Volumetric and Sedimentation Survey of ALAN HENRY RESERVOIR

August 2017 Survey

Texas Water Development Board

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City of Lubbock

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Executive summary

In June 2017, the Texas Water Development Board (TWDB) entered into an agreement with the City of Lubbock to perform a volumetric survey of Alan Henry Reservoir (Garza and Kent counties, Texas). In February 2018, the agreement was amended to include a sedimentation survey of Alan Henry Reservoir. Surveying was performed using a multi-frequency (208 kHz, 50 kHz, and 24 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.

John T. Montford Dam and Alan Henry Reservoir are located on the South Fork of the Double Mountain Fork of the Brazos River, approximately 65 miles southeast of the City of Lubbock, in Garza and Kent counties, Texas. The conservation pool elevation of Alan Henry Reservoir is 2,220.0 feet above mean sea level (NGVD29). The TWDB collected bathymetric data for Alan Henry Reservoir on June 20-22, 2017, while daily average water surface elevations measured between 2,216.49 and 2,216.55 feet above mean sea level (NGVD29), and August 29-31, 2017, while daily average water surface elevations measured between 2,215.82 and 2,215.88 feet above mean sea level (NGVD29). Additional data was collected on May 16, 2018, while the daily average water surface elevation measured 2,212.22 feet above mean sea level (NGVD29).

The 2017 TWDB volumetric survey indicates Alan Henry Reservoir has a total reservoir capacity of 96,207 acre-feet and encompasses 2,800 acres at conservation pool elevation (2,220.0 feet above mean sea level, NGVD29). Previous capacity estimates include the original design of 115,937 acre-feet and a TWDB survey in 2005. The 2005 TWDB survey was re-evaluated using current processing procedures resulting in an updated capacity estimate of 98,974 acre-feet. Comparison of the 2005 and 2017 volumetric survey results indicate Alan Henry Reservoir is losing an average of 231 acre-feet of capacity per year.

The 2017 TWDB sedimentation survey indicates Alan Henry Reservoir has lost capacity at an average of 507 acre-feet per year since impoundment due to sedimentation below conservation pool elevation (2,220.0 feet NGVD29). The sedimentation survey indicates sediment accumulation is primarily occurring throughout the main channels of the reservoir. The TWDB recommends that a similar methodology be used to resurvey Alan Henry Reservoir 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 June 2017, the TWDB entered into an agreement with the City of Lubbock, to perform a volumetric survey of Alan Henry Reservoir (Texas Water Development Board, 2017a). In February 2018, the agreement was amended to include a sedimentation survey of Alan Henry Reservoir (Texas Water Development Board, 2017b). 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 E and F).

Alan Henry Reservoir general information

John T. Montford Dam and Alan Henry Reservoir are located on the South Fork of the Double Mountain Fork of the Brazos River, approximately 65 miles southeast of the City of Lubbock, in Garza and Kent counties, Texas (Figure 1). Construction of the dam began in 1991 and the dam was completed in October 1993 (City of Lubbock, 2018, Texas Water Development Board, 2006). Alan Henry Reservoir is owned and operated by the City of Lubbock. Alan Henry Reservoir is primarily a water supply reservoir for the City of Lubbock and currently accounts for 19 percent of the city's drinking water (City of Lubbock, 2018). Additional pertinent data about John T. Montford Dam and Alan Henry Reservoir can be found in Table 1.

Water rights for Alan Henry Reservoir have been appropriated to the City of Lubbock through Permit to Appropriate State Water No. 4146 and amendments to the water use permit Nos. 4146A and 4146B. The complete permits are on file in the Information Resources Division of the Texas Commission on Environmental Quality.

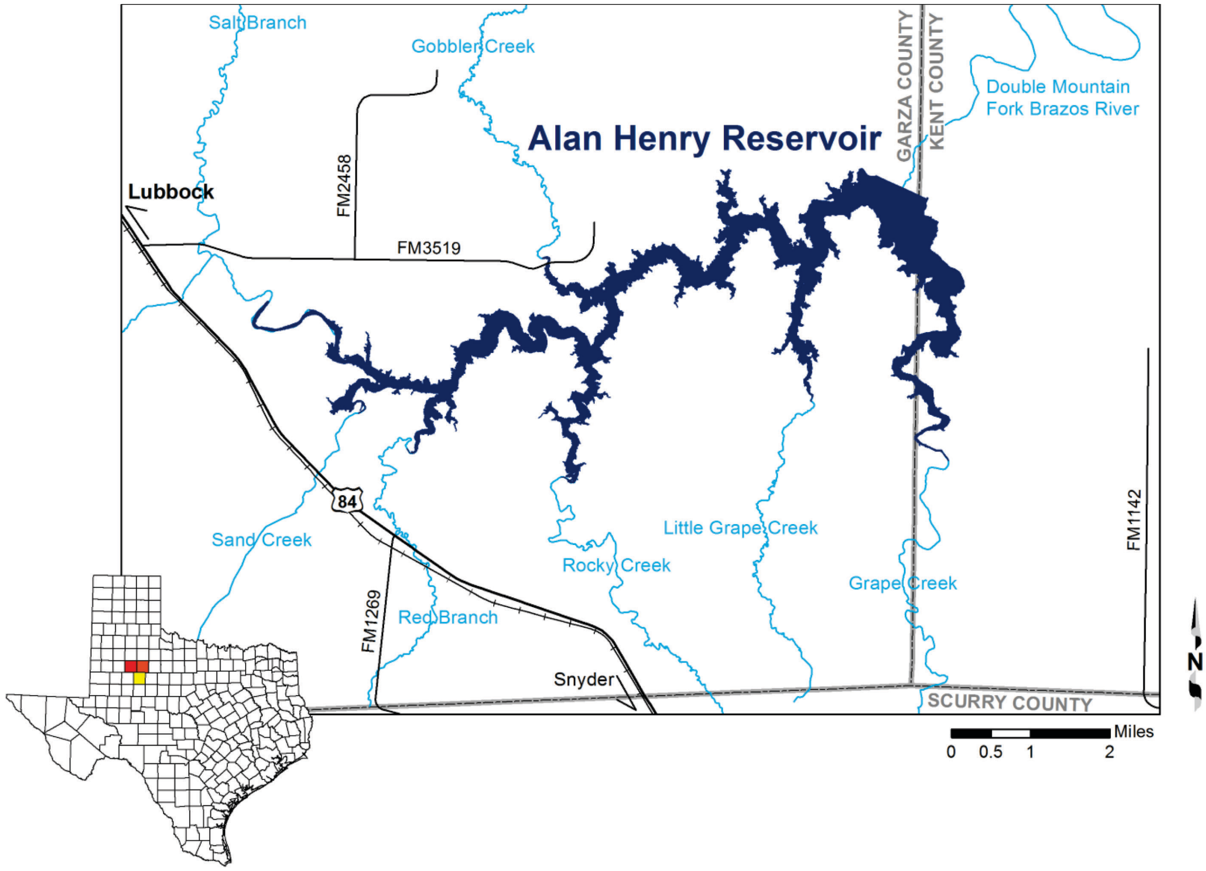


Figure 1. Location map of Alan Henry Reservoir.

Table 1. Pertinent data for John T. Montford Dam and Alan Henry Reservoir.

