed sediment. 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).

After the pre-impoundment surface for all cross-sections is identified, a pre-impoundment TIN model and a sediment thickness TIN model are created following standard GIS techniques (Furnans and Austin, 2007). 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 at each LIDAR data point and the reservoir boundary was 0 feet (defined as the 649.4-foot elevation contour). LIDAR data points overlapping survey data were deleted from the pre-impoundment and sediment thickness TIN models. The sediment thickness TIN model was converted to a raster representation using a cell size of 5 feet by 5 feet and was used to produce a sediment thickness map of Eagle Mountain Lake (Figure 10). Using ArcInfo software, the pre-impoundment TIN model was used to compute elevation-capacity and elevation-area tables for the purpose of calculating the total volume of accumulated sediment.

Although LIDAR and linear interpolation were used to estimate topography in areas inaccessible by boat or too shallow for the instruments to work properly, development of some flat triangles (triangles whose vertices all have the same elevation) in the pre-impoundment TIN model are unavoidable. The flat triangles and lack of pre-impoundment elevations for the LIDAR data led to anomalous calculations of the pre-impoundment surface area and volume for the higher elevations. The TWDB evaluated the availability and distribution of bathymetric survey data and the shape of the elevation-area curve to determine the highest pre-impoundment contour accurately modeled by survey data was 644.0 feet. To mitigate the effects of insufficient data in the upper elevations on area and volume calculations, areas between elevations 644.0 and 649.4 feet were linearly interpolated between the computed values, and volumes above elevation 644.0 feet were calculated based on the corrected areas.

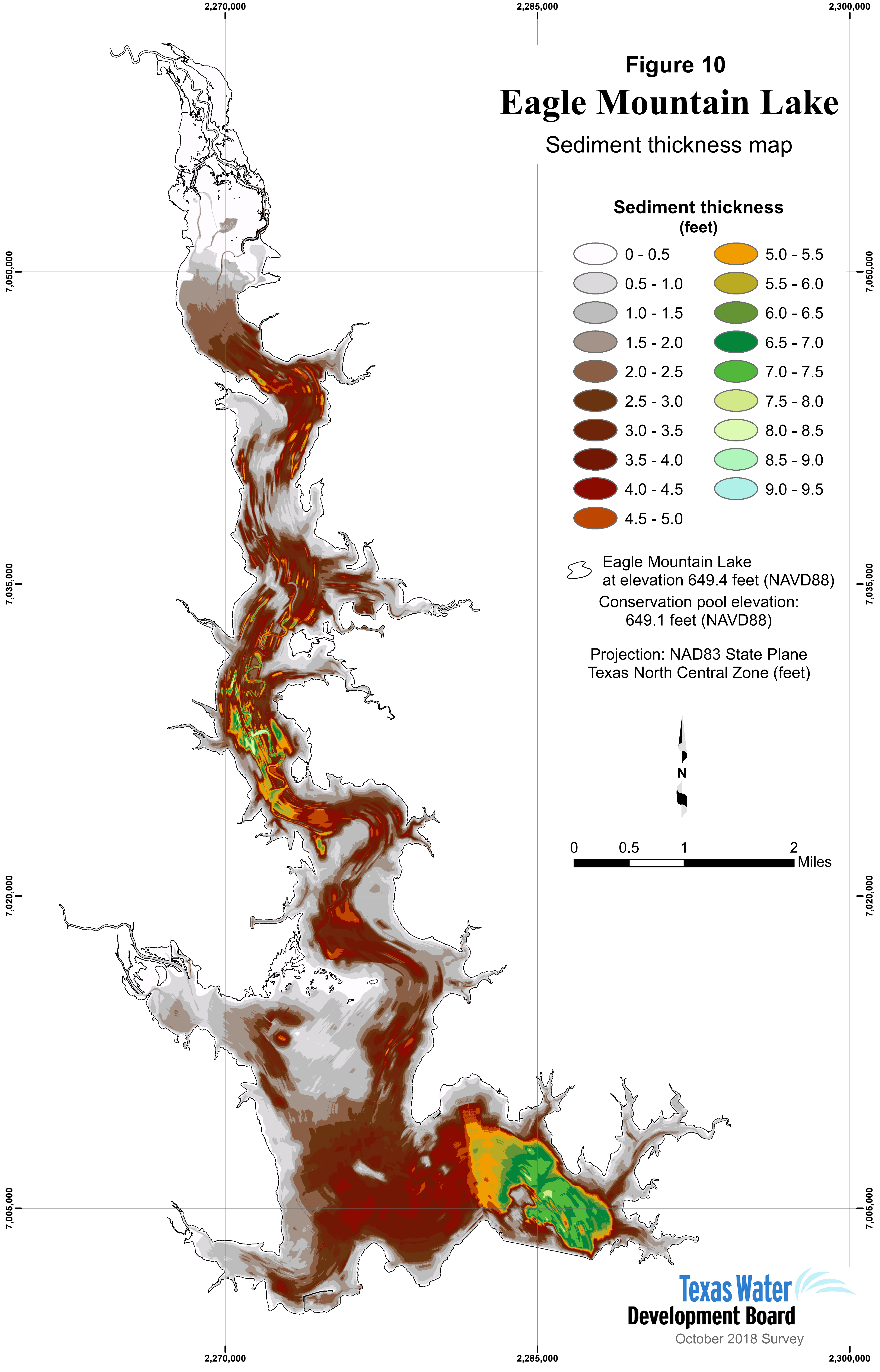

Figure 10
Eagle Mountain Lake
Sediment thickness map

Survey results

Volumetric survey

The 2018 TWDB volumetric survey indicates that Eagle Mountain Lake has a total reservoir capacity of 185,087 acre-feet and encompasses 9,246 acres at conservation pool elevation (649.1 feet NAVD88). Previous capacity estimates include three U.S. Department of Agriculture estimates of 211,000 acre-feet, 205,175 acre-feet and 182,000 acre-feet in 1934, 1939, and 1952, respectively, a 1968 U.S. Army Corps of Engineers estimate of 190,460 acre-feet, and a 1988 Freese and Nichols estimate of 178,440 acre-feet. Re-evaluation of the 2001 and 2008 TWDB surveys resulted in updated capacity estimates of 184,157 acre-feet and 187,387 acre-feet (Table 3). Differences in surface area are most likely attributable to differences in reservoir boundary delineation methods. Because of differences in past and present survey methodologies, direct comparison of volumetric surveys to others to estimate loss of area and capacity can be unreliable.

Table 3. Current and previous survey capacity and surface area estimates for Eagle Mountain Lake.

Top of conservation pool elevation (649.1 feet NAVD88)			
Survey	**Surface area (acres)**	**Total capacity (acre-feet)**	**Source**
1934	-	211,000	Dendy and Champion, 1969
1939	-	205,175	Dendy and Champion, 1969
1952	-	182,000	Dendy and Champion, 1969
1968	9,200	190,460	U.S. Army Corps of Engineers, 1968
1988	9,030	178,440	Freese and Nichols, 1988
TWDB 2001	8,702	182,505	Texas Water Development Board, 2001
TWDB 2001 (re-calculated)	8,737	184,157	Texas Water Development Board, 2016
TWDB 2008	8,694	179,880	Texas Water Development Board, 2008
TWDB 2008 (re-calculated)	9,132	187,387	
TWDB 2018	9,246	185,087	

Sedimentation survey

The 2018 TWDB sedimentation survey indicates Eagle Mountain Lake has lost capacity at an average of 260 acre-feet per year since impoundment due to sedimentation below conservation pool elevation (649.1 feet NAVD88). Long-term trends indicate Eagle Mountain Lake loses capacity at an average of 274 acre-feet per year since impoundment due to sedimentation below conservation pool elevation (649.1 feet NAVD88). The sedimentation survey indicates sediment accumulation is occurring throughout the reservoir. Comparison of capacity estimates of Eagle Mountain Lake derived using differing methodologies are provided in Table 4 for sedimentation rate calculation.

Table 4. Average annual capacity loss comparisons for Eagle Mountain Lake.

Survey	**Volume comparisons at top of conservation pool elevation 649.1 feet NAVD88 (acre-feet)**					
1934[a]	211,000	<>	<>	<>	<>	<>
1939[a]	<>	205,175	<>	<>	<>	<>
1968[b]	<>	<>	190,460	<>	<>	<>
TWDB 2001 (re-calculated)	<>	<>	<>	184,157	<>	<>
TWDB 2008 (re-calculated)	<>	<>	<>	<>	187,387	<>
TWDB pre-impoundment estimate based on 2018 survey	<>	<>	<>	<>	<>	206,914
2018 volumetric survey	185,087	185,087	185,087	185,087	185,087	185,087
Volume difference (acre-feet)	25,913 (12.3%)	20,088 (9.8%)	5,373 (2.8%)	-930 (-0.5%)	2,300 (1.2%)	21,827 (10.5%)
Number of years	84	79	50	17	10	84
Capacity loss rate (acre-feet/year)	308	254	107	-55	230	260
Capacity loss rate (acre-feet/square mile of drainage area of 1,970[a] square miles /year)	0.16	0.13	0.05	-0.03	0.12	0.13

[a] Source: (Dendy and Champion, 1969), note: Eagle Mountain Dam was completed in October 24, 1932, and the deliberate impoundment began on February 28, 1934.
[b] Source: U.S. Army Corps of Engineers, 1968.

To account for short-term variances in sedimentation rate, the TWDB generated a trend line utilizing the pre-impoundment value identified in the 2018 survey and all TWDB volumetric estimates generated in 2001, 2008, and 2018 to show the sedimentation rate trend since impoundment. The 1934, 1939, 1952, 1968 and 1988 estimates were not considered in the long-term rate calculation. Results show a 274 acre-feet per year sedimentation rate and are shown in Figure 11.

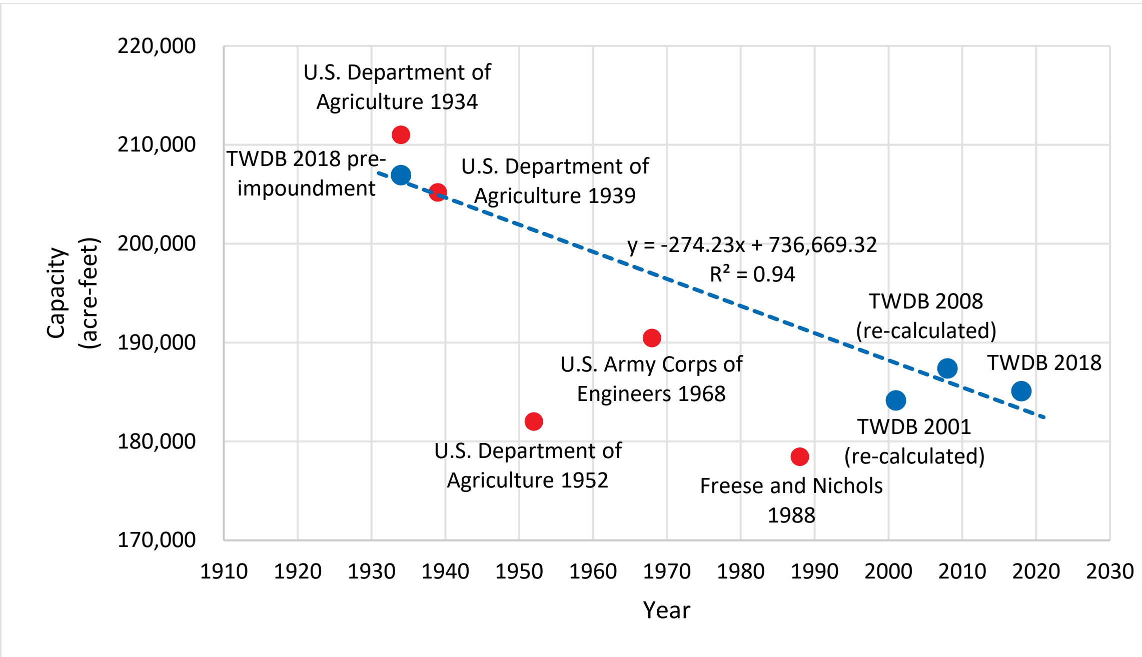

Figure 11. **Plot of current and previous capacity estimates (acre-feet) for Eagle Mountain Lake. Capacity estimates for each TWDB survey plotted as blue dots and other surveys as red dots. The blue trend line illustrates the total average loss of capacity through 2018.**

Sediment range lines

In 2001, the TWDB established seventeen sediment range lines throughout Eagle Mountain Lake to measure sediment accumulation over time. A cross-sectional comparison of the seventeen sediment range lines comparing the current bottom surface from the 2018 TWDB survey, the 2008 TWDB re-calculated survey, and the 2001 TWDB re-calculated survey is presented in Appendix M. Also presented in Appendix M are a map, depicting the locations of the sediment range lines and Table M1, a list of the endpoint coordinates for each line. Some differences in the cross-sections may be a result of spatial interpolation and the interpolation routine of the TIN Model.

Axial profile

At the request of the Tarrant Regional Water District, the TWDB surveyed the axial profile of the reservoir. This profile showing both the 2018 current and pre-impoundment surfaces is plotted in Appendix N. Also presented in Appendix N are a map, depicting the TWDB location of the axial profile, and a table listing the coordinates of each vertex defining the axial line.

Identification of the pre-impoundment surface on the axial profile was based on the acoustic returns identified in the cross-sections where sediment cores were collected. Sediment core sites were selected to recollect cores where previously collected in 2008 and to correlate with unique acoustic returns throughout the reservoir. Axial profile data points within 1.5 feet of survey data points were compared to refine identification of the pre-impoundment surface along survey transects. Pre-impoundment acoustic signature interpretation was refined based on the agreement between intersecting data and applied during pre-impoundment identifications throughout the reservoir.

Recommendations

The TWDB recommends a detailed analysis of sediment deposits in the areas where exposure of the lake bottom may have led to identification of a false pre-impoundment using augured-coring techniques, as well as a volumetric and sedimentation survey in 10 years or after a major flood event to further improve estimates of sediment accumulation rates.

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:

Hydrosurvey@twdb.texas.gov

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Appendix A

Eagle Mountain Lake

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — May 2001 Survey re-calculated October 2016

CAPACITY IN ACRE-FEET — Conservation pool elevation 649.1 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
598	0	0	0	0	0	0	0	0	0	0
599	0	1	1	1	1	1	2	2	2	3
600	3	4	4	5	6	6	7	8	9	10
601	11	12	13	14	15	17	18	20	21	23
602	24	26	28	30	32	34	36	38	40	43
603	45	47	50	53	56	59	62	65	68	72
604	76	80	84	89	94	100	106	112	119	127
605	136	146	158	173	190	210	233	258	286	315
606	347	380	414	450	488	526	567	608	652	696
607	742	790	838	888	939	991	1,045	1,100	1,156	1,214
608	1,272	1,332	1,393	1,456	1,519	1,584	1,650	1,718	1,786	1,855
609	1,925	1,997	2,069	2,143	2,219	2,297	2,376	2,457	2,540	2,624
610	2,710	2,797	2,887	2,979	3,073	3,169	3,268	3,369	3,472	3,578
611	3,686	3,795	3,906	4,019	4,136	4,256	4,379	4,505	4,635	4,767
612	4,902	5,040	5,180	5,323	5,469	5,617	5,768	5,921	6,076	6,233
613	6,392	6,553	6,716	6,881	7,048	7,217	7,388	7,561	7,737	7,916
614	8,097	8,280	8,465	8,653	8,843	9,036	9,231	9,429	9,629	9,831
615	10,035	10,242	10,450	10,659	10,871	11,084	11,299	11,516	11,735	11,956
616	12,180	12,405	12,632	12,861	13,092	13,324	13,558	13,793	14,029	14,267
617	14,507	14,747	14,989	15,232	15,477	15,723	15,970	16,218	16,468	16,720
618	16,973	17,227	17,483	17,740	17,998	18,258	18,519	18,782	19,046	19,312
619	19,579	19,847	20,117	20,389	20,663	20,937	21,213	21,491	21,770	22,050
620	22,332	22,615	22,902	23,190	23,482	23,775	24,070	24,366	24,664	24,964
621	25,265	25,568	25,872	26,178	26,485	26,794	27,105	27,417	27,731	28,047
622	28,364	28,683	29,003	29,324	29,647	29,971	30,297	30,623	30,951	31,280
623	31,609	31,940	32,272	32,605	32,939	33,273	33,609	33,947	34,285	34,625
624	34,967	35,310	35,655	36,001	36,348	36,697	37,047	37,399	37,751	38,106
625	38,462	38,819	39,178	39,539	39,901	40,265	40,631	40,998	41,368	41,740
626	42,114	42,489	42,867	43,247	43,628	44,011	44,396	44,782	45,169	45,558
627	45,949	46,342	46,736	47,132	47,531	47,931	48,333	48,738	49,144	49,554
628	49,966	50,379	50,796	51,214	51,635	52,058	52,483	52,912	53,342	53,775
629	54,209	54,646	55,084	55,524	55,966	56,409	56,854	57,300	57,748	58,197
630	58,648	59,101	59,555	60,011	60,469	60,928	61,388	61,850	62,314	62,779
631	63,245	63,714	64,184	64,656	65,130	65,607	66,086	66,567	67,051	67,537
632	68,025	68,515	69,007	69,501	69,997	70,494	70,994	71,497	72,001	72,507
633	73,016	73,527	74,040	74,555	75,073	75,593	76,116	76,643	77,172	77,703
634	78,238	78,775	79,314	79,857	80,401	80,948	81,498	82,049	82,603	83,158
635	83,715	84,274	84,835	85,397	85,961	86,527	87,094	87,663	88,233	88,805
636	89,379	89,954	90,531	91,110	91,690	92,271	92,854	93,439	94,026	94,615
637	95,205	95,798	96,392	96,988	97,586	98,186	98,788	99,394	100,001	100,612
638	101,225	101,840	102,457	103,075	103,695	104,317	104,941	105,567	106,195	106,826
639	107,459	108,094	108,731	109,371	110,013	110,657	111,302	111,951	112,602	113,257
640	113,917	114,580	115,248	115,919	116,594	117,271	117,950	118,632	119,316	120,003
641	120,692	121,386	122,085	122,789	123,496	124,204	124,915	125,627	126,341	127,056
642	127,773	128,491	129,211	129,932	130,656	131,382	132,109	132,838	133,570	134,303
643	135,038	135,775	136,514	137,255	137,998	138,743	139,489	140,238	140,989	141,742
644	142,497	143,254	144,013	144,774	145,538	146,304	147,072	147,844	148,617	149,394
645	150,173	150,954	151,738	152,524	153,312	154,103	154,897	155,694	156,493	157,296
646	158,101	158,908	159,719	160,531	161,346	162,163	162,982	163,804	164,627	165,453
647	166,281	167,111	167,943	168,777	169,613	170,452	171,292	172,135	172,980	173,827
648	174,676	175,527	176,380	177,236	178,094	178,954	179,815	180,680	181,546	182,414
649	183,285	184,157								

Note: Capacities above elevation 647.0 feet calculated from interpolated areas

Appendix B

Eagle Mountain Lake

RESERVOIR AREA TABLE

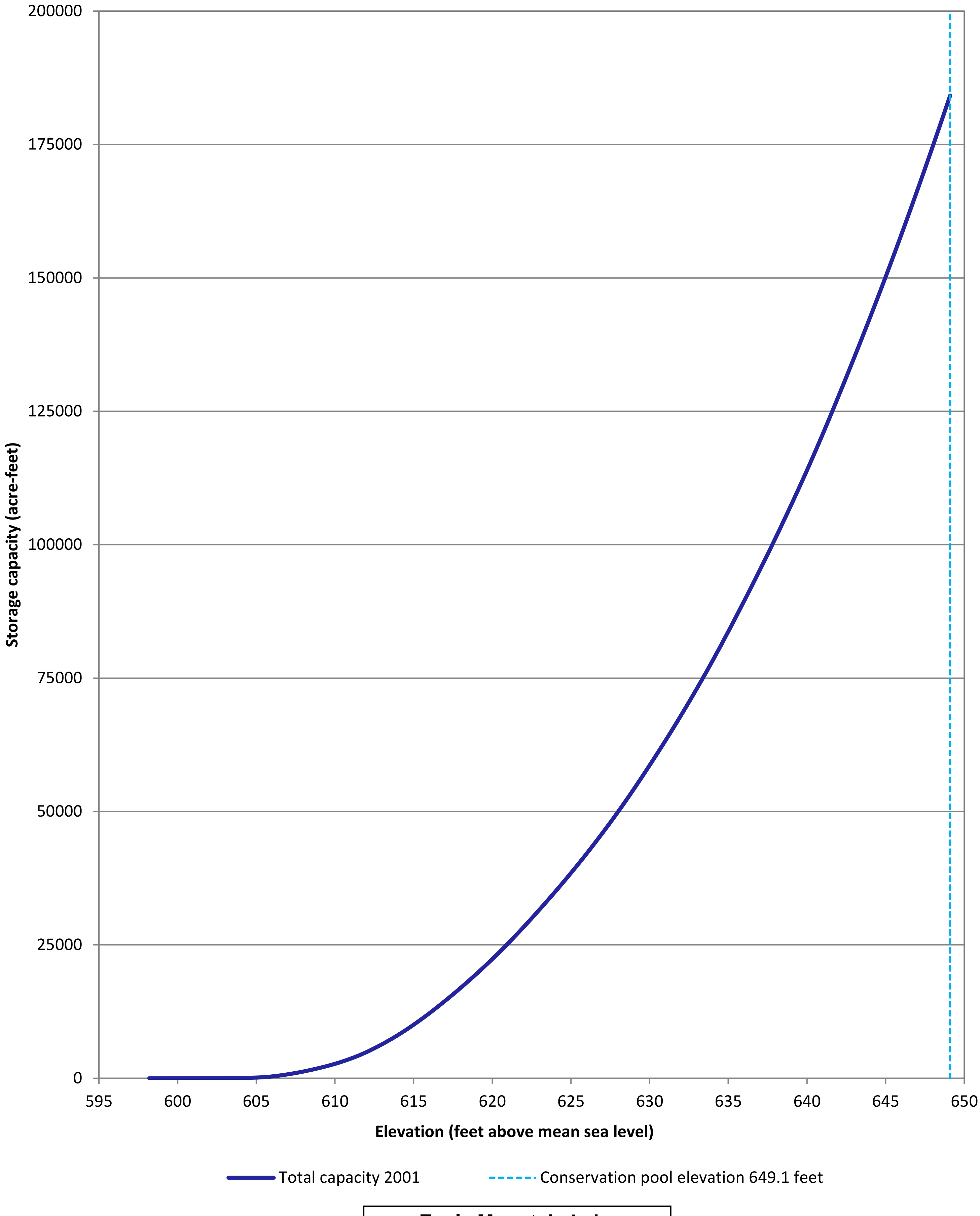
TEXAS WATER DEVELOPMENT BOARD — May 2001 Survey re-calculated October 2016

AREA IN ACRES — Conservation pool elevation 649.1 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

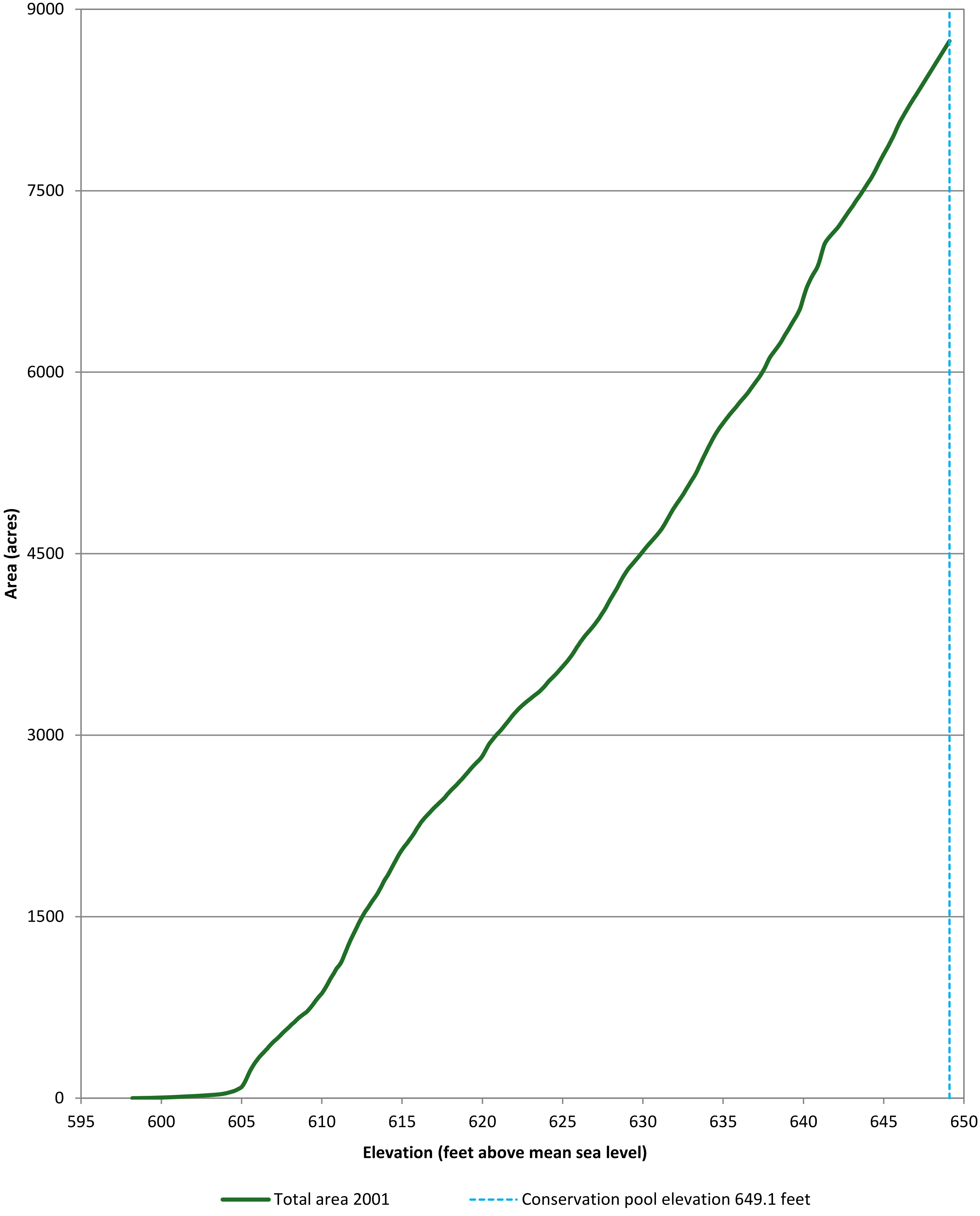
ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
598	0	0	0	0	0	0	0	1	1	1
599	1	2	2	2	2	3	3	4	4	5
600	5	5	6	6	7	7	8	8	9	9
601	10	11	12	12	13	14	14	15	16	16
602	17	17	18	19	20	21	21	22	23	24
603	25	26	27	28	29	30	31	33	35	37
604	40	43	46	50	54	57	63	69	76	82
605	92	109	132	159	189	217	242	264	285	304
606	321	338	354	367	381	396	409	426	440	454
607	467	479	490	503	516	530	544	556	568	580
608	593	607	618	629	643	656	667	678	688	698
609	707	719	734	749	766	783	803	819	836	851
610	865	885	906	929	953	978	1,000	1,021	1,043	1,068
611	1,084	1,101	1,121	1,150	1,183	1,215	1,248	1,279	1,309	1,336
612	1,364	1,391	1,417	1,446	1,471	1,496	1,519	1,541	1,560	1,579
613	1,600	1,620	1,640	1,658	1,677	1,698	1,723	1,747	1,774	1,800
614	1,821	1,841	1,865	1,890	1,914	1,940	1,963	1,989	2,012	2,034
615	2,053	2,072	2,089	2,105	2,124	2,142	2,160	2,179	2,200	2,223
616	2,243	2,263	2,283	2,299	2,315	2,329	2,344	2,357	2,372	2,387
617	2,400	2,413	2,425	2,439	2,451	2,463	2,476	2,491	2,508	2,523
618	2,537	2,551	2,564	2,577	2,591	2,605	2,619	2,633	2,648	2,664
619	2,679	2,694	2,710	2,726	2,740	2,755	2,768	2,781	2,794	2,809
620	2,827	2,850	2,874	2,899	2,923	2,941	2,957	2,974	2,990	3,005
621	3,020	3,033	3,049	3,065	3,081	3,098	3,114	3,131	3,149	3,165
622	3,181	3,194	3,209	3,223	3,235	3,247	3,259	3,270	3,281	3,292
623	3,302	3,313	3,324	3,334	3,344	3,354	3,366	3,380	3,393	3,407
624	3,424	3,440	3,454	3,467	3,480	3,494	3,507	3,522	3,537	3,552
625	3,567	3,583	3,598	3,613	3,631	3,648	3,666	3,686	3,708	3,729
626	3,748	3,769	3,786	3,805	3,822	3,837	3,853	3,868	3,884	3,900
627	3,917	3,934	3,953	3,971	3,993	4,013	4,033	4,056	4,081	4,105
628	4,129	4,151	4,173	4,195	4,218	4,243	4,269	4,293	4,316	4,337
629	4,357	4,376	4,392	4,407	4,423	4,439	4,454	4,470	4,486	4,503
630	4,519	4,536	4,552	4,568	4,583	4,598	4,613	4,628	4,643	4,659
631	4,675	4,692	4,710	4,731	4,754	4,778	4,801	4,825	4,848	4,871
632	4,890	4,911	4,930	4,949	4,968	4,988	5,010	5,033	5,054	5,076
633	5,098	5,119	5,140	5,164	5,190	5,220	5,247	5,276	5,303	5,330
634	5,357	5,384	5,409	5,435	5,460	5,483	5,504	5,525	5,544	5,562
635	5,580	5,598	5,615	5,632	5,649	5,665	5,681	5,696	5,711	5,729
636	5,746	5,761	5,777	5,791	5,807	5,823	5,841	5,859	5,878	5,896
637	5,914	5,933	5,950	5,969	5,991	6,013	6,037	6,065	6,093	6,119
638	6,139	6,157	6,175	6,192	6,211	6,230	6,249	6,272	6,296	6,318
639	6,339	6,360	6,384	6,407	6,429	6,450	6,473	6,499	6,528	6,570
640	6,616	6,658	6,697	6,728	6,757	6,783	6,807	6,829	6,851	6,879
641	6,918	6,965	7,012	7,054	7,079	7,098	7,114	7,130	7,145	7,160
642	7,175	7,189	7,207	7,225	7,245	7,265	7,284	7,304	7,324	7,342
643	7,360	7,379	7,400	7,420	7,439	7,458	7,477	7,498	7,519	7,539
644	7,560	7,580	7,600	7,623	7,647	7,673	7,699	7,726	7,752	7,777
645	7,801	7,825	7,849	7,872	7,898	7,924	7,950	7,979	8,010	8,038
646	8,066	8,090	8,113	8,136	8,159	8,182	8,204	8,226	8,247	8,269
647	8,288	8,309	8,331	8,352	8,373	8,395	8,416	8,438	8,459	8,480
648	8,502	8,523	8,545	8,566	8,587	8,609	8,630	8,652	8,673	8,694
649	8,716	8,737								

Note: Areas between elevations 647.0 and 649.1 feet linearly interpolated



Eagle Mountain Lake
May 2001 Survey
re-calculated October 2016
Prepared by: TWDB

Appendix C: Capacity curve



Eagle Mountain Lake
May 2001 Survey
re-calculated October 2016
Prepared by: TWDB

Appendix D: Area curve

Appendix E

Eagle Mountain Lake

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD | February 2008 Survey re-calculated October 2018

CAPACITY IN ACRE-FEET | Conservation pool elevation 649.1 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
598	0	0	0	0	0	0	0	0	0	0
599	0	0	0	0	0	0	0	0	0	0
600	1	1	1	1	2	2	3	3	4	5
601	5	6	7	8	9	11	12	13	14	15
602	17	18	20	22	23	25	27	29	31	33
603	35	37	39	42	44	47	49	52	55	58
604	61	64	67	71	74	78	82	86	90	94
605	100	106	112	119	127	136	146	157	170	184
606	202	222	245	270	297	326	357	390	424	461
607	499	539	580	623	667	713	760	808	857	908
608	959	1,012	1,066	1,121	1,178	1,236	1,295	1,356	1,418	1,481
609	1,546	1,612	1,679	1,747	1,817	1,889	1,962	2,037	2,112	2,189
610	2,268	2,348	2,430	2,514	2,601	2,690	2,781	2,875	2,971	3,070
611	3,170	3,273	3,378	3,485	3,594	3,704	3,817	3,934	4,054	4,178
612	4,306	4,437	4,572	4,710	4,852	4,997	5,144	5,294	5,446	5,601
613	5,758	5,918	6,080	6,244	6,410	6,579	6,749	6,922	7,098	7,276
614	7,458	7,642	7,829	8,019	8,212	8,407	8,605	8,806	9,009	9,215
615	9,423	9,634	9,847	10,062	10,279	10,498	10,718	10,941	11,164	11,390
616	11,617	11,847	12,078	12,311	12,546	12,782	13,021	13,260	13,501	13,743
617	13,986	14,231	14,477	14,725	14,975	15,226	15,478	15,732	15,986	16,242
618	16,499	16,758	17,017	17,278	17,541	17,804	18,070	18,337	18,605	18,875
619	19,146	19,418	19,692	19,967	20,244	20,522	20,802	21,083	21,366	21,651
620	21,937	22,226	22,517	22,810	23,105	23,401	23,699	23,999	24,300	24,602
621	24,906	25,211	25,517	25,825	26,135	26,447	26,760	27,075	27,392	27,709
622	28,029	28,349	28,671	28,994	29,319	29,644	29,971	30,299	30,627	30,957
623	31,288	31,621	31,954	32,289	32,626	32,963	33,302	33,642	33,984	34,327
624	34,671	35,017	35,364	35,713	36,064	36,416	36,771	37,127	37,484	37,844
625	38,205	38,568	38,933	39,300	39,669	40,039	40,412	40,786	41,161	41,539
626	41,918	42,298	42,681	43,065	43,451	43,838	44,227	44,618	45,011	45,407
627	45,805	46,204	46,607	47,011	47,417	47,825	48,236	48,649	49,064	49,482
628	49,901	50,323	50,749	51,177	51,607	52,039	52,472	52,908	53,345	53,784
629	54,225	54,667	55,111	55,556	56,003	56,451	56,901	57,353	57,805	58,260
630	58,715	59,173	59,632	60,093	60,556	61,020	61,485	61,952	62,421	62,893
631	63,366	63,840	64,318	64,796	65,277	65,760	66,245	66,732	67,222	67,714
632	68,207	68,702	69,199	69,697	70,198	70,700	71,204	71,711	72,220	72,732
633	73,247	73,765	74,287	74,812	75,341	75,873	76,408	76,947	77,489	78,035
634	78,584	79,136	79,691	80,247	80,805	81,365	81,926	82,489	83,053	83,619
635	84,186	84,755	85,326	85,898	86,472	87,047	87,624	88,203	88,784	89,367
636	89,951	90,538	91,126	91,716	92,308	92,902	93,498	94,097	94,697	95,300
637	95,905	96,512	97,122	97,733	98,348	98,964	99,582	100,203	100,826	101,452
638	102,080	102,710	103,343	103,978	104,617	105,258	105,901	106,546	107,194	107,845
639	108,498	109,153	109,811	110,471	111,134	111,798	112,464	113,132	113,803	114,479
640	115,158	115,840	116,526	117,213	117,904	118,597	119,293	119,992	120,694	121,399
641	122,107	122,818	123,531	124,246	124,964	125,684	126,406	127,131	127,858	128,587
642	129,319	130,052	130,789	131,527	132,268	133,011	133,757	134,505	135,255	136,008
643	136,762	137,520	138,279	139,041	139,805	140,572	141,340	142,112	142,885	143,661
644	144,439	145,220	146,003	146,788	147,576	148,366	149,158	149,953	150,750	151,550
645	152,352	153,157	153,963	154,772	155,583	156,397	157,213	158,031	158,852	159,675
646	160,501	161,328	162,158	162,991	163,825	164,662	165,501	166,342	167,186	168,032
647	168,881	169,732	170,585	171,441	172,300	173,161	174,026	174,893	175,763	176,637
648	177,513	178,392	179,275	180,160	181,049	181,941	182,836	183,734	184,635	185,539
649	186,447	187,359								