Owner
City of Lubbock

Location of dam
On the South Fork of the Double Mountain Fork of the Brazos River

Drainage area
394 square miles

Dam

Composition	6.5 million cubic yards of soil, clay, and soil-cement
Length	3,600 feet
Height	138 feet
Width	1,000 feet at the base

Spillway

Service	Concrete, designed to pass 15.6 million gallons per minute
Emergency	Earthen, designed to pass 211 million gallons per minute

Reservoir data (Based on 2017 TWDB survey)

Feature	**Elevation (feet NGVD29[a])**	**Capacity (acre-feet)**	**Area (acres)**
Top of dam	2,263.0	N/A	N/A
Maximum design elevation	2,245.0	N/A	N/A
Emergency spillway crest	2,240.0	N/A	N/A
Service spillway crest/ Top of conservation pool	2,220.0	96,207	2,800

Source: (City of Lubbock, 2018, Freese and Nichols, 1978)
[a] NGVD29 = National Geodetic Vertical Datum 1929

Volumetric and sedimentation survey of Alan Henry Reservoir

Datum

The vertical datum used during this survey is the National Geodetic Vertical Datum 1929 (NGVD29). This datum also is utilized by the United States Geological Survey (USGS) for the reservoir elevation gage *USGS 08079700 Lk Alan Henry Res nr Justiceburg, TX* (U.S. Geological Survey, 2018). Elevations herein are reported in feet relative to the NGVD29 datum. Volume and area calculations in this report are referenced to water levels provided by the USGS gage. The horizontal datum used for this report is North American Datum 1983 (NAD83), and the horizontal coordinate system is State Plane Texas North Central Zone (feet).

TWDB bathymetric and sedimentation data collection

The TWDB collected bathymetric data for Alan Henry Reservoir on June 20-22, 2017, while daily average water surface elevations measured between 2,216.49 and 2,216.55 feet above mean sea level (NGVD29), and August 29-31, 2017, while daily average water surface elevations measured between 2,215.82 and 2,215.88 feet above mean sea level (NGVD29). Additional data was collected on May 16, 2018, while the daily average water surface elevation measured 2,212.22 feet above mean sea level (NGVD29). For data collection, the TWDB used a Specialty Devices, Inc. (SDI), single-beam, multi-frequency (208 kHz, 50 kHz, and 24 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 during the 2005 survey. The depth sounder was calibrated daily using a velocity profiler to measure the speed of sound in the water column and a weighted tape or stadia rod for depth reading verification. Figure 2 shows the data collection locations for the 2017 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 eight locations to collect sediment core samples (Figure 2). Sediment cores were collected on May 16, 2018, with a custom-coring boat and an SDI VibeCore system. Sediment core AH-4 could not be collected due to its location.

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.

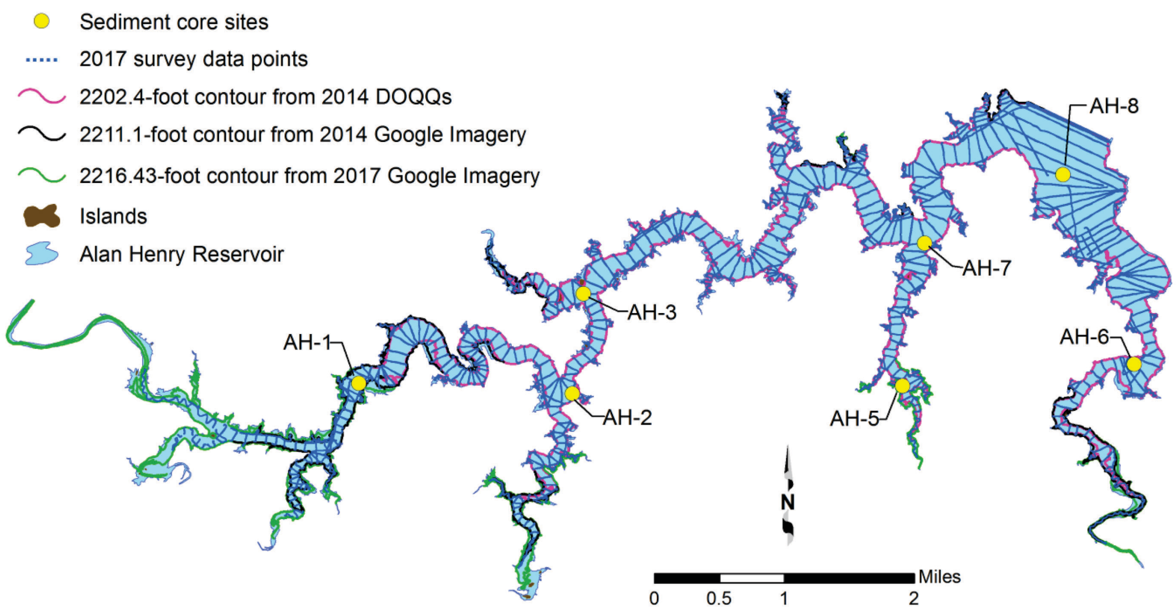


Figure 2. **2017 TWDB Alan Henry Reservoir survey data (*blue dots*), sediment coring locations (*yellow circles*), 2,202.4-foot contour from 2014 DOQQ (*pink line*), 2,211.1-foot contour from 2014 Google Imagery (*black line*), and 2,216.43-foot contour from 2017 Google Imagery (*green line*).**

Data processing

Model boundary

Alan Henry Reservoir's model boundary was digitized from aerial photographs, also known as digital orthophoto quarter-quadrangle images (DOQQs), obtained from the Texas Natural Resources Information System (Texas Natural Resources Information System, 2017) using Environmental Systems Research Institute's ArcGIS software. The quarter-quadrangles that cover Alan Henry Reservoir are Justiceburg (SW, SE) and Justiceburg SE (NW, NE, SW, SE). The DOQQs were photographed on August 11, 2010, and August 14, 2010, while the daily average water surface elevation measured 2,220.14 and 2,220.06 feet, respectively. The DOQQs have a resolution or ground sample distance of 1.0 meters and a horizontal accuracy within ± 6 meters to true ground, according to the associated metadata (U.S. Department of Agriculture, 2016). The model boundary was digitized at the land-water interface in the 2010 photographs, with some interpretation in the upper reaches to account for channel migration evident in more recent photographs, and assigned an elevation of 2,220.0 feet.

Additional elevation contours were digitized from aerial photographs taken in 2014 and 2017 to better model the bathymetric surfaces. For modeling the current bathymetric surface, a complete contour at elevation 2,202.4 feet was digitized from DOQQs photographed on August 7, 2014. In areas where the pre-impoundment surface model and the contour did not agree, the contour was removed from the pre-impoundment surface model. The 2014 DOQQs have a resolution or ground sample distance of 1.0-meters and a horizontal accuracy within ± 6 meters to true ground, according to the associated metadata (Texas Natural Resources Information System, 2015, U.S. Department of Agriculture, 2016). In areas where data alone did not accurately represent the reservoir bathymetry, partial contours were digitized from 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, 2018). Partial contours were digitized from DOQQs photographed on October 2, 2014, while the daily average water surface elevation measured 2,211.1 feet and October 9, 2017, while the daily average water surface elevation measured 2,216.43 feet. The DOQQs have a resolution of 6 inches (Texas Natural Resources Information System, 2018).

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 and manually digitizing the reservoir-bottom surface at the time of initial impoundment (*i.e.* pre-impoundment surface). For further analysis, HydroTools, software developed by TWDB staff, was used to merge all the data 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 and others, 2011a). Finally, the point file resulting from spatial interpolation is 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).

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. Linear interpolation follows a line linking the survey points file to the lake boundary file (McEwen and others, 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 elevations of the reservoir boundary and contours. 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 Alan Henry Reservoir. 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 E) and elevation-area (Appendix F) tables.