Note: Capacities above elevation 641.0 feet calculated from interpolated areas

Appendix F

Eagle Mountain Lake

RESERVOIR AREA TABLE

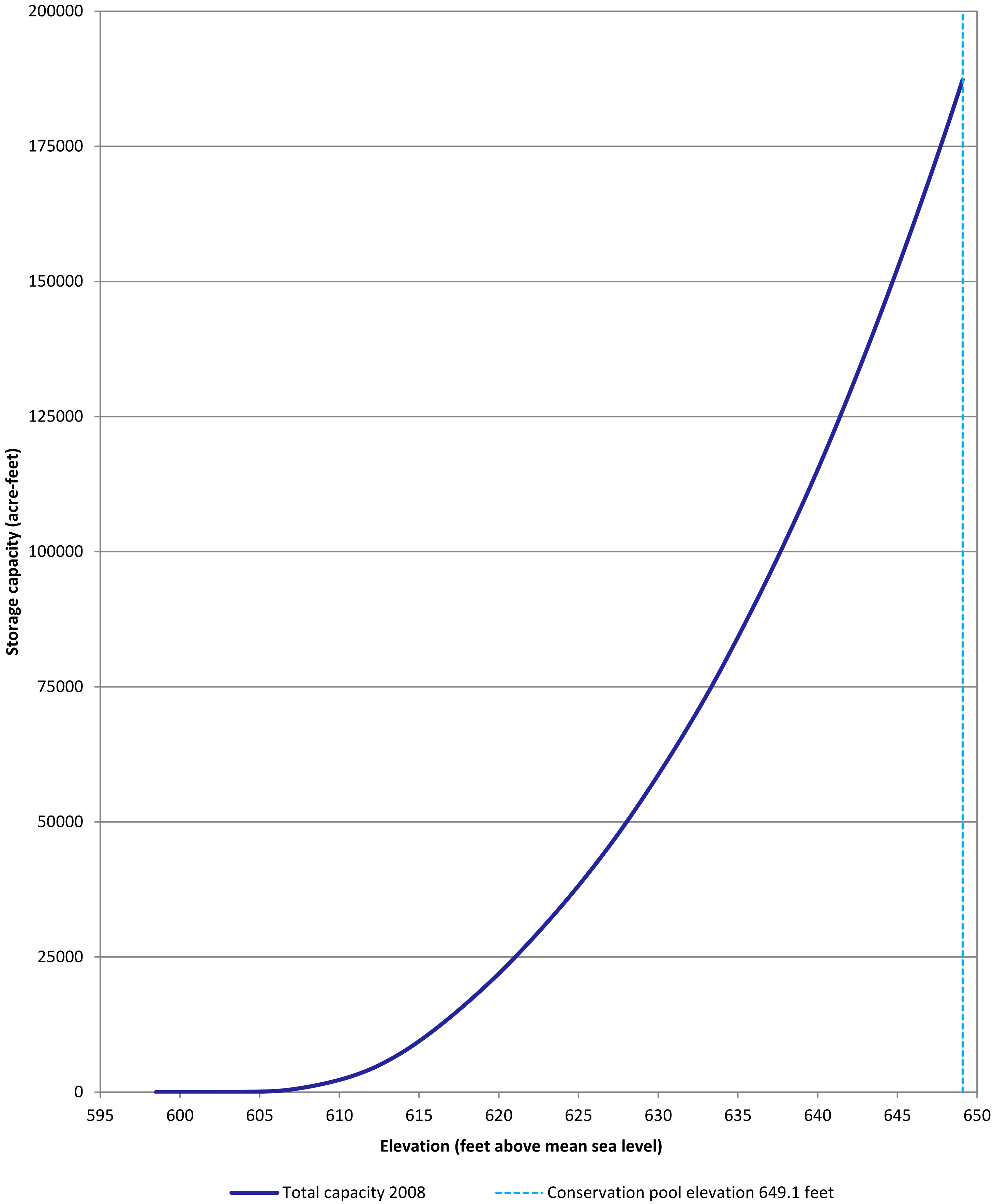
TEXAS WATER DEVELOPMENT BOARD — February 2008 Survey re-calculated October 2018

AREA IN ACRES — Conservation pool elevation 649.1 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

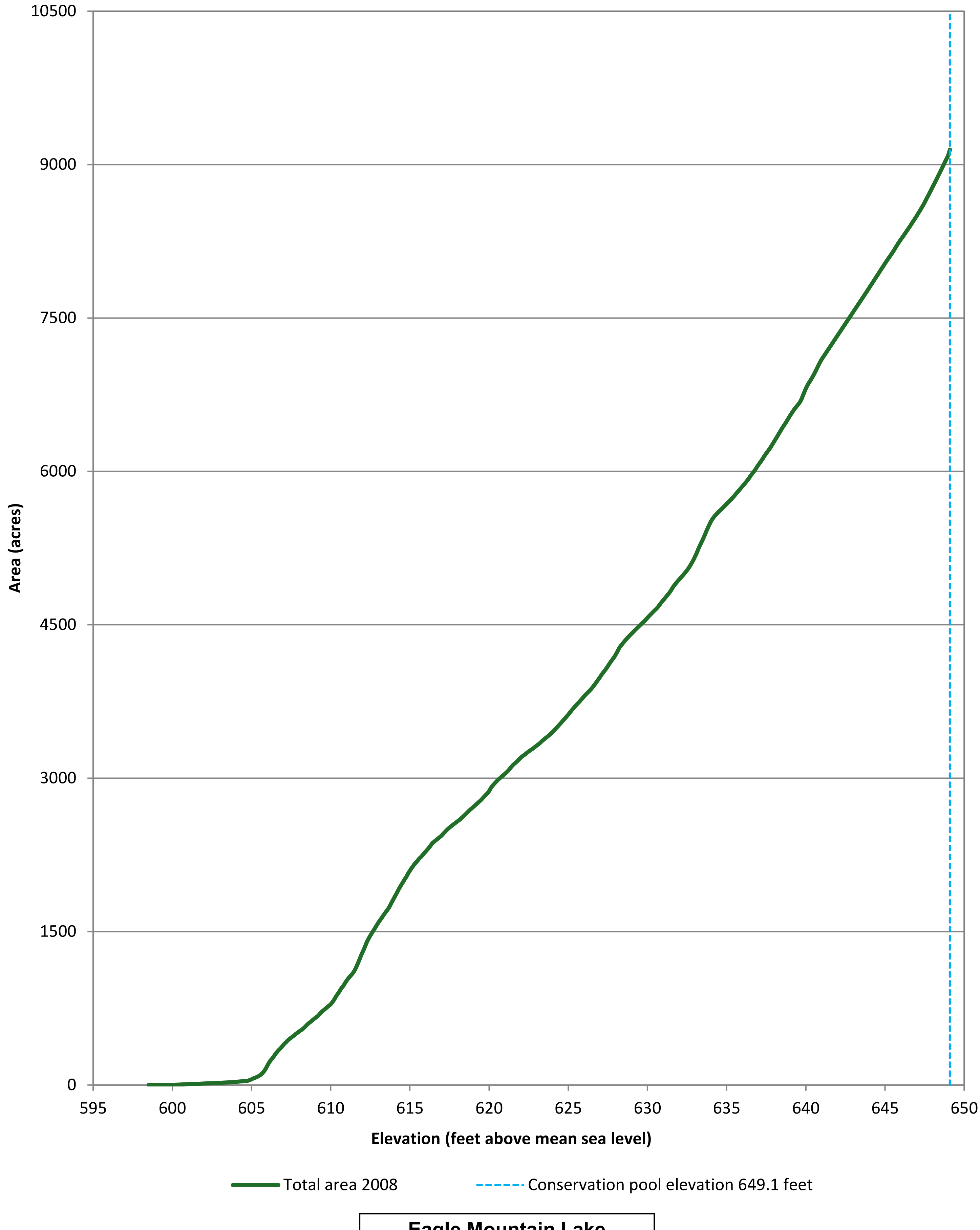
ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
598	0	0	0	0	0	0	0	0	0	0
599	0	0	0	0	0	0	1	1	1	1
600	2	2	3	3	4	5	5	6	7	8
601	9	9	10	10	11	11	12	12	13	14
602	15	15	16	16	17	18	19	19	20	21
603	22	22	23	24	25	25	26	27	29	30
604	31	32	34	35	36	37	39	41	43	49
605	56	64	69	76	83	92	103	118	137	160
606	190	216	240	258	278	302	321	339	354	370
607	390	407	421	438	450	462	475	486	500	511
608	523	533	544	557	572	588	602	614	627	641
609	652	664	676	693	710	725	737	751	764	777
610	789	808	830	857	881	903	927	952	970	996
611	1,019	1,040	1,058	1,076	1,094	1,118	1,148	1,183	1,221	1,259
612	1,296	1,329	1,366	1,403	1,433	1,460	1,486	1,511	1,535	1,560
613	1,585	1,608	1,629	1,652	1,675	1,695	1,716	1,741	1,771	1,799
614	1,828	1,857	1,885	1,915	1,942	1,967	1,994	2,018	2,042	2,072
615	2,095	2,119	2,140	2,161	2,178	2,197	2,216	2,230	2,248	2,266
616	2,283	2,302	2,319	2,339	2,361	2,375	2,388	2,401	2,413	2,426
617	2,438	2,456	2,472	2,488	2,503	2,517	2,530	2,542	2,554	2,565
618	2,577	2,589	2,602	2,616	2,631	2,645	2,661	2,677	2,691	2,704
619	2,718	2,732	2,745	2,760	2,774	2,787	2,805	2,821	2,838	2,853
620	2,874	2,900	2,923	2,941	2,957	2,974	2,988	3,003	3,016	3,029
621	3,043	3,057	3,072	3,090	3,110	3,127	3,141	3,155	3,169	3,185
622	3,201	3,214	3,225	3,236	3,250	3,261	3,272	3,283	3,293	3,306
623	3,318	3,330	3,341	3,357	3,370	3,383	3,396	3,408	3,421	3,435
624	3,450	3,465	3,483	3,499	3,516	3,533	3,551	3,568	3,585	3,603
625	3,621	3,641	3,661	3,678	3,697	3,714	3,731	3,747	3,764	3,781
626	3,800	3,817	3,833	3,848	3,864	3,882	3,902	3,922	3,944	3,965
627	3,987	4,011	4,032	4,052	4,072	4,095	4,119	4,142	4,162	4,183
628	4,209	4,237	4,267	4,290	4,310	4,329	4,347	4,365	4,382	4,398
629	4,413	4,429	4,445	4,461	4,476	4,491	4,506	4,521	4,535	4,551
630	4,568	4,585	4,601	4,617	4,632	4,647	4,662	4,680	4,702	4,722
631	4,740	4,759	4,778	4,797	4,817	4,839	4,865	4,886	4,906	4,924
632	4,942	4,960	4,977	4,995	5,014	5,033	5,055	5,078	5,105	5,133
633	5,165	5,197	5,236	5,270	5,304	5,335	5,370	5,407	5,443	5,475
634	5,507	5,533	5,554	5,572	5,589	5,605	5,620	5,635	5,650	5,666
635	5,682	5,698	5,713	5,728	5,745	5,763	5,782	5,800	5,818	5,836
636	5,854	5,872	5,891	5,910	5,930	5,954	5,974	5,994	6,015	6,039
637	6,062	6,084	6,105	6,129	6,153	6,176	6,197	6,218	6,241	6,267
638	6,292	6,317	6,342	6,369	6,395	6,421	6,444	6,468	6,492	6,518
639	6,543	6,567	6,591	6,612	6,631	6,651	6,671	6,697	6,734	6,771
640	6,809	6,841	6,866	6,891	6,916	6,945	6,974	7,005	7,037	7,067
641	7,095	7,118	7,141	7,165	7,188	7,211	7,234	7,258	7,281	7,304
642	7,328	7,351	7,374	7,397	7,421	7,444	7,467	7,490	7,514	7,537
643	7,560	7,583	7,607	7,630	7,653	7,677	7,700	7,723	7,746	7,770
644	7,794	7,818	7,842	7,865	7,889	7,913	7,937	7,961	7,985	8,009
645	8,033	8,056	8,078	8,101	8,123	8,146	8,171	8,196	8,221	8,245
646	8,267	8,289	8,311	8,334	8,356	8,379	8,402	8,426	8,449	8,473
647	8,497	8,522	8,548	8,574	8,600	8,628	8,659	8,688	8,718	8,748
648	8,779	8,809	8,840	8,871	8,902	8,933	8,964	8,996	9,028	9,061
649	9,094	9,147								

Note: Areas between elevations 641.0 and 643.85 feet, and 643.85 and 645.0 feet adjusted using cubic spline interpolation. Values used for cubic spline interpolation equal to average of computed values at 0.1-foot increments.



Eagle Mountain Lake
February 2008 Survey
re-calculated October 2018
Prepared by: TWDB

Appendix G: Capacity curve



Eagle Mountain Lake
February 2008 Survey
re-calculated October 2018
Prepared by: TWDB

Appendix H: Area curve

Appendix I

Eagle Mountain Lake

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — October 2018 Survey

CAPACITY IN ACRE-FEET — Conservation pool elevation 649.1 feet NAVD88

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
599	0	0	0	0	0	0	0	0	0	0
600	0	0	0	0	0	0	0	0	0	0
601	0	0	1	1	1	1	2	2	3	3
602	4	5	5	6	7	8	9	11	12	13
603	15	16	18	19	21	22	24	26	28	30
604	32	34	36	39	41	44	46	49	52	55
605	58	61	65	68	72	76	80	85	90	96
606	103	111	119	129	142	157	174	194	217	243
607	271	302	336	372	409	449	490	533	578	625
608	673	721	771	822	874	927	982	1,038	1,096	1,155
609	1,216	1,278	1,341	1,406	1,472	1,539	1,607	1,676	1,747	1,818
610	1,892	1,966	2,042	2,120	2,199	2,280	2,363	2,448	2,535	2,623
611	2,714	2,806	2,901	2,997	3,096	3,196	3,298	3,402	3,508	3,615
612	3,724	3,835	3,948	4,064	4,184	4,307	4,436	4,569	4,706	4,846
613	4,989	5,134	5,281	5,431	5,583	5,737	5,894	6,053	6,214	6,378
614	6,543	6,711	6,881	7,054	7,230	7,408	7,589	7,773	7,960	8,150
615	8,344	8,541	8,741	8,944	9,148	9,355	9,565	9,777	9,991	10,208
616	10,426	10,646	10,868	11,092	11,317	11,544	11,772	12,003	12,235	12,468
617	12,703	12,939	13,177	13,417	13,658	13,901	14,145	14,390	14,637	14,886
618	15,135	15,386	15,639	15,893	16,148	16,405	16,664	16,924	17,185	17,448
619	17,712	17,977	18,243	18,511	18,780	19,050	19,322	19,596	19,870	20,146
620	20,424	20,703	20,983	21,265	21,548	21,833	22,120	22,408	22,698	22,991
621	23,286	23,583	23,882	24,183	24,485	24,788	25,093	25,400	25,709	26,020
622	26,333	26,647	26,963	27,280	27,599	27,919	28,240	28,563	28,887	29,212
623	29,538	29,865	30,194	30,523	30,853	31,185	31,518	31,853	32,189	32,526
624	32,864	33,204	33,545	33,888	34,232	34,577	34,923	35,271	35,620	35,971
625	36,324	36,678	37,034	37,392	37,751	38,111	38,473	38,838	39,203	39,571
626	39,940	40,311	40,685	41,059	41,436	41,815	42,195	42,577	42,961	43,347
627	43,735	44,124	44,516	44,910	45,307	45,706	46,107	46,512	46,919	47,328
628	47,740	48,155	48,573	48,993	49,416	49,841	50,267	50,696	51,126	51,559
629	51,993	52,429	52,867	53,306	53,747	54,190	54,634	55,080	55,527	55,976
630	56,426	56,877	57,330	57,785	58,241	58,698	59,157	59,618	60,081	60,545
631	61,011	61,479	61,949	62,420	62,894	63,370	63,847	64,327	64,809	65,294
632	65,780	66,269	66,759	67,251	67,745	68,241	68,738	69,237	69,738	70,240
633	70,745	71,251	71,761	72,273	72,788	73,307	73,829	74,355	74,886	75,420
634	75,958	76,499	77,045	77,594	78,146	78,700	79,256	79,814	80,374	80,936
635	81,499	82,064	82,631	83,199	83,769	84,341	84,913	85,488	86,065	86,643
636	87,222	87,804	88,387	88,972	89,560	90,149	90,740	91,333	91,928	92,526
637	93,126	93,727	94,332	94,939	95,548	96,160	96,774	97,391	98,010	98,632
638	99,255	99,881	100,510	101,142	101,777	102,416	103,058	103,703	104,351	105,003
639	105,657	106,314	106,974	107,636	108,301	108,968	109,638	110,311	110,986	111,663
640	112,343	113,025	113,710	114,398	115,089	115,784	116,482	117,184	117,889	118,598
641	119,309	120,023	120,740	121,459	122,181	122,905	123,632	124,362	125,094	125,829
642	126,566	127,306	128,049	128,794	129,541	130,291	131,043	131,798	132,554	133,314
643	134,075	134,838	135,605	136,373	137,144	137,917	138,692	139,470	140,249	141,031
644	141,815	142,600	143,387	144,176	144,968	145,761	146,557	147,355	148,155	148,959
645	149,764	150,572	151,382	152,194	153,009	153,826	154,646	155,469	156,294	157,122
646	157,952	158,785	159,621	160,458	161,299	162,142	162,987	163,836	164,686	165,540
647	166,396	167,254	168,116	168,980	169,848	170,718	171,591	172,468	173,347	174,231
648	175,117	176,006	176,900	177,796	178,696	179,599	180,505	181,415	182,328	183,244
649	184,164	185,087	186,013	186,942	187,876					

Appendix J

Eagle Mountain Lake

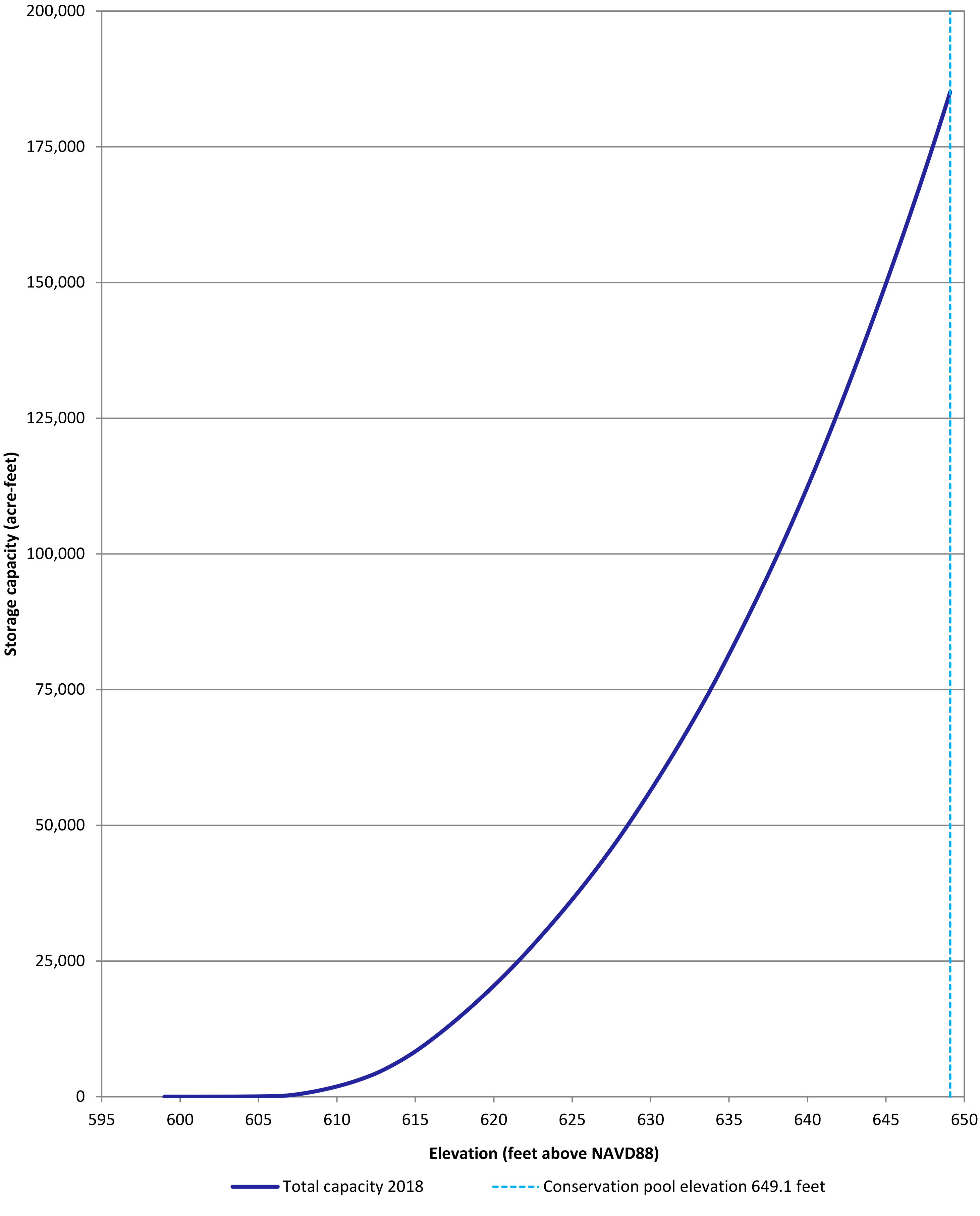
RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD — October 2018 Survey

AREA IN ACRES — Conservation pool elevation 649.1 feet NAVD88

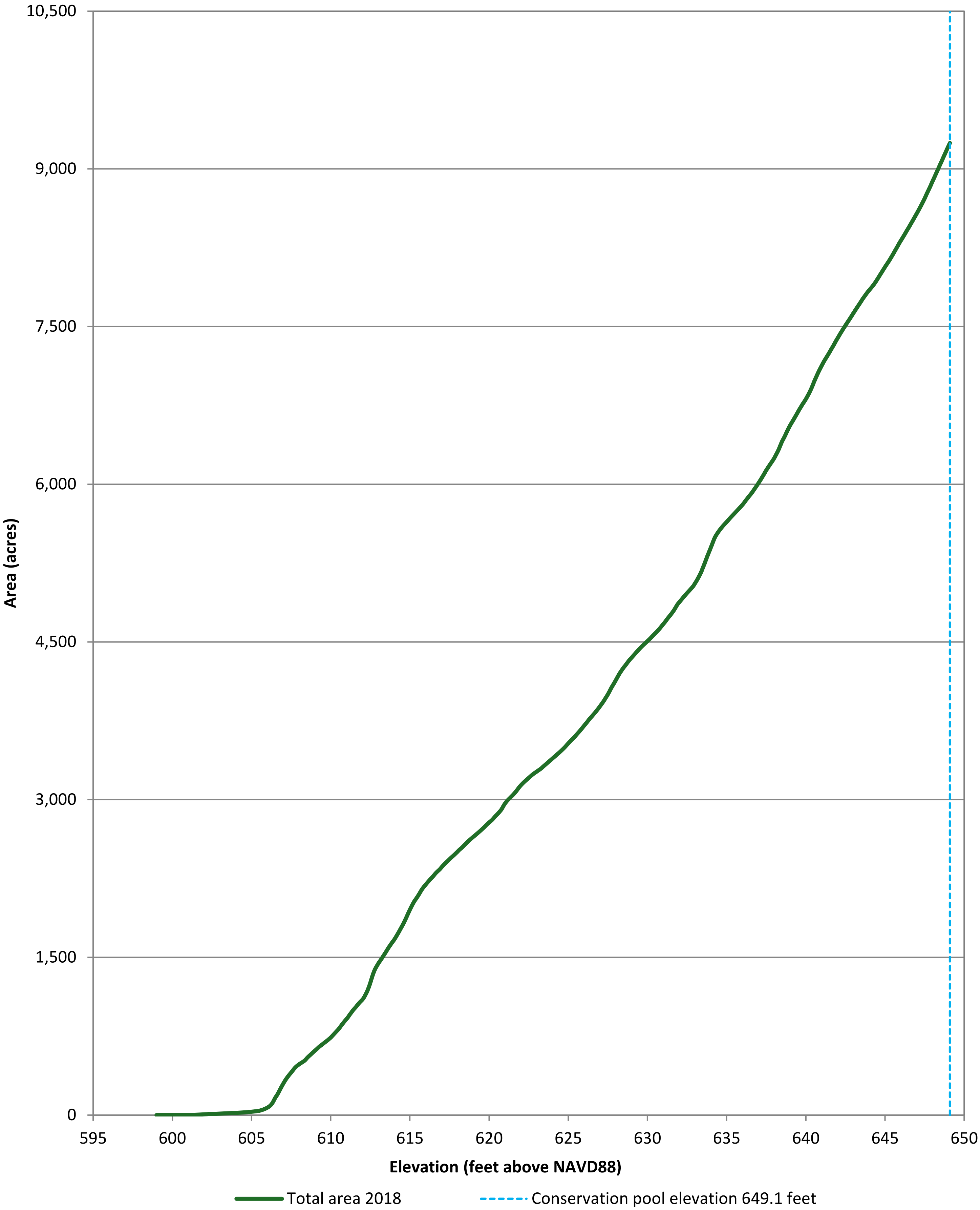
ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
599	0	0	0	0	0	0	0	0	0	0
600	0	0	0	0	0	0	0	0	1	1
601	1	1	2	2	3	3	4	5	5	6
602	7	8	8	10	10	11	11	12	13	13
603	14	15	15	16	17	17	18	19	20	20
604	21	22	23	24	24	25	26	27	28	30
605	32	34	35	37	39	42	46	51	56	63
606	71	80	93	110	137	165	187	214	244	271
607	298	323	346	367	386	404	423	442	458	471
608	482	493	502	512	525	542	557	571	585	599
609	612	625	639	653	664	676	688	700	711	724
610	737	753	769	786	802	818	838	858	878	897
611	914	933	955	975	996	1,013	1,030	1,049	1,066	1,082
612	1,097	1,119	1,147	1,177	1,214	1,258	1,307	1,351	1,387	1,415
613	1,440	1,463	1,484	1,508	1,531	1,555	1,580	1,603	1,625	1,646
614	1,666	1,690	1,715	1,741	1,769	1,796	1,824	1,855	1,888	1,921
615	1,954	1,984	2,013	2,038	2,059	2,082	2,106	2,132	2,155	2,175
616	2,192	2,211	2,228	2,245	2,261	2,277	2,296	2,311	2,325	2,339
617	2,358	2,374	2,390	2,404	2,419	2,433	2,448	2,461	2,475	2,490
618	2,504	2,520	2,533	2,546	2,562	2,577	2,592	2,606	2,620	2,633
619	2,646	2,658	2,671	2,684	2,697	2,711	2,725	2,739	2,755	2,769
620	2,783	2,795	2,809	2,826	2,843	2,858	2,874	2,892	2,911	2,939
621	2,962	2,982	2,999	3,013	3,029	3,044	3,060	3,078	3,098	3,118
622	3,136	3,151	3,166	3,180	3,193	3,207	3,220	3,233	3,245	3,256
623	3,266	3,277	3,287	3,298	3,312	3,326	3,339	3,352	3,365	3,378
624	3,391	3,404	3,417	3,431	3,444	3,458	3,472	3,486	3,502	3,519
625	3,535	3,551	3,567	3,581	3,597	3,615	3,632	3,649	3,666	3,685
626	3,703	3,722	3,740	3,760	3,778	3,794	3,812	3,829	3,848	3,867
627	3,888	3,908	3,929	3,953	3,977	4,001	4,028	4,058	4,084	4,109
628	4,135	4,163	4,190	4,214	4,236	4,257	4,276	4,296	4,316	4,334
629	4,351	4,368	4,385	4,402	4,418	4,435	4,451	4,465	4,480	4,494
630	4,508	4,522	4,537	4,553	4,568	4,584	4,599	4,615	4,632	4,651
631	4,670	4,688	4,708	4,728	4,747	4,766	4,786	4,808	4,833	4,858
632	4,876	4,894	4,913	4,930	4,948	4,965	4,981	4,998	5,015	5,033
633	5,056	5,081	5,108	5,136	5,167	5,206	5,243	5,283	5,323	5,359
634	5,397	5,435	5,474	5,505	5,530	5,552	5,572	5,591	5,609	5,625
635	5,641	5,658	5,675	5,692	5,707	5,723	5,739	5,755	5,772	5,788
636	5,805	5,823	5,844	5,863	5,883	5,901	5,920	5,942	5,964	5,986
637	6,008	6,032	6,056	6,081	6,107	6,132	6,156	6,179	6,201	6,223
638	6,247	6,276	6,304	6,335	6,372	6,407	6,435	6,465	6,498	6,529
639	6,557	6,583	6,609	6,634	6,660	6,687	6,713	6,738	6,763	6,785
640	6,809	6,836	6,864	6,895	6,928	6,966	7,002	7,035	7,068	7,098
641	7,127	7,155	7,182	7,206	7,231	7,257	7,282	7,308	7,334	7,362
642	7,387	7,413	7,438	7,463	7,487	7,510	7,533	7,556	7,579	7,602
643	7,626	7,649	7,673	7,695	7,718	7,741	7,765	7,786	7,807	7,827
644	7,845	7,863	7,881	7,901	7,922	7,946	7,970	7,994	8,018	8,042
645	8,066	8,089	8,112	8,135	8,160	8,186	8,212	8,239	8,266	8,292
646	8,317	8,341	8,366	8,392	8,417	8,443	8,468	8,494	8,521	8,547
647	8,574	8,601	8,629	8,657	8,687	8,717	8,750	8,782	8,814	8,847
648	8,881	8,913	8,947	8,980	9,014	9,047	9,080	9,114	9,147	9,181
649	9,214	9,246	9,279	9,311	9,457					



Eagle Mountain Lake
October 2018 Survey
Prepared by: TWDB

Appendix K: Capacity curve



Eagle Mountain Lake
October 2018 Survey
Prepared by: TWDB

Appendix L: Area curve

Appendix M

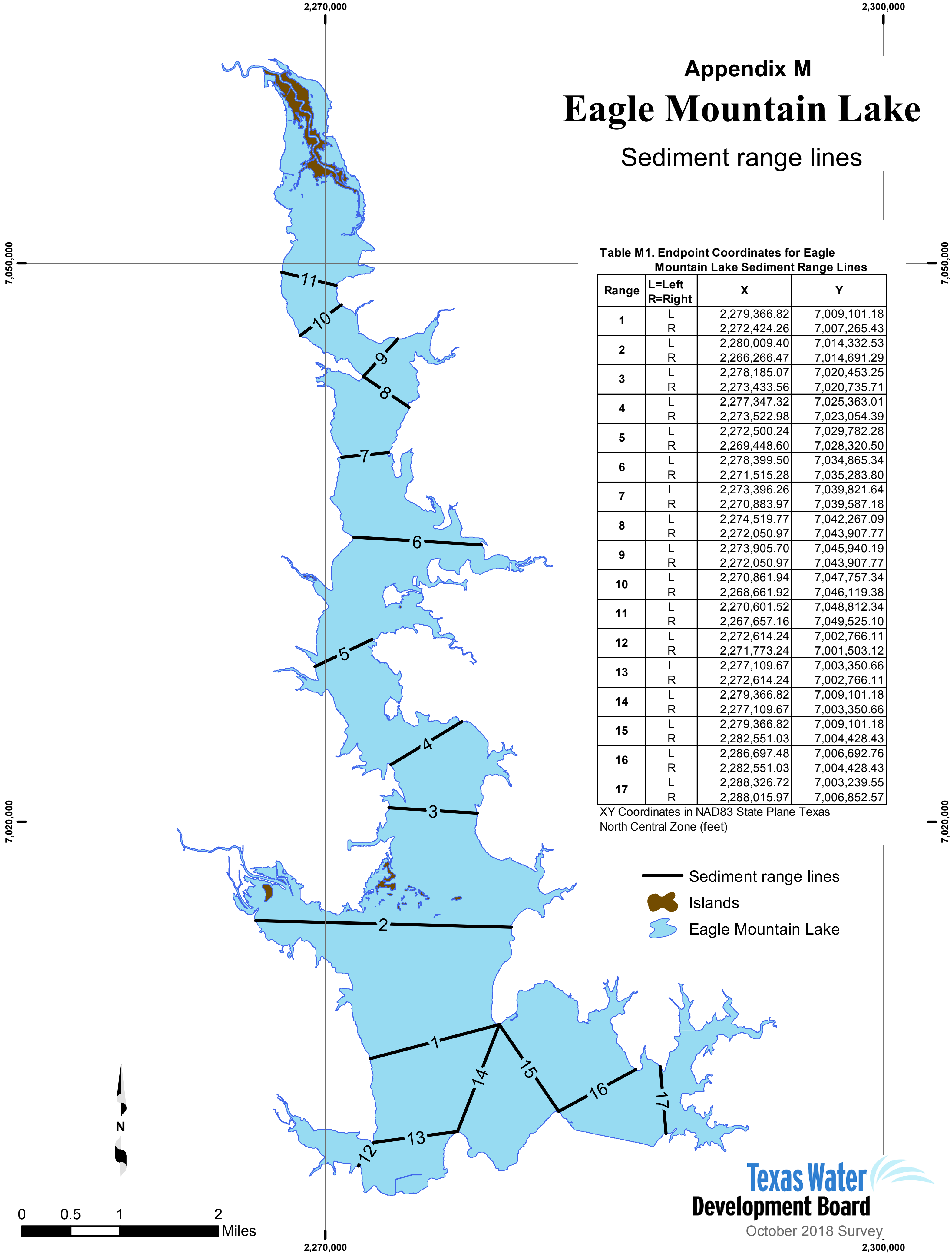
Eagle Mountain Lake

Sediment range lines

Table M1. Endpoint Coordinates for Eagle Mountain Lake Sediment Range Lines

Range	L=Left R=Right	X	Y
1	L	2,279,366.82	7,009,101.18
	R	2,272,424.26	7,007,265.43
2	L	2,280,009.40	7,014,332.53
	R	2,266,266.47	7,014,691.29
3	L	2,278,185.07	7,020,453.25
	R	2,273,433.56	7,020,735.71
4	L	2,277,347.32	7,025,363.01
	R	2,273,522.98	7,023,054.39
5	L	2,272,500.24	7,029,782.28
	R	2,269,448.60	7,028,320.50
6	L	2,278,399.50	7,034,865.34
	R	2,271,515.28	7,035,283.80
7	L	2,273,396.26	7,039,821.64
	R	2,270,883.97	7,039,587.18
8	L	2,274,519.77	7,042,267.09
	R	2,272,050.97	7,043,907.77
9	L	2,273,905.70	7,045,940.19
	R	2,272,050.97	7,043,907.77
10	L	2,270,861.94	7,047,757.34
	R	2,268,661.92	7,046,119.38
11	L	2,270,601.52	7,048,812.34
	R	2,267,657.16	7,049,525.10
12	L	2,272,614.24	7,002,766.11
	R	2,271,773.24	7,001,503.12
13	L	2,277,109.67	7,003,350.66
	R	2,272,614.24	7,002,766.11
14	L	2,279,366.82	7,009,101.18
	R	2,277,109.67	7,003,350.66
15	L	2,279,366.82	7,009,101.18
	R	2,282,551.03	7,004,428.43
16	L	2,286,697.48	7,006,692.76
	R	2,282,551.03	7,004,428.43
17	L	2,288,326.72	7,003,239.55
	R	2,288,015.97	7,006,852.57