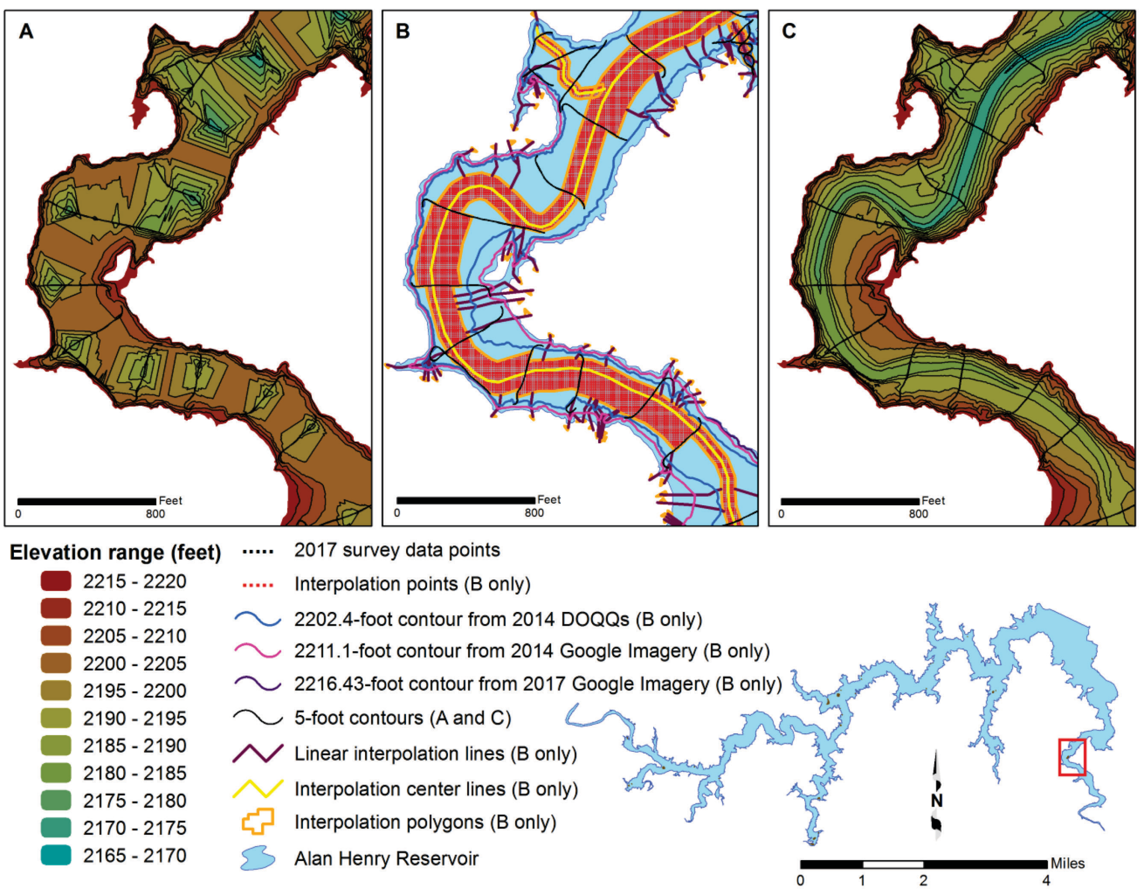


Figure 3. Anisotropic spatial interpolation and linear interpolation of Alan Henry Reservoir sounding data; A) bathymetric contours without interpolated points, B) sounding points (*black*) and interpolated points (*red*), C) bathymetric contours with interpolated points.

In 2007, the TWDB updated the spatial interpolation of the 2005 survey using the Self-Similar Interpolation method. The Self-Similar Interpolation method applies linear interpolation to add interpolated points in-between survey data transects. In 2010, the

Anisotropic Elliptical Inverse Distance Weighted Interpolation method replaced the Self-Similar Interpolation method (Texas Water Development Board, 2016). The 2005 survey boundary was digitized from aerial photographs taken on October 18, 2004, while the daily average water surface elevation of the reservoir measured 2,220.2 feet above mean sea level. The boundary was assigned an elevation of 2,220.0 feet for modeling purposes. According to the associated metadata, the 2004 DOQQs have a resolution or ground sample distance of 1-meter, with a horizontal positional accuracy within ± 5 meters of reference DOQQs from the National Digital Ortho Program (U.S. Department of Agriculture, 2016). 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 2,220.0 feet. In 2016, areas between elevations 2,217.0 feet and 2,220.0 feet were linearly interpolated between the computed values, and volumes above 2,217.0 feet were calculated based on the corrected areas for the 2005 survey (Texas Water Development Board, 2016). The re-calculated 2005 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.

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 2,144.9 to 2,220.0 feet. While linear interpolation was used to estimate topography in areas that were inaccessible by boat or too shallow for survey instruments to work properly, development of some flat triangles (triangles whose vertices all have the same elevation) in the TIN model are unavoidable. The flat triangles in turn lead to anomalous calculations of surface area and volume at the boundary elevations 2,202.4, 2,211.1, 2,216.43, and 2,220.0 feet. To eliminate the effects of the flat triangles on area and volume calculations, areas between elevations 2,202.0 and 2,203.0 feet, 2,210.6 and 2,211.5 feet, and 2,214.5 and 2,220.0 feet were linearly interpolated between the computed values, and volumes above elevation 2,202.0 feet were calculated from the interpolated and computed areas. The elevation-capacity table and elevation-area table, based on the 2017 survey and analysis, are presented in Appendices E and F, respectively. The capacity curve is presented in Appendix G, and the area curve is presented in Appendix H.

The volumetric TIN model was converted to a raster representation using a cell size of 1 foot by 1 foot. 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 Alan Henry Reservoir (Figure 5); and, (3) a 5-foot contour map (Figure 6).

Figure 4

Alan Henry Reservoir

Elevation relief map

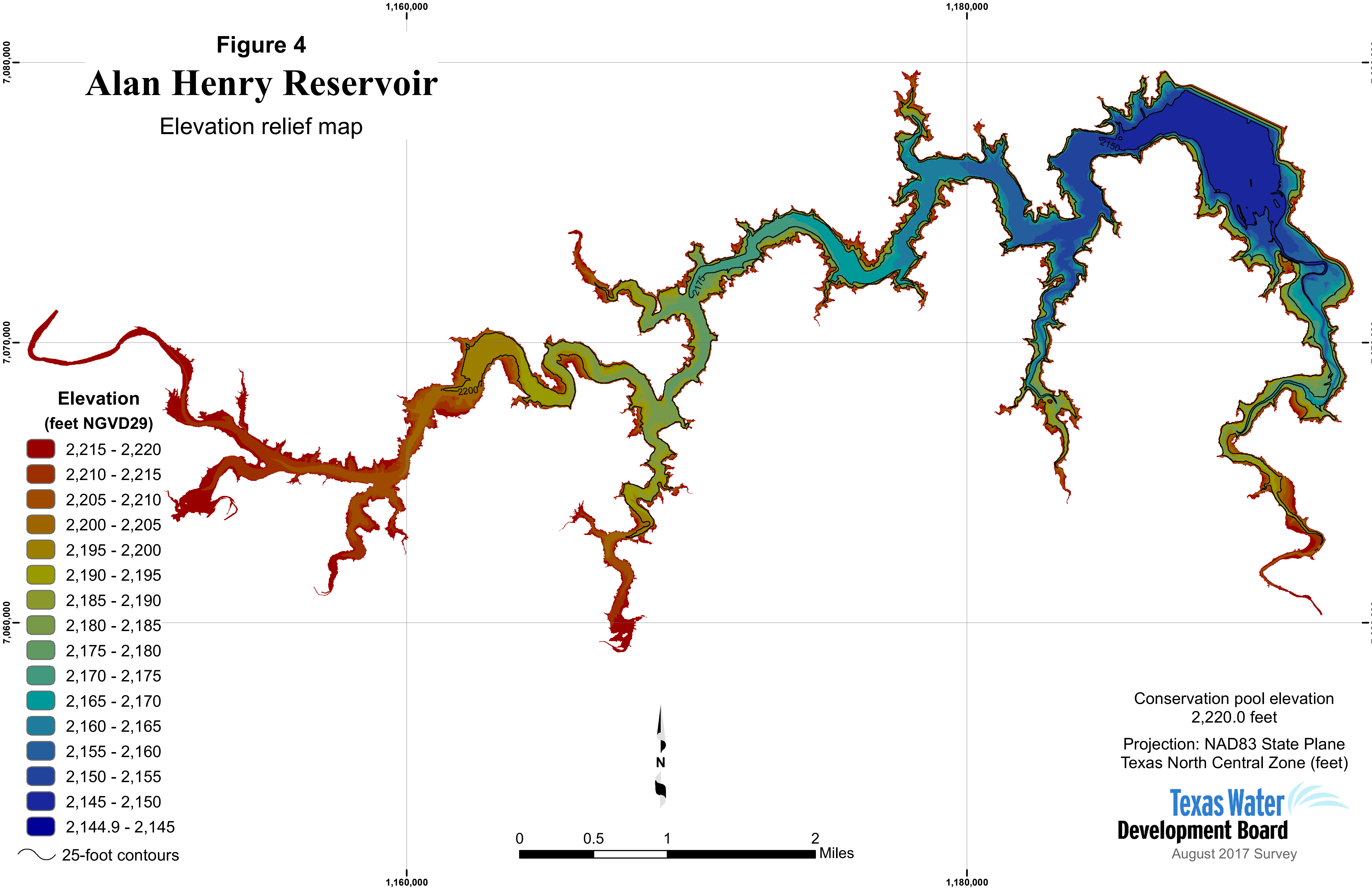
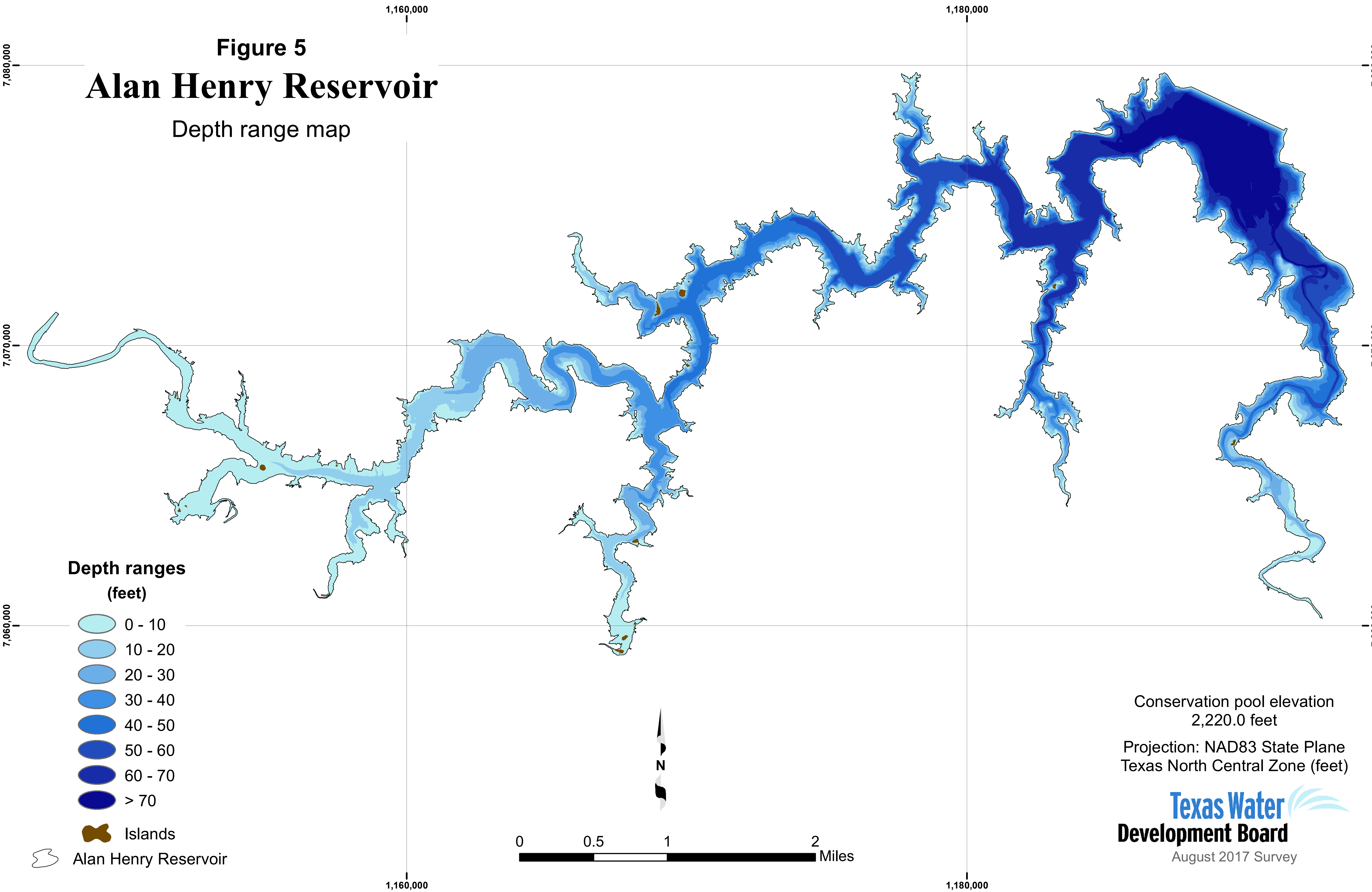


Figure 5

Alan Henry Reservoir

Depth range map



Analysis of sediment data from Alan Henry Reservoir

Sedimentation in Alan Henry Reservoir was determined by analyzing the acoustic signal returns of all three depth sounder frequencies in the DepthPic© software. While the 208 kHz signal is used to determine the current bathymetric surface, the 208 kHz, 50 kHz, and 24 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 Alan Henry Reservoir.

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample/ post-impoundment sediment	Sediment core description		Munsell soil color
AH-1	1160792.93	7067758.14	120.0"/N/A	post-impoundment	0.0–27.0" silt, pudding-like consistency, some darker layering with similar consistency	5YR 4/4 reddish brown with 5YR 4/2 dark reddish gray
					27.0-30.0" sand, fine grained with some 1/16" grains	10YR 5/3 brown
					30.0-51.0" silt, with some darker layers of same pudding-like consistency, similar to layer 1 but slightly lower water content	5YR 4/4 reddish brown with 5YR 4/2 dark reddish gray
					51.0-52.0" more sandy than layers 1 and 3, but less than layer 2, sandy loam	10YR 3/1 very dark gray
					52.0-118.0" similar to layers 1 and 3 inconsistency with slightly lower water content, pudding-like, silt	5YR 4/4 reddish brown with occasional darker layers 5YR 4/2 dark reddish gray
					118.0-120.0" sandier than above, similar texture to layer 4 but lighter in color, sandy loam	N/A
AH-2	1169466.38	7067336.93	120.0"/N/A	post-impoundment	0.0–84.0" high water content, clay or silt, silt, pudding-like, darker layers with similar consistency, silt	5YR 4/4 reddish brown (85%) with 10YR 4/2 dark grayish brown (15%)
					84.0-87.0" color shift, grittier than above, sandy loam, consistent color throughout	7.5YR 4/3 brown
					87.0-99.0" same as layer 1, pudding-like, silt or clay with a high water content	5YR 4/4 with streaks of 10YR 4/3
					99.0-106.0" identical to layer 2, consistent color throughout with more sand than above and below, sandy loam	7.5YR 4/3 brown
					106.0-120.0" similar to layers 1 and 3 with slightly less water content/higher density	N/A

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

Table 2. Sediment core sample analysis data for Alan Henry Reservoir (continued).