XY Coordinates in NAD83 State Plane Texas North Central Zone (feet)



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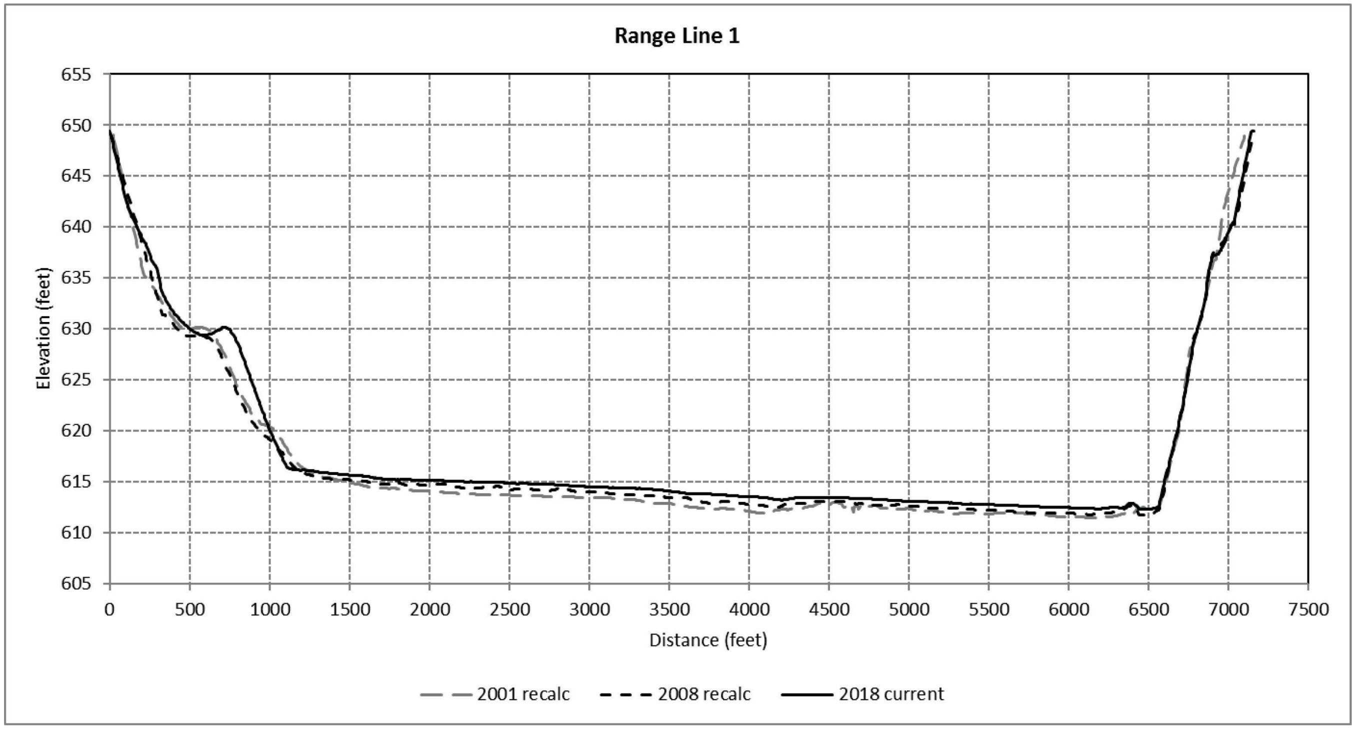
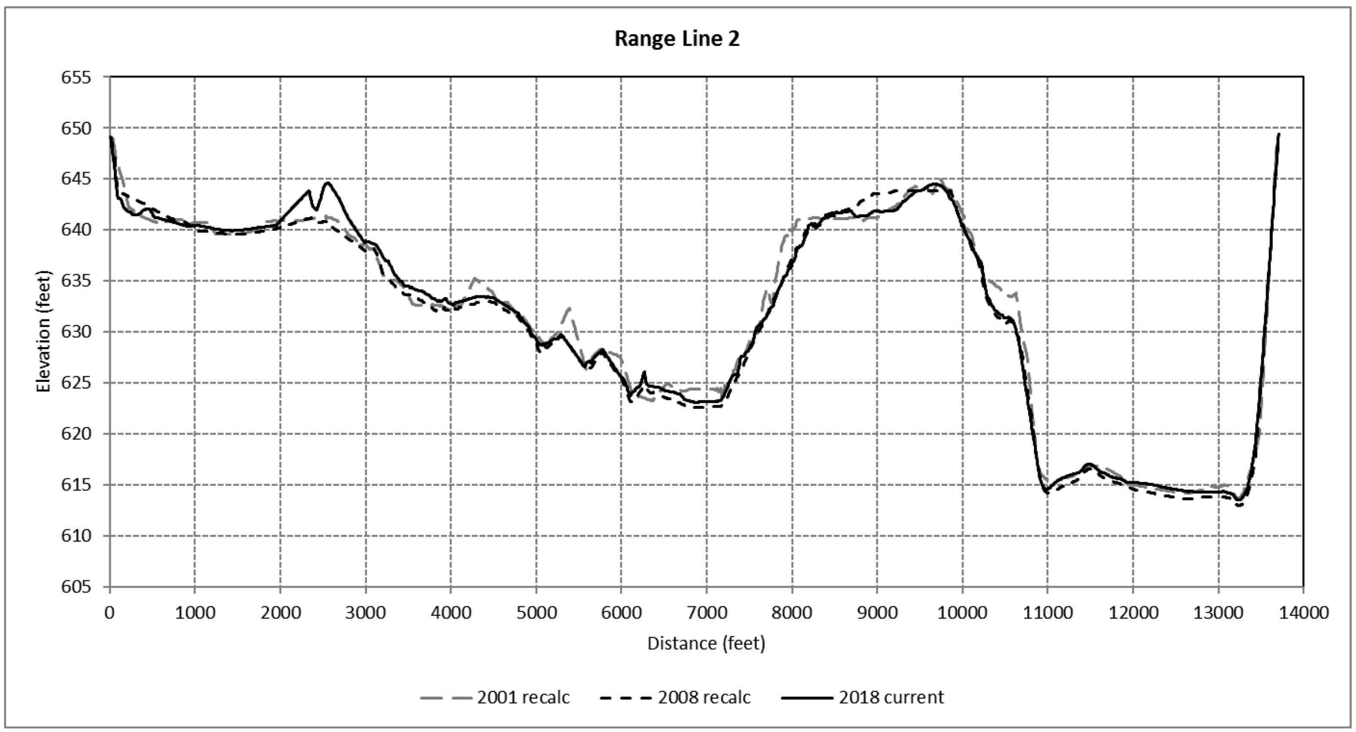
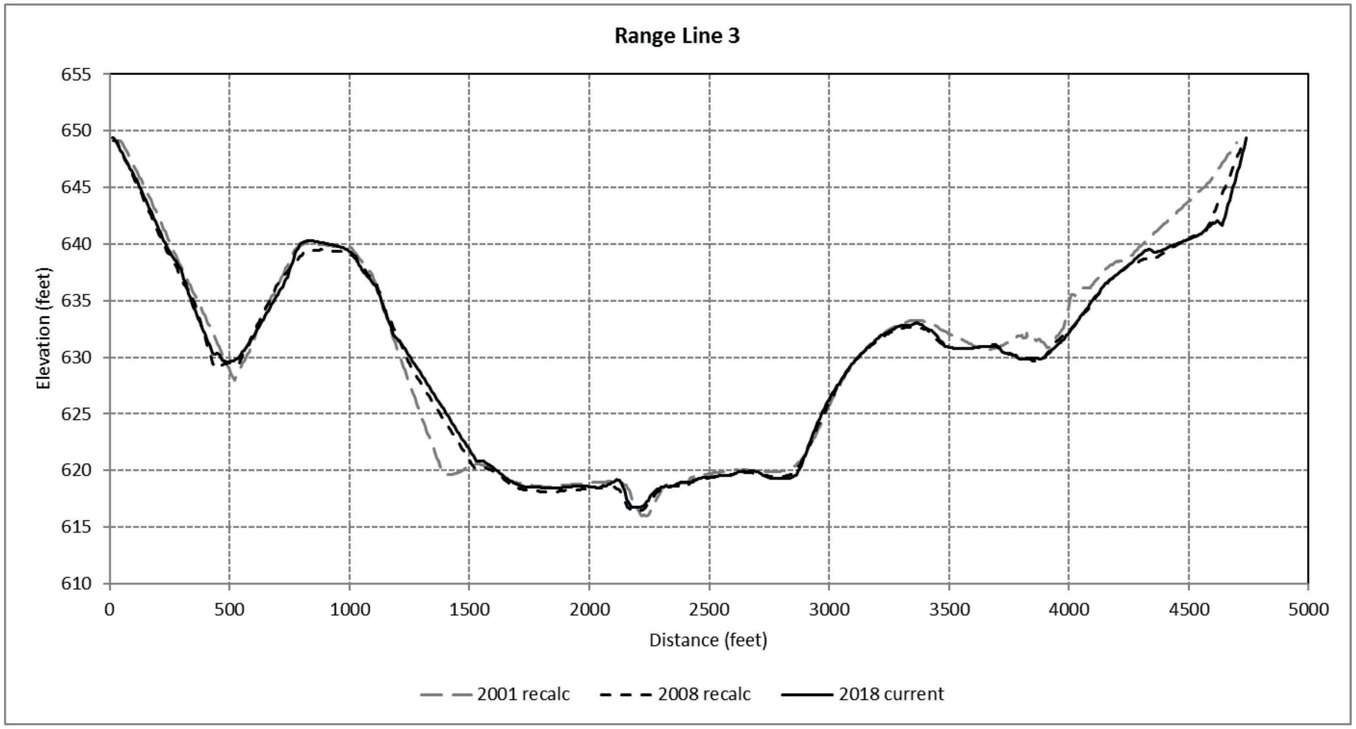
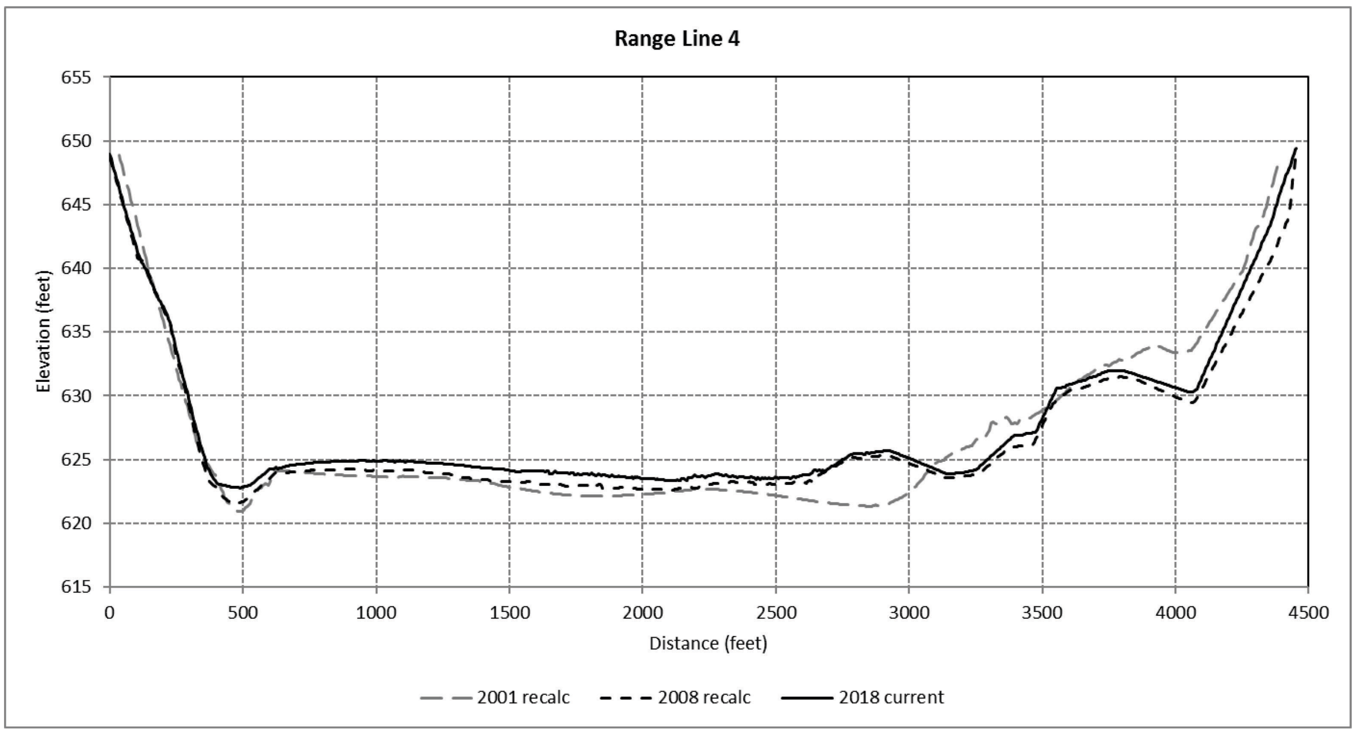
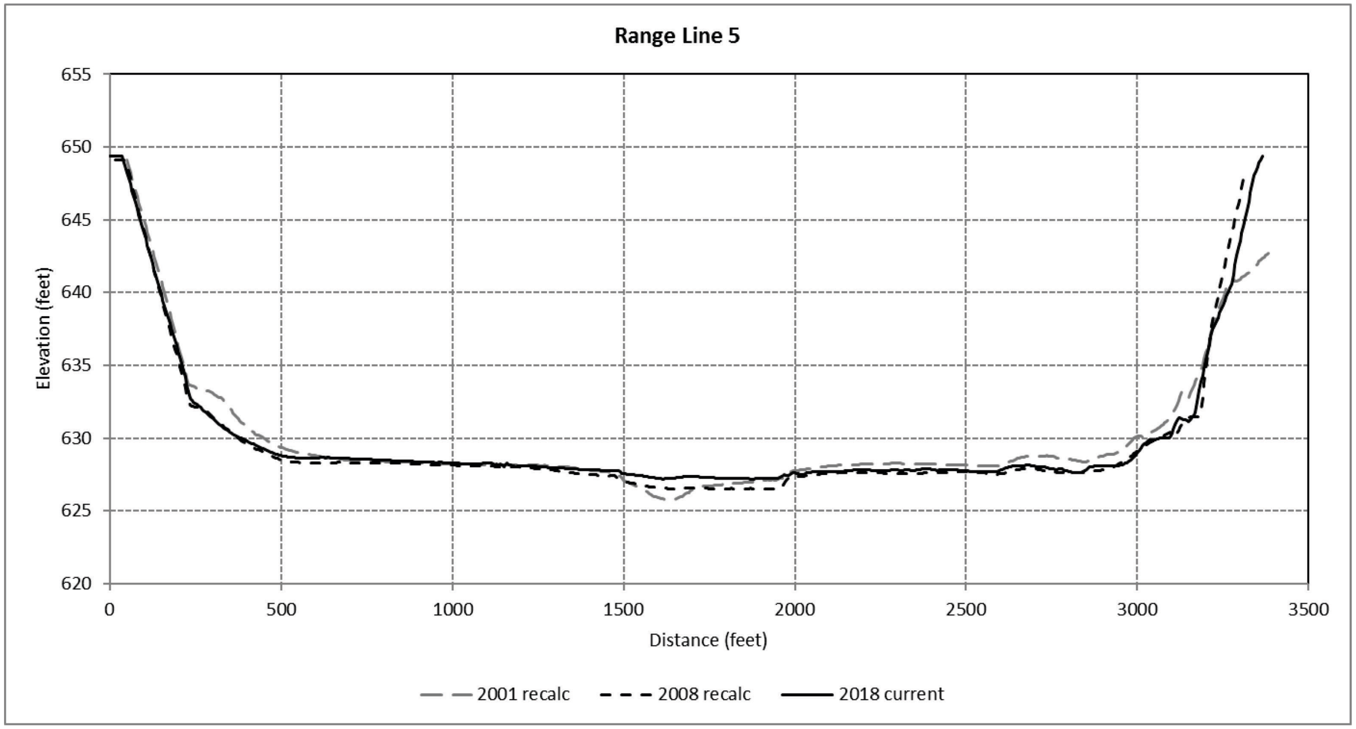
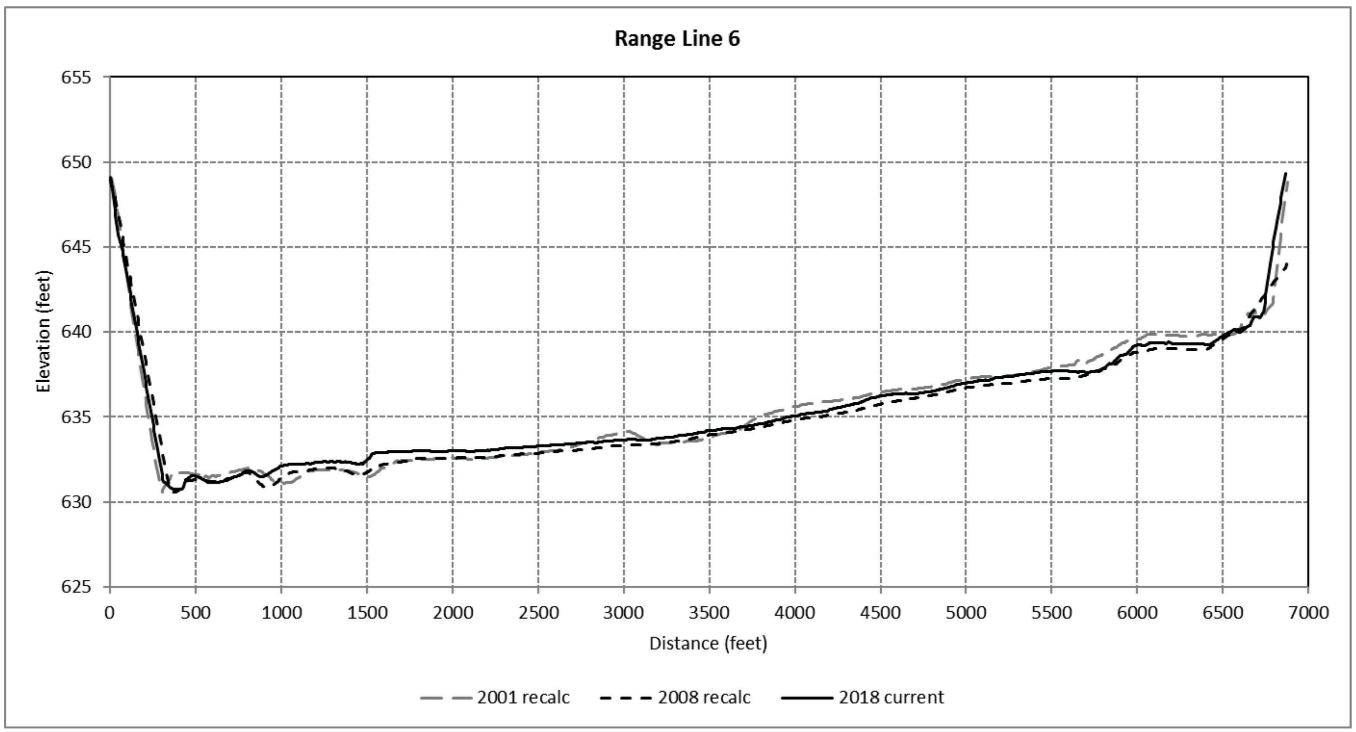

Range Line 1
655
650
645
640
635
630
625
620
615
610
605
Elevation (feet)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
Distance (feet)
2001 recalc
2008 recalc
2018 current

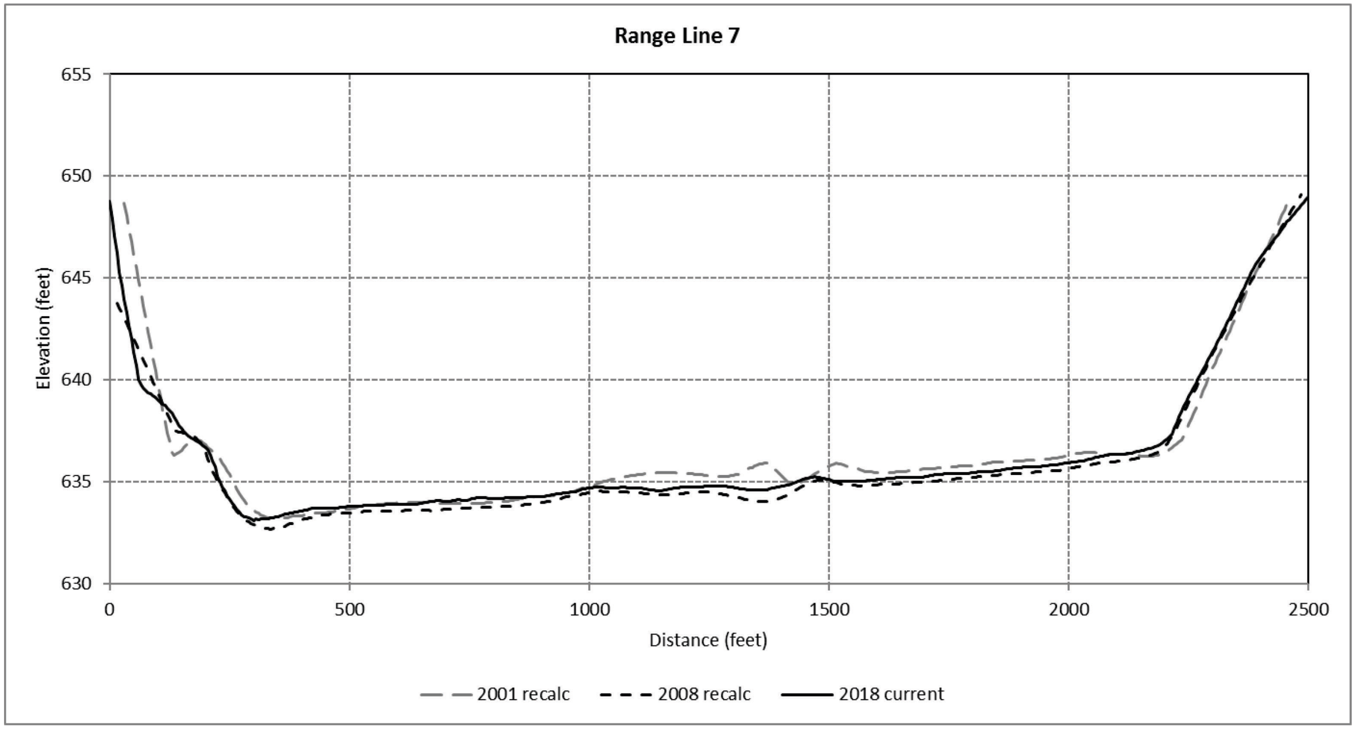

Range Line 2
655
650
645
640
635
630
625
620
615
610
605
Elevation (feet)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
Distance (feet)
2001 recalc
2008 recalc
2018 current

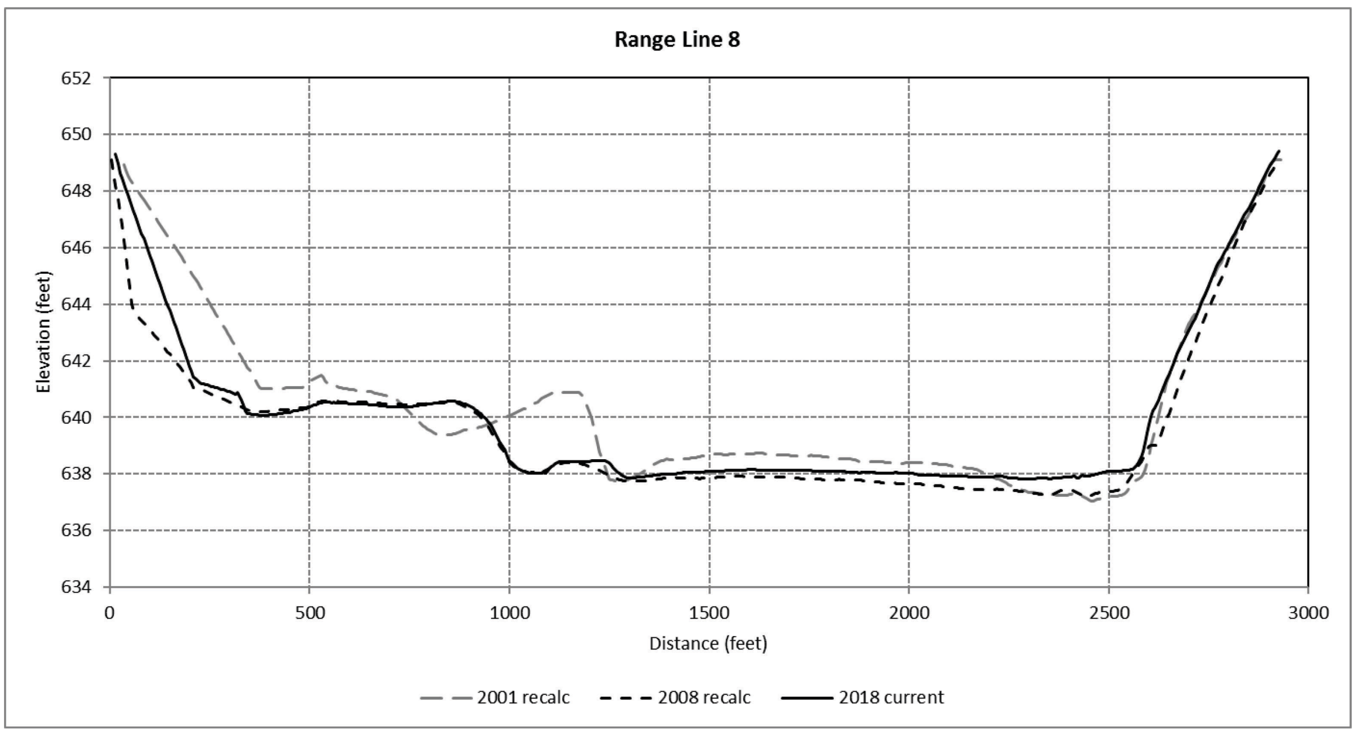

Range Line 3
Elevation (feet)
655
650
645
640
635
630
625
620
615
610
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Distance (feet)
2001 recalc
2008 recalc
2018 current

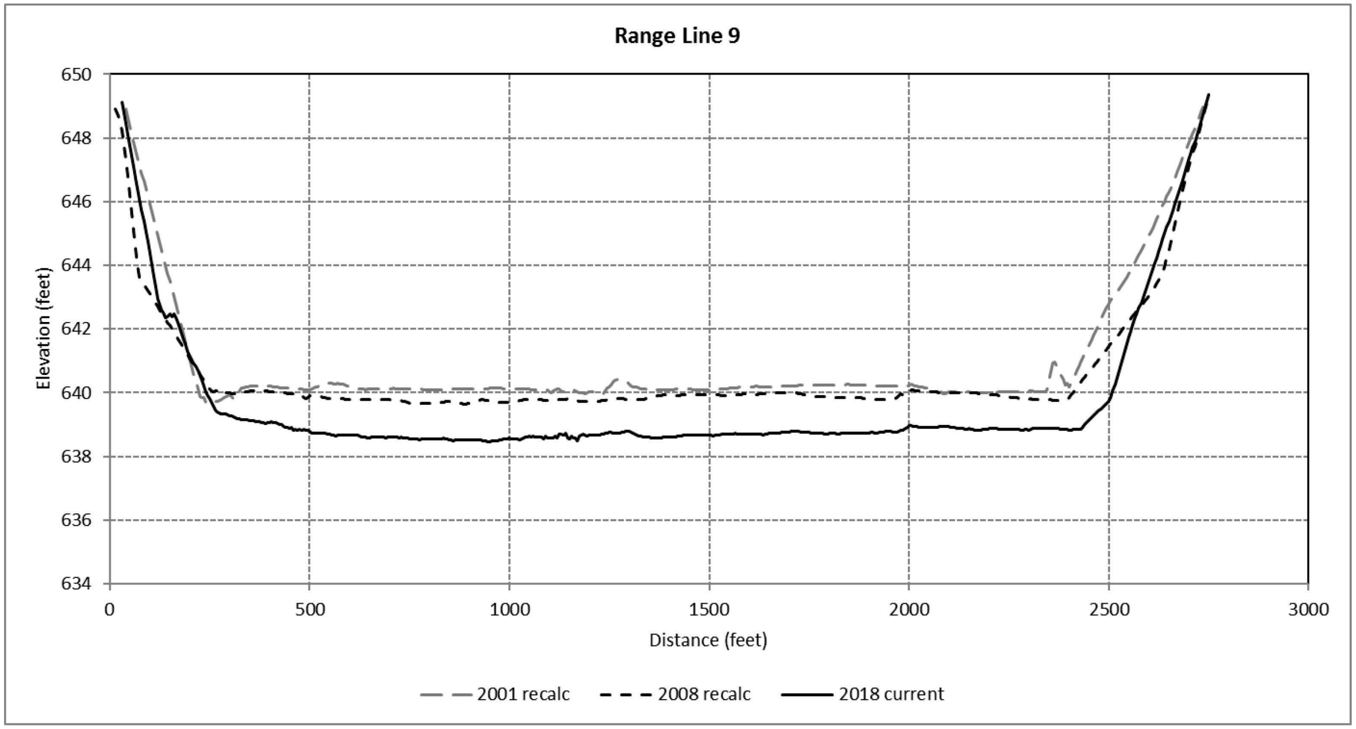

Range Line 4
Elevation (feet)
655
650
645
640
635
630
625
620
615
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Distance (feet)
2001 recalc
2008 recalc
2018 current


Range Line 5
Elevation (feet)
655
650
645
640
635
630
625
620
0
500
1000
1500
2000
2500
3000
3500
Distance (feet)
2001 recalc
2008 recalc
2018 current

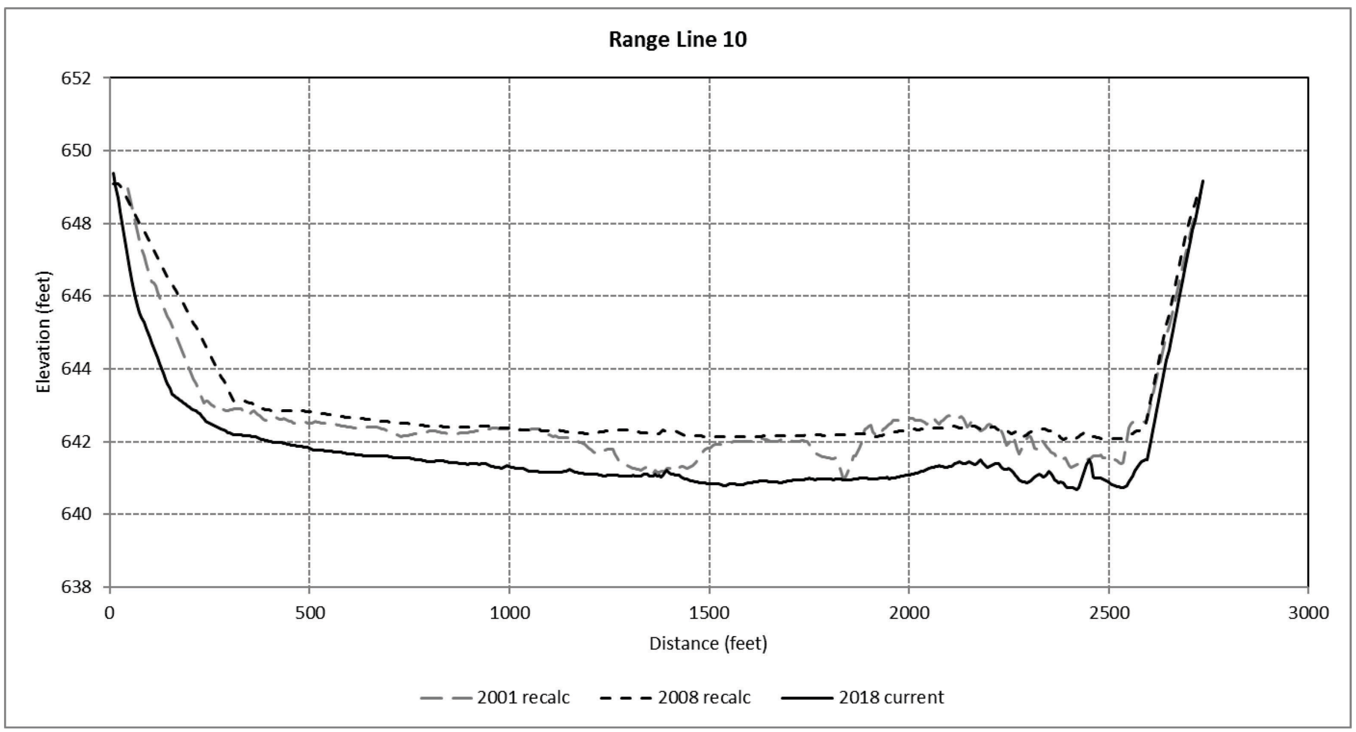

Range Line 6
Elevation (feet)
655
650
645
640
635
630
625
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
Distance (feet)
2001 recalc
2008 recalc
2018 current


Range Line 7
Elevation (feet)
Distance (feet)
655
650
645
640
635
630
0
500
1000
1500
2000
2500
2001 recalc
2008 recalc
2018 current