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample/ post-impoundment sediment		Sediment core description	Munsell soil color
AH-3	1169918.90	7071399.91	84.0”/N/A	post-impoundment	0–15.0” silt, pudding-like, high water content, color variations	5YR 4/4 reddish brown, 5YR 4/2 dark reddish gray, 5YR 2.5/1 black
					15.0-84.0” homogenous color and texture throughout, but shift in both from above layer, sandy loam, lower water content	7.5YR 4/3 brown
AH-5	1182893.22	7067652.55	64.0”/3.0”	post-impoundment	0.0–0.5” water and fluff	N/A
					0.5-3.0” soupy mix of water and below material, loam/sandy loam with poorly sorted particles up to 1/16”	7.5YR 4/1 dark gray
				pre-impoundment	3.0-35.0” lower water content, not pudding-like, sandy loam, some large (up to 1.0”) pebbles, fine but long roots throughout	10YR 3/2 very dark grayish brown
					35.0-64.0” slight color shift from above, same texture, sandy loam with roots (very fine throughout layer), no pebbles	5YR 3/2 dark reddish brown
AH-6	1192313.57	7068547.39	30.0”/3.5”	post-impoundment	0.0–1.5” water and fluff, very high water content, silt	N/A
					1.5-3.5” very soupy, silt, slightly less water than above	5YR 4/3 reddish brown
				pre-impoundment	3.5-30.0” clear textural change from above, organics throughout, large stick at top of layer (0.5”diameter by 1.0”), leaf litter at top, fine roots throughout, clay	7.5Y 4/3 brown
AH-7	1183800.90	7073468.36	120.0”/N/A	post-impoundment	0.0–120.0” no significant changes, silt, with water content decreasing and penetration resistance gradually increasing with depth, intermittent darker layers with no changes to texture or penetration resistance	5YR 4/4 reddish brown with 5YR 1/1 black

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

Table 2. Sediment core sample analysis data for Alan Henry Reservoir (continued).

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample/ post-impoundment sediment	Sediment core description		Munsell soil color
AH-8	1189416.63	7076256.03	115.0"/104.5"	post-impoundment	0.0-2.5" high water content, pudding-like, silt	5YR 4/4 reddish brown
					2.5-38.0" lower water content than above, same parent material, silt	5YR 4/4 reddish brown
					38.0-40.5" incomplete layer/chunk of dark colored material, similar consistency to above, silt	5YR 1/1 black
					40.5-101.0" similar texture/consistency as above two layers, slightly darker than layer 2, dark streaks at 70-71", 74-75", and 88-89"	5YR 4/3 reddish brown with 5YR 1/1 black streaks
					101.0-104.5" more dense than layer above, color and texture change, silty clay	5YR 1/1 black
				pre-impoundment	104.5-115.0" clay, significant texture and consistency change at 104.5"	5YR 3/3 dark reddish brown

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

A photograph of sediment core AH-8 (for location, refer to Figure 2) is shown in Figure 7 and is representative of sediment cores sampled from Alan Henry Reservoir. 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 104.5 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 AH-8 from Alan Henry Reservoir. Post-impoundment sediment layers occur in the top 104.5 inches of this sediment core (identified by the yellow box). Pre-impoundment sediment layers were identified and are defined by the blue box.

Figures 8 and 9 illustrate how measurements from sediment core samples are used with sonar data to help identify the post- and pre-impoundment layers in the acoustic signal. Figure 8 compares sediment core sample AH-8 with the acoustic signals for each frequency combined (8A, 8A'), and the individual frequencies: 208 kHz (8B, 8B'), 50 kHz (8C, 8C'), and 24 kHz (8D, 8D'). Within DepthPic©, the current bathymetric surface is automatically determined based on signal returns from the 208 kHz transducer as represented by the top black line in Figure 8A' and red line in Figures 8B', 8C', and 8D'. The pre-impoundment surface is identified by comparing boundaries observed in the 208 kHz, 50 kHz, and 24 kHz signals to the location of the pre-impoundment surface as determined by the sediment core sample analysis. Many layers of sediment may be identified during core 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. 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.

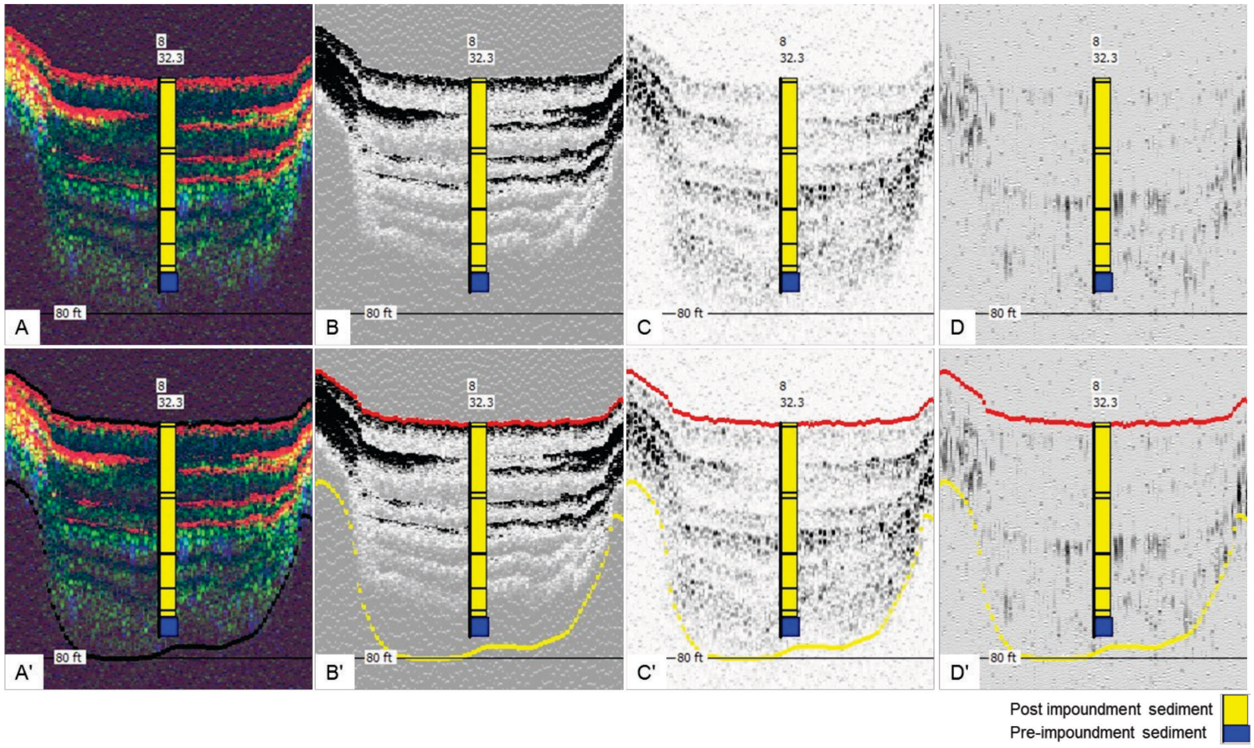


Figure 8. **Comparison of sediment core AH-8 with acoustic signal returns A, A') combined acoustic signal returns, B, B') 208 kHz frequency, C, C') 50 kHz frequency, and D, D') 24 kHz frequency.**

In this case, the pre-impoundment boundary as identified from the pre-impoundment interface of the sediment core sample was most visible in the 50 kHz acoustic signal returns; therefore, the 50 kHz signal returns were used to locate the pre-impoundment surface (yellow line in Figure 8). Figure 9 shows sediment core sample AH-8 correlated with the 50 kHz acoustic signal returns of the nearest surveyed cross-section. The pre-impoundment surface was first identified along cross-sections for which sediment core samples have been collected. This information was then used as a guide for identifying the pre-impoundment surface along cross-sections where sediment core samples were not collected.