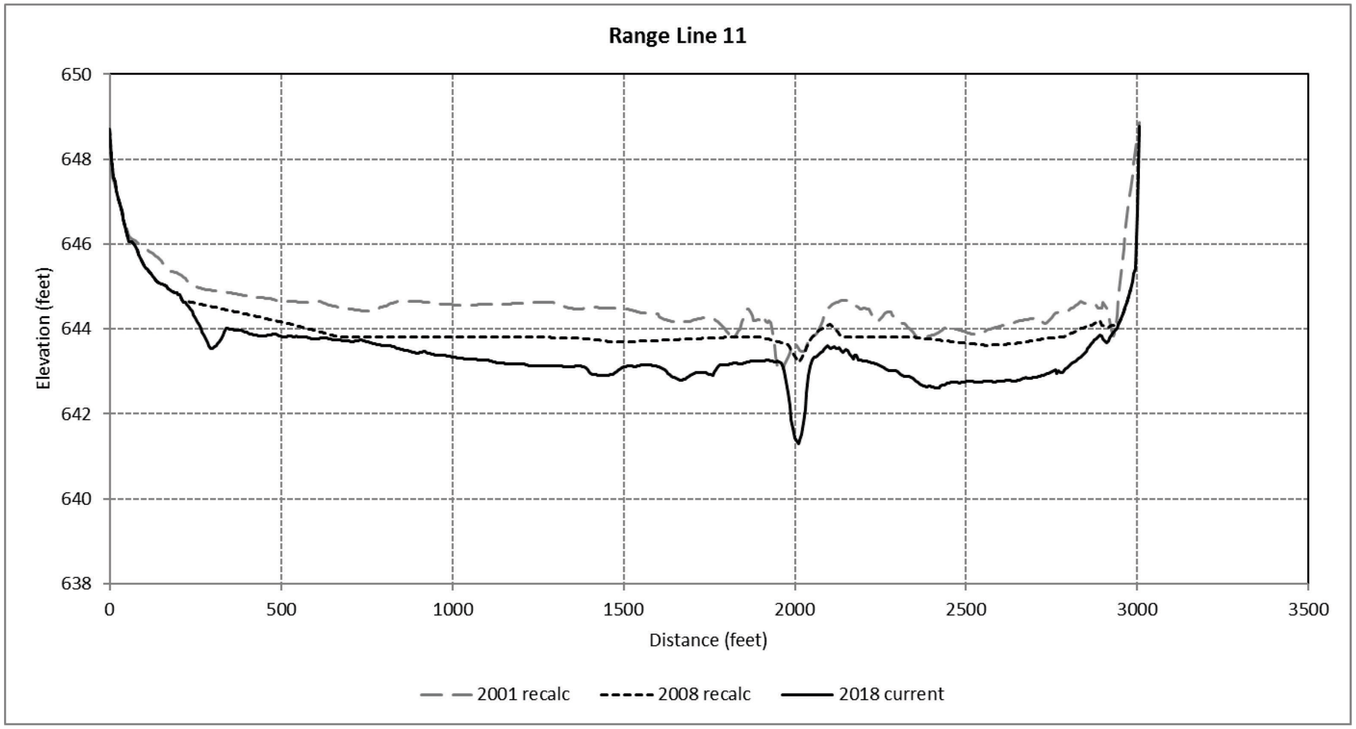

Range Line 8
Elevation (feet)
Distance (feet)
652
650
648
646
644
642
640
638
636
634
0
500
1000
1500
2000
2500
3000
2001 recalc
2008 recalc
2018 current

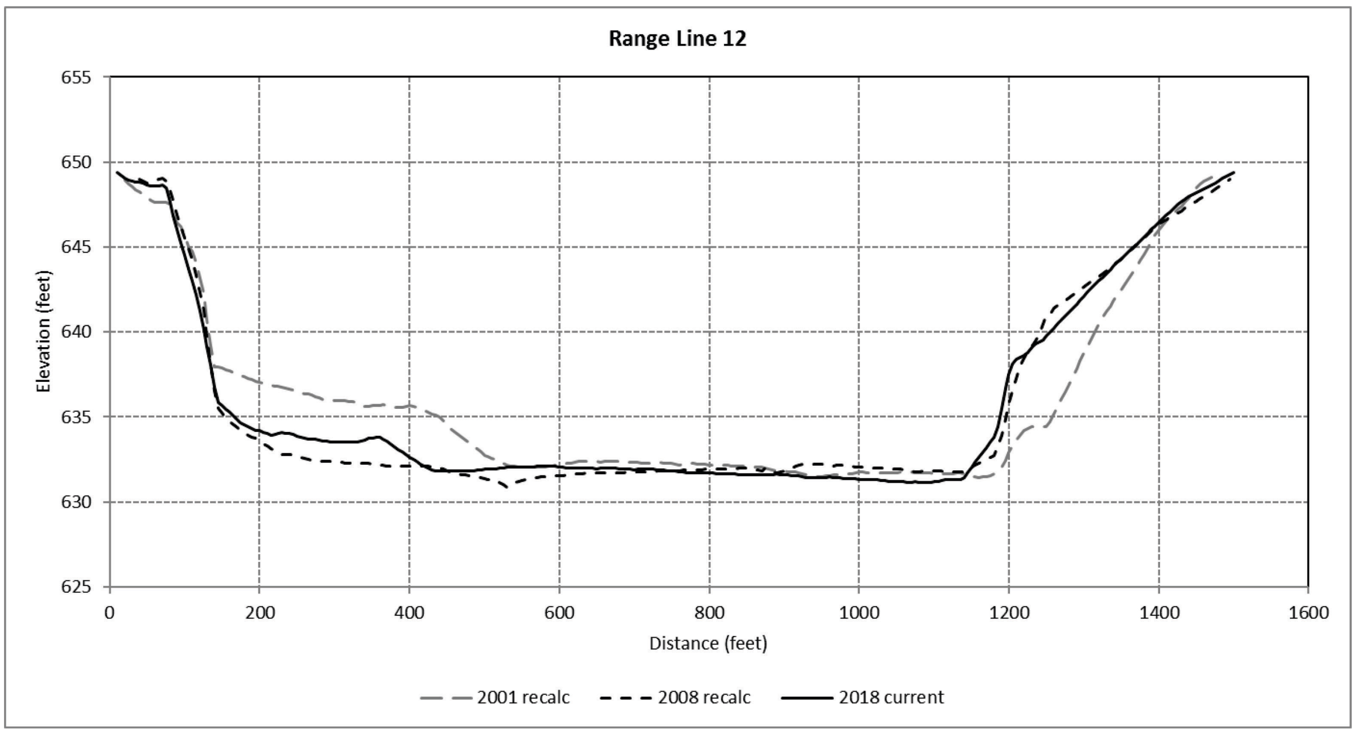


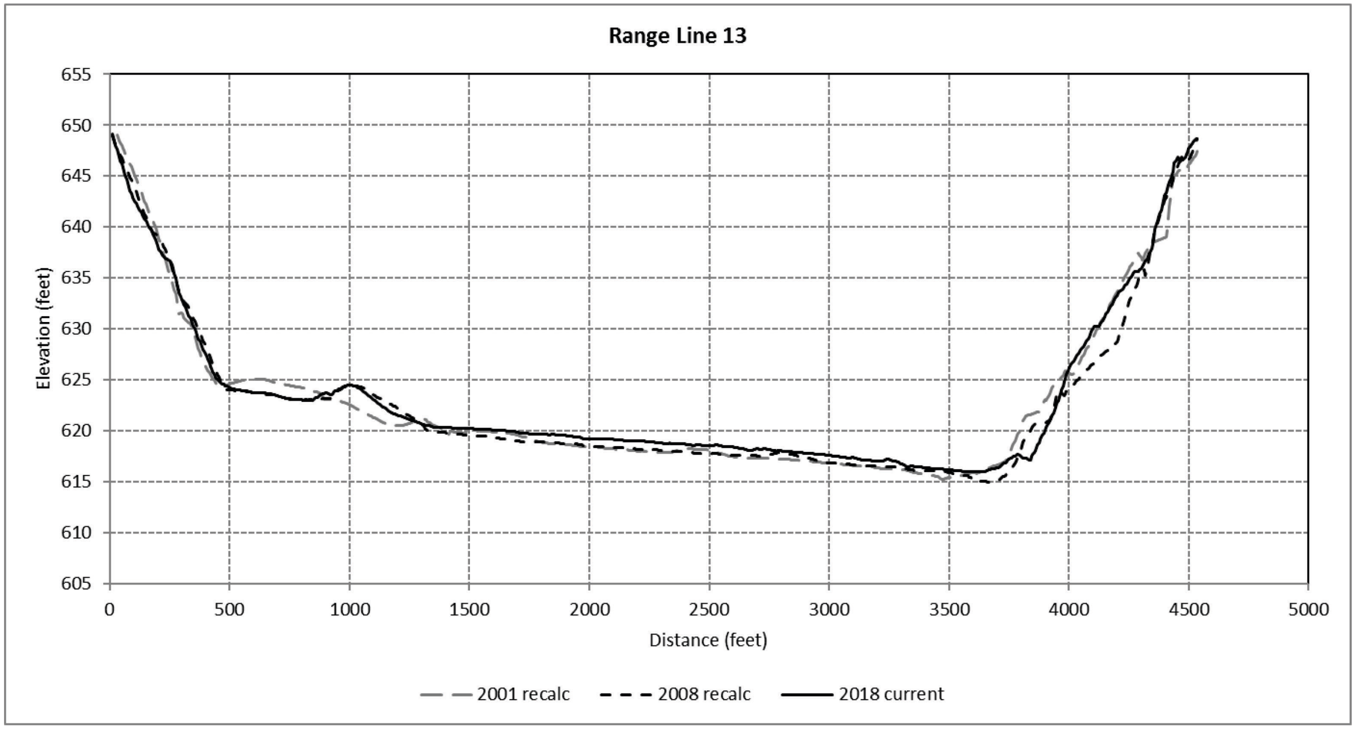
Range Line 9
Elevation (feet)
650
648
646
644
642
640
638
636
634
0
500
1000
1500
2000
2500
3000
Distance (feet)
2001 recalc
2008 recalc
2018 current



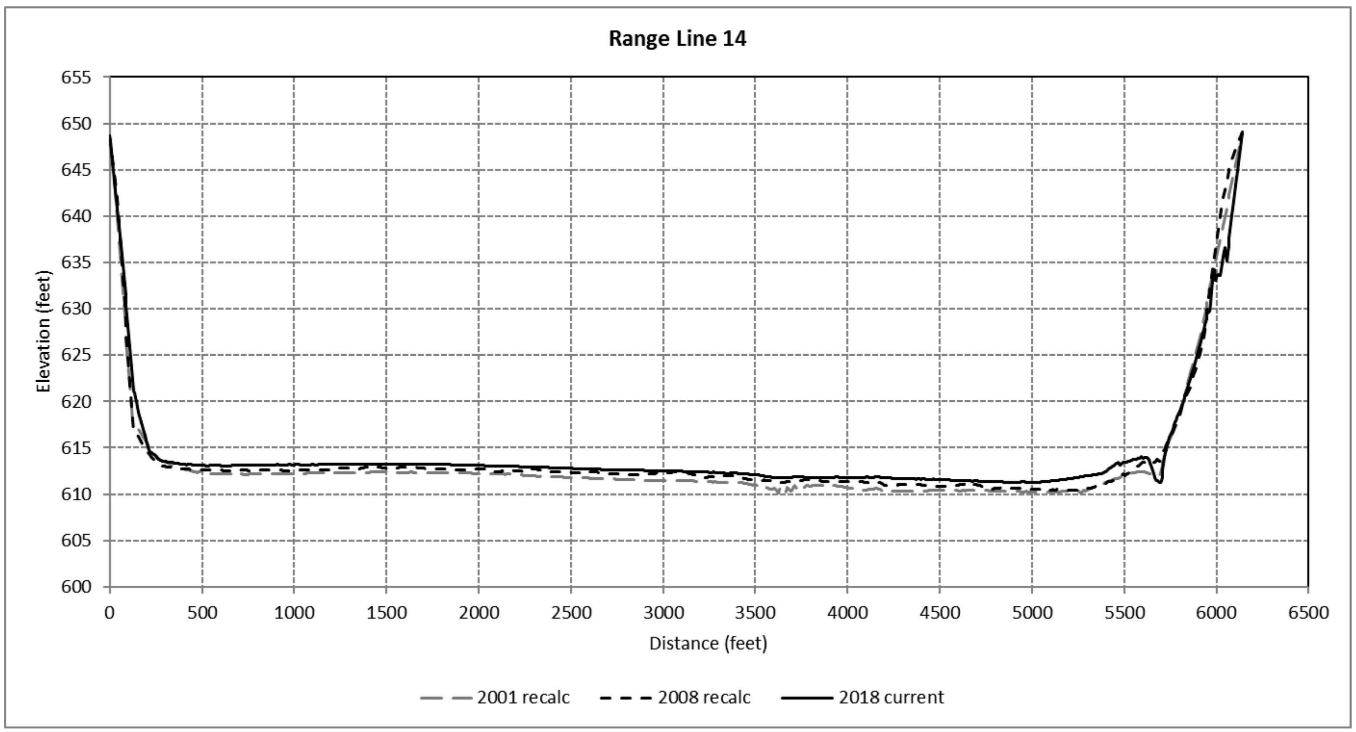
Range Line 10
Elevation (feet)
652
650
648
646
644
642
640
638
0
500
1000
1500
2000
2500
3000
Distance (feet)
2001 recalc
2008 recalc
2018 current


Range Line 11
Elevation (feet)
650
648
646
644
642
640
638
0
500
1000
1500
2000
2500
3000
3500
Distance (feet)
2001 recalc
2008 recalc
2018 current

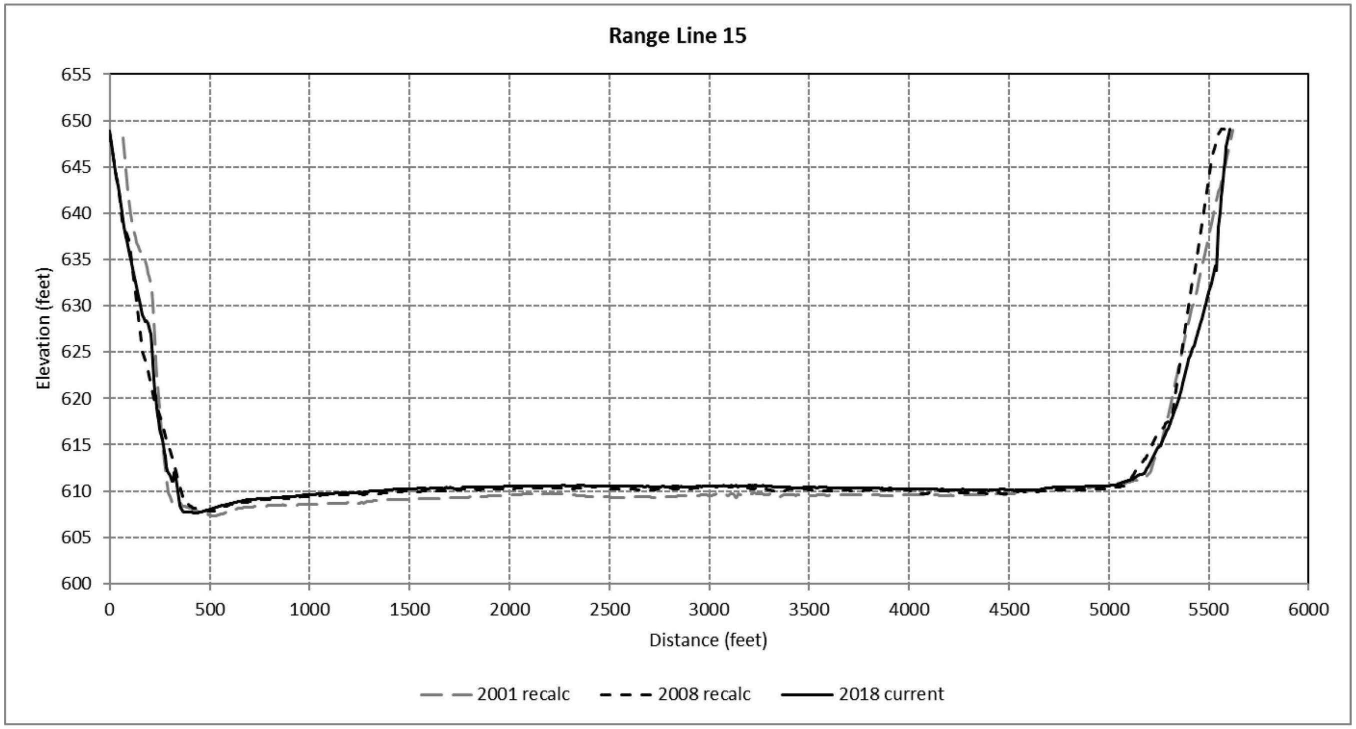

Range Line 12
Elevation (feet)
655
650
645
640
635
630
625
0
200
400
600
800
1000
1200
1400
1600
Distance (feet)
2001 recalc
2008 recalc
2018 current



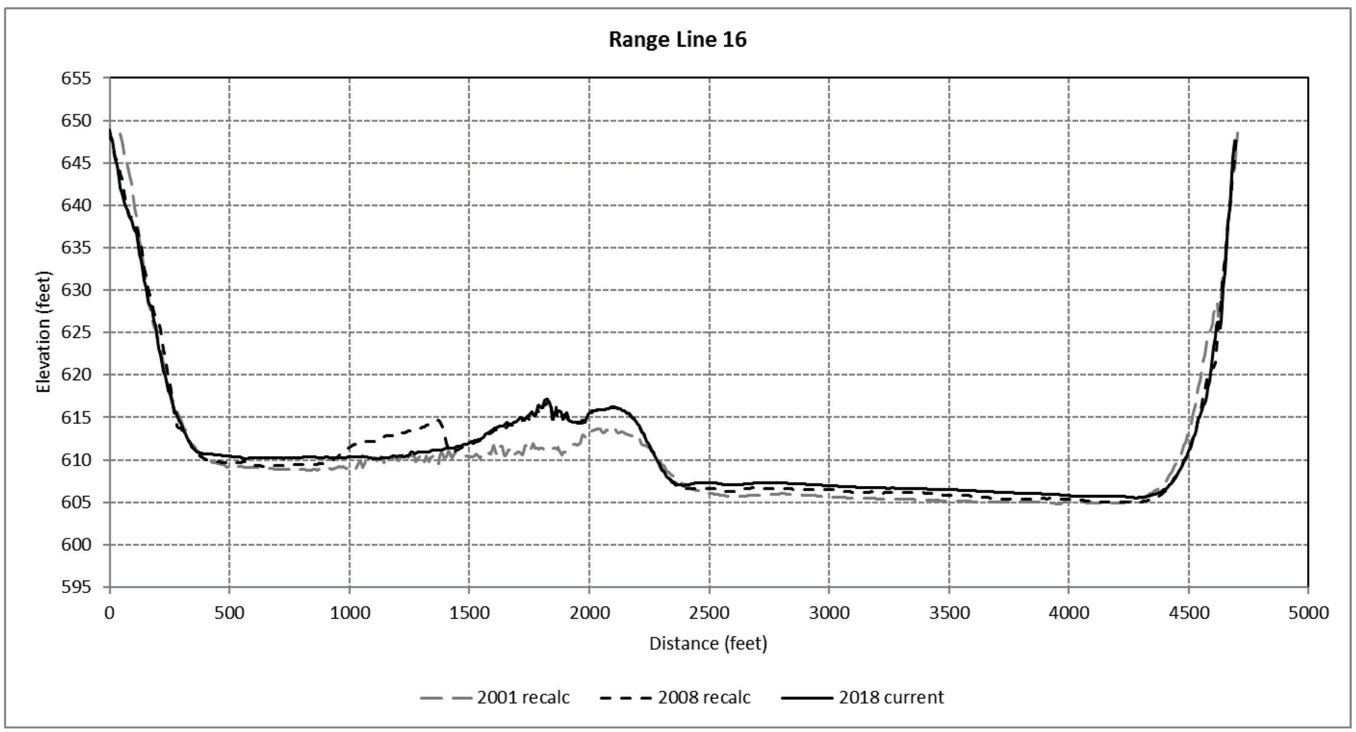
Range Line 13
Elevation (feet)
Distance (feet)
2001 recalc
2008 recalc
2018 current



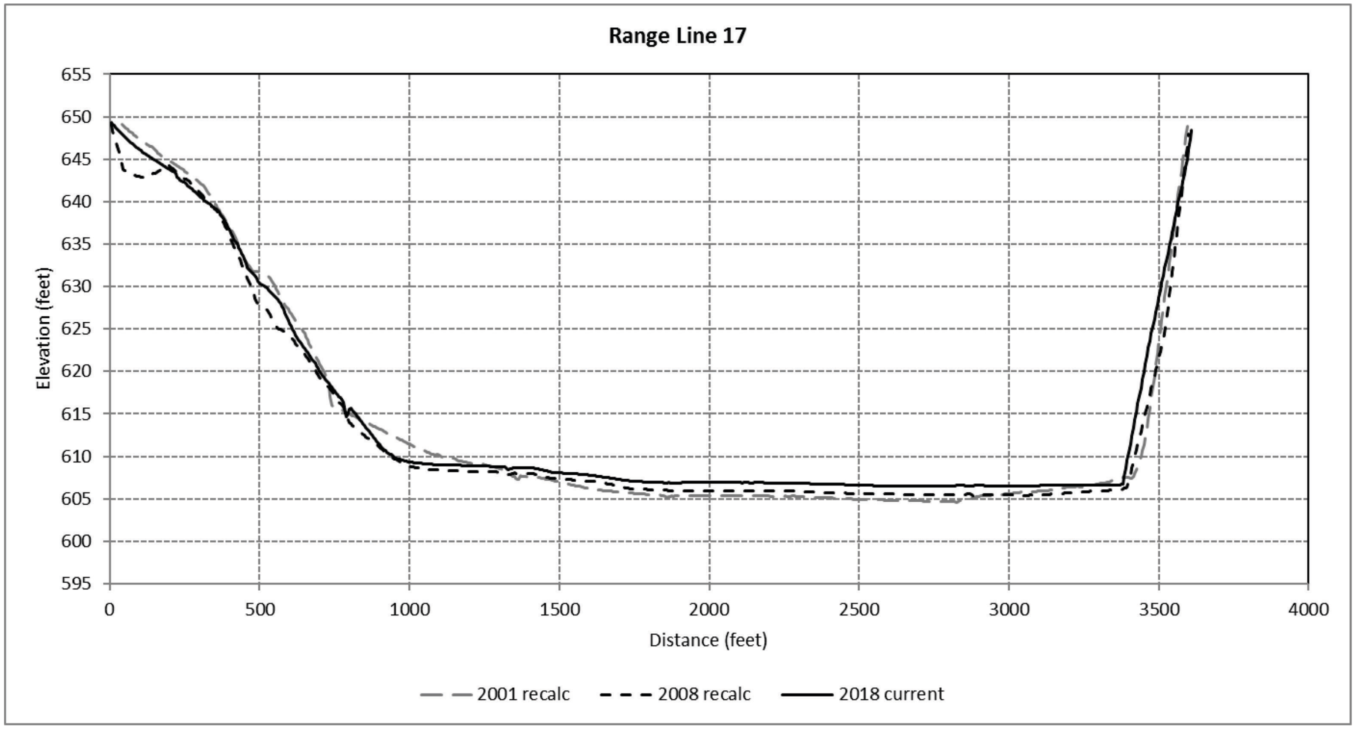
Range Line 14
Elevation (feet)
Distance (feet)
2001 recalc
2008 recalc
2018 current



Range Line 15
Elevation (feet)
655
650
645
640
635
630
625
620
615
610
605
600
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
Distance (feet)
2001 recalc
2008 recalc
2018 current



Range Line 16
Elevation (feet)
655
650
645
640
635
630
625
620
615
610
605
600
595
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Distance (feet)
2001 recalc
2008 recalc
2018 current


Range Line 17
655
650
645
640
635
630
625
620
615
610
605
600
595
Elevation (feet)
0
500
1000
1500
2000
2500
3000
3500
4000
Distance (feet)
2001 recalc
2008 recalc
2018 current

Appendix N Axial profile

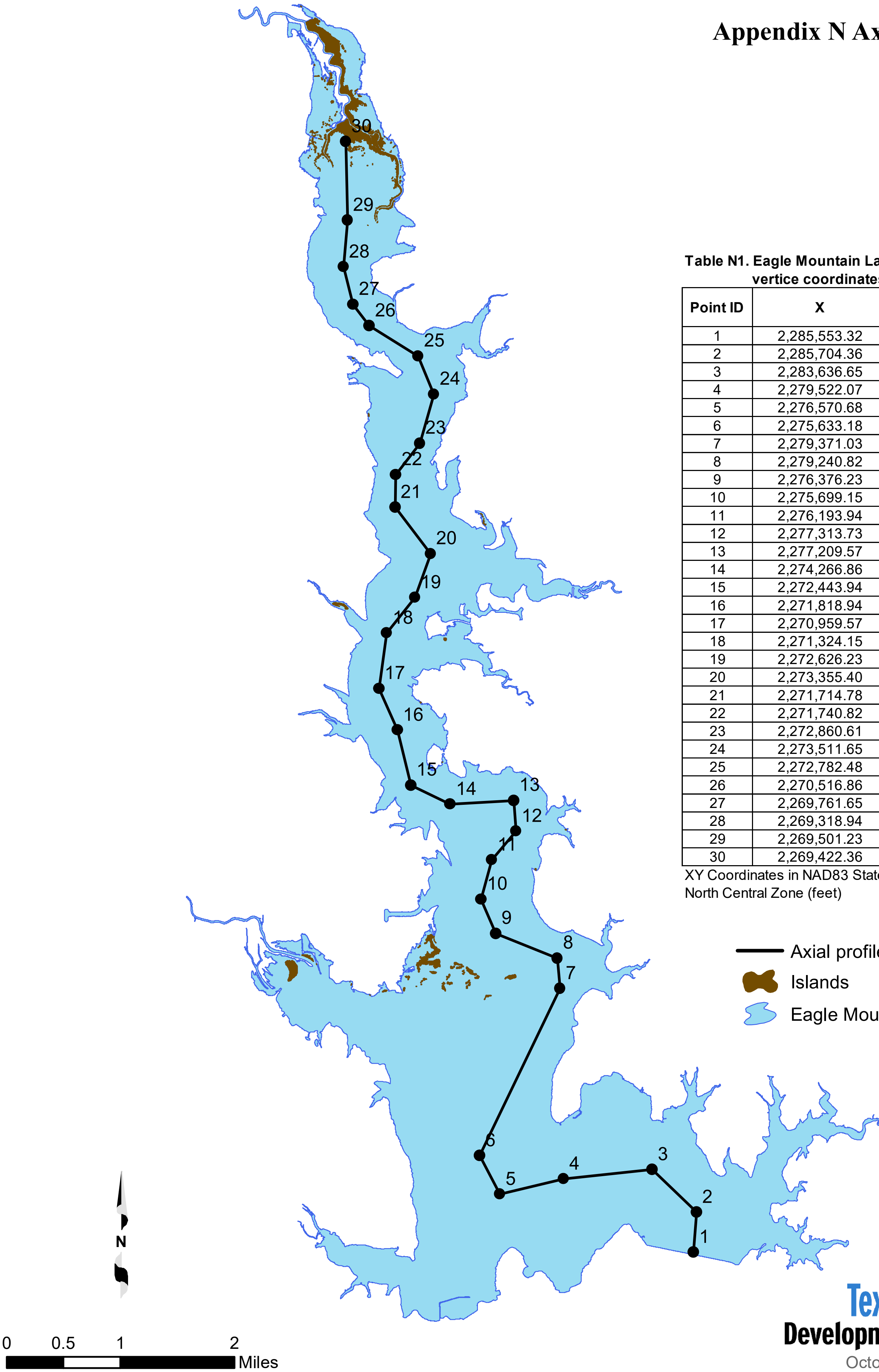


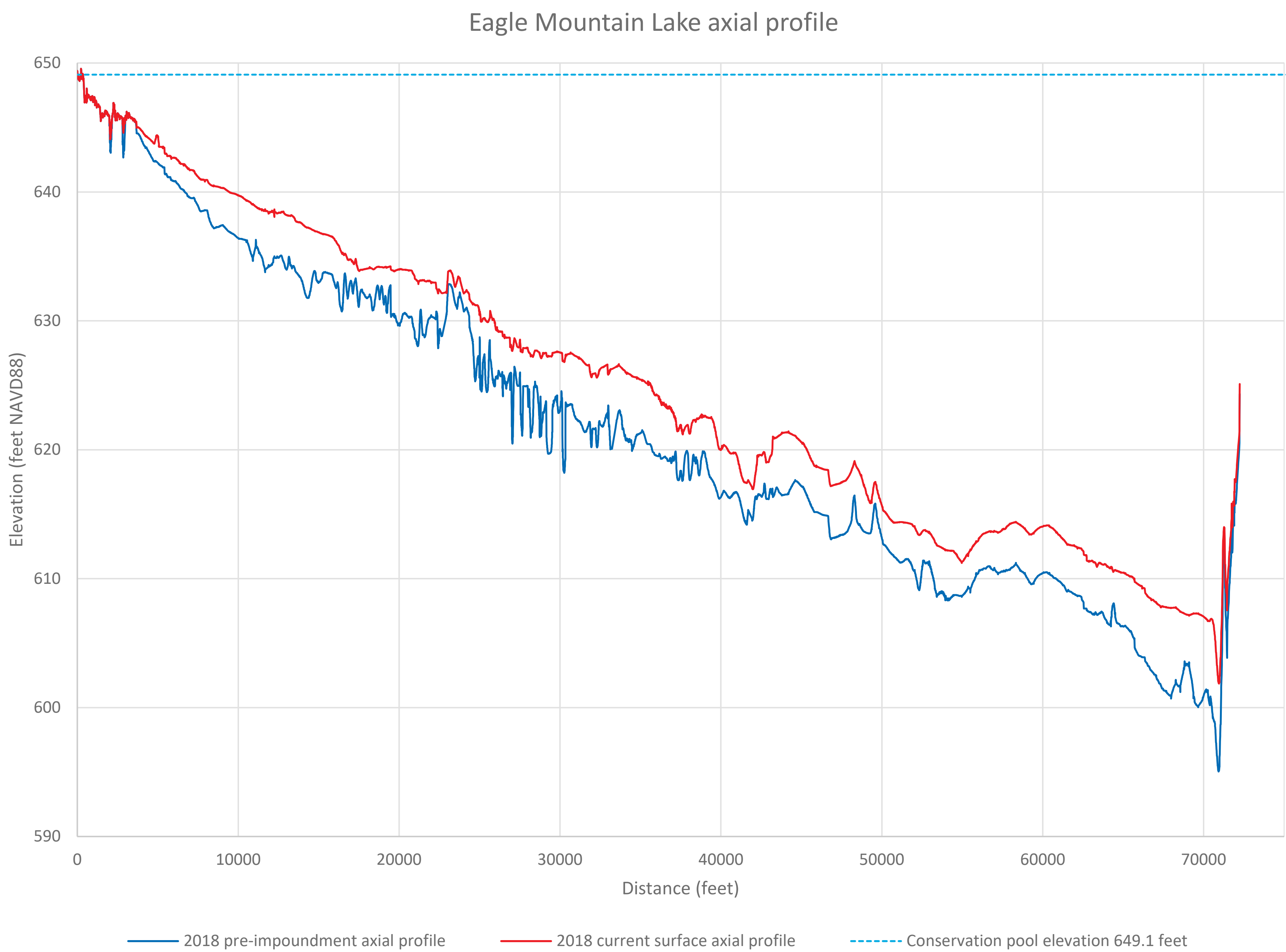
Table N1. Eagle Mountain Lake axial profile vertice coordinates

Point ID	X	Y
1	2,285,553.32	7,003,109.99
2	2,285,704.36	7,004,969.37
3	2,283,636.65	7,006,949.40
4	2,279,522.07	7,006,515.38
5	2,276,570.68	7,005,803.57
6	2,275,633.18	7,007,591.77
7	2,279,371.03	7,015,343.50
8	2,279,240.82	7,016,749.75
9	2,276,376.23	7,017,895.58
10	2,275,699.15	7,019,484.13
11	2,276,193.94	7,021,307.04
12	2,277,313.73	7,022,635.17
13	2,277,209.57	7,024,067.46
14	2,274,266.86	7,023,885.17
15	2,272,443.94	7,024,770.58
16	2,271,818.94	7,027,322.67
17	2,270,959.57	7,029,249.75
18	2,271,324.15	7,031,827.88
19	2,272,626.23	7,033,468.50
20	2,273,355.40	7,035,499.75
21	2,271,714.78	7,037,661.21
22	2,271,740.82	7,039,171.63
23	2,272,860.61	7,040,629.96
24	2,273,511.65	7,042,895.58
25	2,272,782.48	7,044,666.42
26	2,270,516.86	7,046,072.67
27	2,269,761.65	7,047,062.25
28	2,269,318.94	7,048,807.04
29	2,269,501.23	7,050,968.50
30	2,269,422.36	7,054,611.56

XY Coordinates in NAD83 State Plane Texas North Central Zone (feet)

Texas Water Development Board

October 2018 Survey



Eagle Mountain Lake axial profile
650
640
630
620
610
600
590
0
10000
20000
30000
40000
50000
60000
70000
Elevation (feet NAVD88)
Distance (feet)
2018 pre-impoundment axial profile
2018 current surface axial profile
Conservation pool elevation 649.1 feet

Figure 6

Contours
feet (NAVD88)

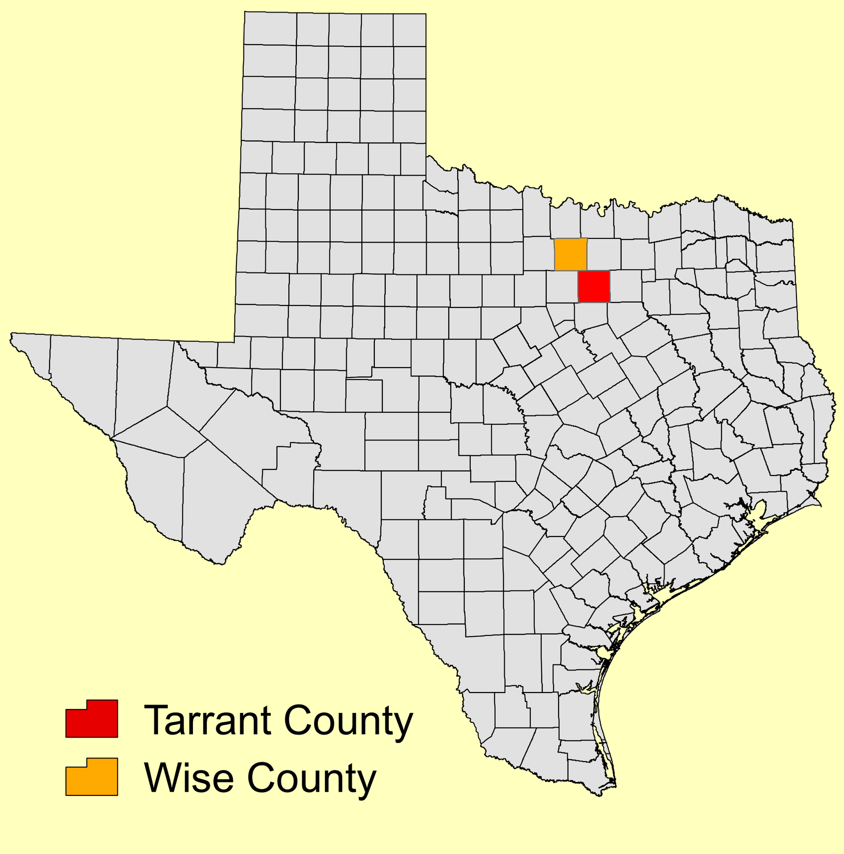
649.1
648
646
644
642
640
638
636
634
632
630
628
626
624
622
620
618
616
614
612
610
608
606
604
602

Islands

Eagle Mountain Lake at elevation 649.4 feet (NAVD88)

Conservation pool elevation 649.1 feet (NAVD88)

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 Eagle Mountain Lake. The Texas Water Development Board makes no representations nor assumes any liability.