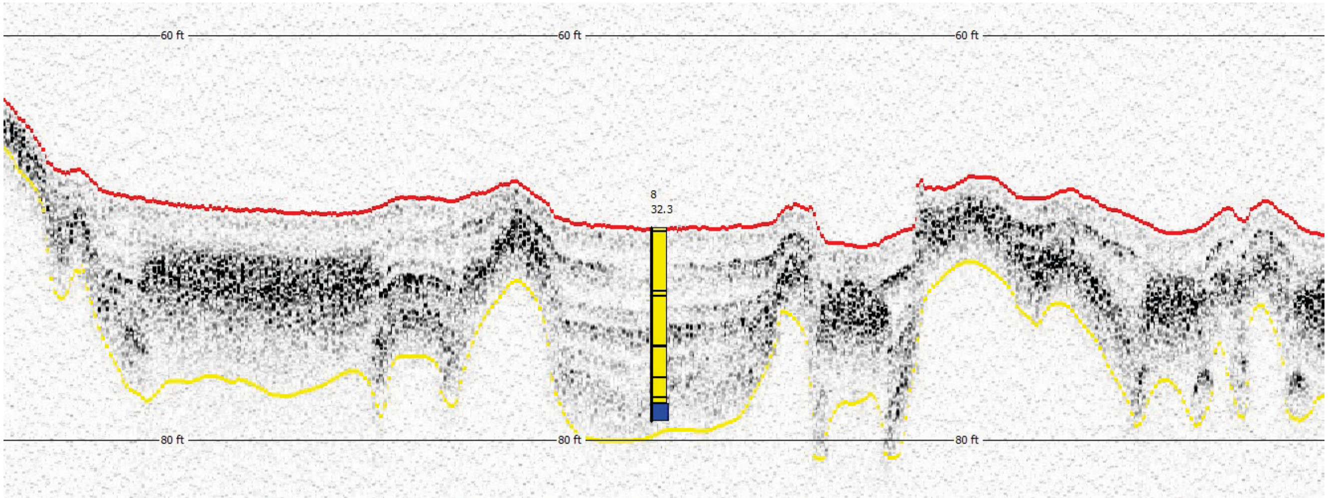


Figure 9. Cross-section of data collected during the 2017 survey, displayed in DepthPic© (50 kHz acoustic signal returns), correlated with sediment core sample AH-8 and showing the current surface as the top red line, and pre-impoundment surface as the bottom yellow line.

After the pre-impoundment surface for all cross-sections was identified, a pre-impoundment TIN model and a sediment thickness TIN model were created following standard GIS techniques (Furnans and Austin, 2007). Pre-impoundment elevations and sediment thicknesses were interpolated between surveyed cross-sections using HydroTools with the same interpolation definition file used for bathymetric interpolation with minor edits to account for pre-impoundment features and the changes made to the digitized elevation contours. For the purposes of TIN model creation, the TWDB assumed the sediment thickness at the reservoir boundary and elevation contours was 0 feet (defined as the 2,220.0-foot, 2,202.4-foot, 2,211.1-foot, and 2,216.43-foot elevation contours). Additionally, any data points between a contour and the boundary were edited to also have a sediment value of 0 feet and a pre-impoundment value equal to the current surface elevation. 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 of Alan Henry Reservoir (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 linear interpolation was 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 lead to anomalous calculations of surface area and volume at the boundary elevation 2,220.0 feet. To eliminate the effects of the flat triangles on area and volume calculations, areas between elevations 2,211.0 and 2,220.0 feet were linearly interpolated between the computed values, and volumes above elevation 2,211.0 feet were calculated based on the corrected areas.

The TWDB sedimentation survey results may not account for all sediment accumulation in areas exposed during low water levels, as occurred between December 2012 and May 2015, due to desiccation of the 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).

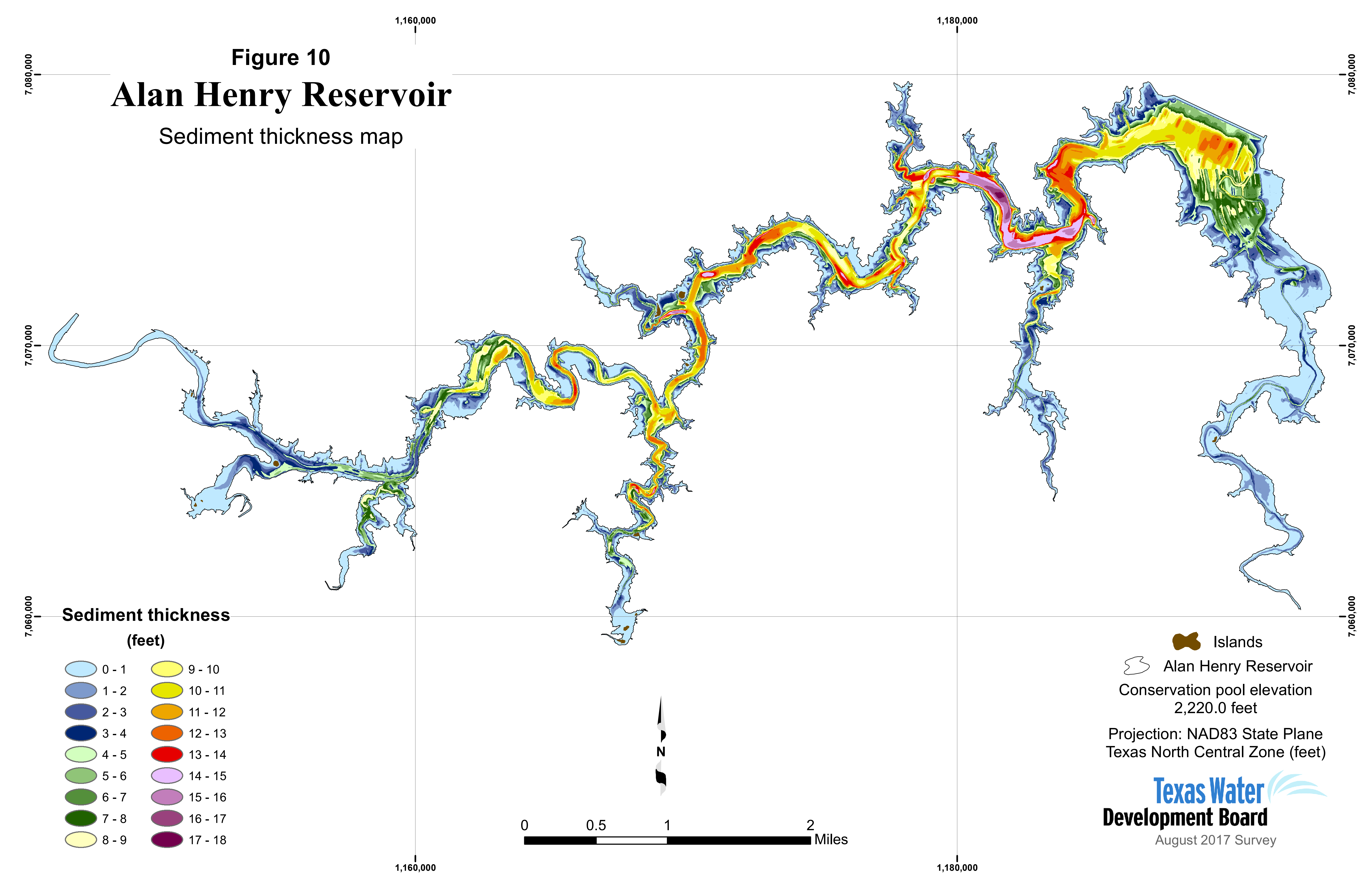


Figure 10
Alan Henry Reservoir
Sediment thickness map
1,160,000
1,180,000
7,080,000
7,070,000
7,060,000
Sediment thickness
(feet)
0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
9 - 10
10 - 11
11 - 12
12 - 13
13 - 14
14 - 15
15 - 16
16 - 17
17 - 18
N
0
0.5
1
2
Miles
Islands
Alan Henry Reservoir
Conservation pool elevation
2,220.0 feet
Projection: NAD83 State Plane
Texas North Central Zone (feet)
Texas Water
Development Board
August 2017 Survey

Survey results

Volumetric survey

The 2017 TWDB volumetric survey indicates that Alan Henry Reservoir has a total reservoir capacity of 96,207 acre-feet and encompasses 2,800 acres at conservation pool elevation (2,220.0 feet above mean sea level, NGVD29). The original design capacity of Alan Henry Reservoir was estimated at 115,937 acre-feet. Re-evaluation of the 2005 survey resulted in an updated capacity estimate of 98,974 acre-feet, or a 4.4 percent increase in total capacity, respectively (Table 3). Comparison of the 2005 and 2017 volumetric survey results indicate Alan Henry Reservoir is losing an average of 231 acre-feet of capacity per year. This may suggest the rate of sedimentation has decreased since initial impoundment. Differences in surface area are most likely attributable to differences in reservoir boundary delineation methods. Comparing volumetric survey results to estimate loss of area and capacity may introduce error due to differences in past and present survey methodologies.

Table 3. Current and previous survey capacity and surface area estimates for Alan Henry Reservoir.

Top of conservation pool elevation (2,220.0 feet, NGVD29)			
Survey	**Surface area (acres)**	**Total capacity (acre-feet)**	**Source**
Original design	2,884	115,937	Freese and Nichols, 1978
TWDB 2005	2,741	94,808	Texas Water Development Board, 2006
TWDB 2005 (re-calculated)	2,741	98,974	Texas Water Development Board, 2016
TWDB 2017	2,800	96,207	

Sedimentation survey

The 2017 TWDB sedimentation survey indicates Alan Henry Reservoir has lost capacity at an average of 507 acre-feet per year since impoundment due to sedimentation below conservation pool elevation (2,220.0 feet NGVD29). The sedimentation survey indicates sediment accumulation is primarily occurring throughout the main channels of the reservoir. Comparison of capacity estimates of Alan Henry Reservoir derived using differing methodologies are provided in Table 4 for sedimentation rate calculation.

Table 4. Average annual capacity loss comparisons for Alan Henry Reservoir.

Previous surveys		TWDB 2017 volumetric survey	Comparison of surveys			
Survey	**Conservation pool capacity (acre-feet)**	**Conservation pool capacity (acre-feet)**	**Volume difference (acre-feet)**	**Years between surveys**	**Capacity loss rate (acre-feet/year)**	**Capacity loss rate (acre-feet/square-mile of drainage area/year)**
Original design[a]	115,937	96,207	19,730	24	822	2.09
TWDB 2005 (re-calculated)	98,974	96,207	2,767	12	231	0.59
TWDB pre-impoundment estimate based on 2017 survey	108,376	96,207	12,169	24	507	1.29

[a] Source: (Freese and Nichols, 1978), note: John T. Montford Dam was completed in October 1993.

Sediment range lines

In 2006, the TWDB established twenty-two sediment range lines throughout Alan Henry Reservoir to measure sediment accumulation over time. A cross-sectional comparison of the twenty-two sediment range lines comparing the current bottom surface from the 2017 TWDB survey and the 2005 TWDB re-calculated survey is presented in Appendix I. Also presented in Appendix I are a map, depicting the TWDB locations of the sediment range lines and Table I1, 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.

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

Alan Henry Reservoir

RESERVOIR VOLUME TABLE

TEXAS WATER DEVELOPMENT BOARD — July 2005 Survey re-calculated November 2016

VOLUME IN ACRE-FEET — Conservation Pool Elevation 2,220.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2,140	0	0	0	0	0	0	0	0	0	0
2,141	0	0	0	0	0	0	0	0	0	0
2,142	0	0	0	0	0	0	0	0	0	0
2,143	0	1	1	1	1	1	1	2	2	3
2,144	3	4	5	6	7	8	10	12	14	16
2,145	19	22	25	29	33	39	46	53	62	72
2,146	82	94	107	121	135	151	167	184	202	220
2,147	240	260	280	302	324	346	370	394	418	443
2,148	469	495	522	549	576	604	632	661	689	719
2,149	748	778	809	840	871	903	936	968	1,001	1,035
2,150	1,068	1,103	1,137	1,171	1,206	1,241	1,277	1,312	1,349	1,385
2,151	1,421	1,458	1,495	1,533	1,571	1,609	1,648	1,687	1,727	1,766
2,152	1,807	1,848	1,889	1,930	1,972	2,014	2,056	2,099	2,142	2,185
2,153	2,229	2,273	2,317	2,362	2,407	2,453	2,499	2,545	2,591	2,638
2,154	2,685	2,732	2,779	2,827	2,876	2,924	2,973	3,022	3,072	3,121
2,155	3,171	3,222	3,272	3,323	3,374	3,426	3,478	3,530	3,583	3,636
2,156	3,689	3,742	3,796	3,850	3,904	3,959	4,014	4,069	4,124	4,180
2,157	4,236	4,292	4,348	4,405	4,462	4,519	4,577	4,634	4,692	4,751
2,158	4,809	4,868	4,927	4,987	5,047	5,107	5,168	5,229	5,290	5,352
2,159	5,414	5,476	5,538	5,601	5,664	5,727	5,791	5,854	5,918	5,983
2,160	6,047	6,112	6,177	6,243	6,309	6,375	6,442	6,508	6,576	6,643
2,161	6,711	6,780	6,848	6,917	6,986	7,056	7,126	7,196	7,266	7,337
2,162	7,408	7,480	7,552	7,624	7,696	7,769	7,842	7,916	7,990	8,064
2,163	8,138	8,213	8,288	8,363	8,439	8,515	8,592	8,668	8,745	8,822
2,164	8,900	8,978	9,056	9,134	9,213	9,292	9,371	9,450	9,530	9,609
2,165	9,689	9,770	9,850	9,932	10,013	10,094	10,176	10,258	10,341	10,423
2,166	10,506	10,590	10,673	10,757	10,841	10,925	11,009	11,094	11,179	11,264
2,167	11,350	11,435	11,521	11,607	11,694	11,780	11,867	11,954	12,041	12,129
2,168	12,216	12,304	12,393	12,481	12,570	12,659	12,748	12,838	12,928	13,018
2,169	13,108	13,199	13,290	13,381	13,472	13,564	13,656	13,748	13,841	13,934
2,170	14,027	14,120	14,213	14,307	14,401	14,495	14,590	14,684	14,779	14,874
2,171	14,969	15,065	15,161	15,257	15,353	15,449	15,546	15,643	15,741	15,838
2,172	15,936	16,034	16,133	16,231	16,330	16,429	16,529	16,628	16,729	16,829
2,173	16,929	17,030	17,131	17,232	17,334	17,436	17,538	17,640	17,743	17,845
2,174	17,948	18,052	18,155	18,259	18,363	18,467	18,572	18,676	18,781	18,886
2,175	18,992	19,098	19,204	19,310	19,416	19,523	19,630	19,737	19,845	19,953
2,176	20,061	20,169	20,278	20,386	20,495	20,605	20,714	20,824	20,934	21,044
2,177	21,155	21,265	21,376	21,487	21,599	21,710	21,822	21,934	22,047	22,159
2,178	22,272	22,385	22,498	22,612	22,726	22,840	22,954	23,069	23,184	23,299
2,179	23,415	23,531	23,647	23,763	23,879	23,996	24,114	24,231	24,349	24,467
2,180	24,585	24,704	24,822	24,941	25,061	25,180	25,300	25,420	25,541	25,661
2,181	25,783	25,904	26,025	26,147	26,269	26,392	26,515	26,638	26,761	26,885
2,182	27,009	27,133	27,258	27,383	27,508	27,634	27,760	27,886	28,013	28,139
2,183	28,267	28,394	28,522	28,650	28,779	28,907	29,037	29,166	29,296	29,425
2,184	29,556	29,686	29,817	29,948	30,080	30,212	30,344	30,476	30,608	30,741
2,185	30,874	31,008	31,141	31,275	31,409	31,543	31,678	31,813	31,948	32,083
2,186	32,219	32,355	32,491	32,628	32,765	32,902	33,039	33,176	33,314	33,452
2,187	33,591	33,730	33,868	34,008	34,147	34,287	34,427	34,567	34,708	34,848
2,188	34,989	35,131	35,272	35,414	35,556	35,699	35,842	35,985	36,128	36,271
2,189	36,415	36,560	36,704	36,849	36,994	37,139	37,285	37,431	37,578	37,724
2,190	37,871	38,019	38,166	38,314	38,462	38,611	38,760	38,909	39,058	39,208
2,191	39,358	39,509	39,659	39,810	39,961	40,113	40,265	40,417	40,569	40,722
2,192	40,875	41,028	41,181	41,335	41,489	41,644	41,799	41,954	42,109	42,265
2,193	42,421	42,577	42,734	42,891	43,048	43,206	43,364	43,522	43,681	43,840
2,194	44,000	44,159	44,319	44,480	44,640	44,802	44,963	45,125	45,287	45,450
2,195	45,613	45,776	45,939	46,103	46,267	46,432	46,597	46,762	46,928	47,094
2,196	47,261	47,428	47,595	47,763	47,931	48,099	48,269	48,438	48,608	48,777
2,197	48,948	49,119	49,290	49,462	49,633	49,806	49,978	50,151	50,324	50,498
2,198	50,672	50,846	51,021	51,196	51,371	51,547	51,723	51,899	52,076	52,253
2,199	52,430	52,608	52,786	52,965	53,144	53,323	53,503	53,682	53,863	54,043

Appendix A (continued)

Alan Henry Reservoir

RESERVOIR VOLUME TABLE

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

July 2005 Survey re-calculated November 2016
Conservation Pool Elevation 2,220.0 feet NGVD29

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2,200	54,224	54,405	54,587	54,769	54,950	55,133	55,316	55,499	55,683	55,866
2,201	56,050	56,235	56,419	56,605	56,790	56,976	57,162	57,348	57,535	57,721
2,202	57,909	58,097	58,285	58,473	58,662	58,851	59,041	59,230	59,421	59,611
2,203	59,802	59,993	60,185	60,377	60,569	60,762	60,956	61,149	61,344	61,538
2,204	61,733	61,929	62,124	62,321	62,517	62,714	62,912	63,109	63,308	63,506
2,205	63,706	63,906	64,105	64,306	64,507	64,709	64,911	65,113	65,316	65,519
2,206	65,723	65,927	66,131	66,336	66,541	66,747	66,953	67,160	67,367	67,574
2,207	67,782	67,990	68,199	68,408	68,618	68,828	69,039	69,251	69,463	69,675
2,208	69,888	70,101	70,315	70,529	70,744	70,960	71,176	71,392	71,609	71,826
2,209	72,044	72,263	72,481	72,701	72,921	73,141	73,362	73,584	73,806	74,028
2,210	74,251	74,475	74,698	74,923	75,148	75,373	75,600	75,826	76,053	76,280
2,211	76,508	76,737	76,966	77,195	77,425	77,655	77,886	78,117	78,349	78,581
2,212	78,814	79,047	79,280	79,515	79,749	79,984	80,220	80,455	80,692	80,928
2,213	81,166	81,404	81,642	81,881	82,120	82,360	82,600	82,840	83,081	83,322
2,214	83,565	83,807	84,050	84,294	84,537	84,781	85,026	85,271	85,517	85,762
2,215	86,009	86,256	86,503	86,751	86,999	87,248	87,497	87,746	87,996	88,246
2,216	88,497	88,748	89,000	89,252	89,504	89,758	90,011	90,265	90,520	90,774
2,217	91,030	91,285	91,542	91,799	92,057	92,315	92,574	92,833	93,093	93,354
2,218	93,616	93,878	94,140	94,404	94,667	94,932	95,197	95,463	95,729	95,996
2,219	96,264	96,532	96,801	97,070	97,340	97,611	97,883	98,154	98,427	98,700
2,220	98,974									

Note: Capacities above elevation 2,217.0 feet calculated from interpolated areas

Appendix B

Alan Henry Reservoir

RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD — July 2005 Survey re-calculated November 2016

AREA IN ACRES — Conservation Pool Elevation 2,220.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2,140	0	0	0	0	0	0	0	0	0	0
2,141	0	0	0	0	0	0	0	0	0	0
2,142	0	0	0	0	0	0	0	0	1	1
2,143	1	1	1	2	2	2	3	3	4	5
2,144	6	8	10	12	14	16	17	20	22	24
2,145	27	30	35	42	50	61	71	81	91	103
2,146	113	123	132	142	150	159	167	175	182	189
2,147	196	203	210	217	224	230	236	242	249	255
2,148	260	264	268	272	275	279	282	286	290	294
2,149	298	303	307	312	318	322	326	329	332	335
2,150	339	342	345	347	350	353	356	359	362	364
2,151	367	370	374	378	382	385	388	393	397	402
2,152	406	409	413	416	419	422	425	428	431	435
2,153	438	442	445	449	453	456	459	462	465	468
2,154	471	474	477	481	484	487	490	493	496	498
2,155	502	504	508	511	514	517	521	524	528	531
2,156	534	537	539	542	544	547	550	553	555	558
2,157	560	562	565	567	570	573	576	579	582	585
2,158	587	590	595	599	602	605	608	611	614	617
2,159	620	623	626	628	631	633	636	639	641	644
2,160	647	650	654	657	660	664	668	671	675	678
2,161	681	684	687	690	694	697	700	704	707	710
2,162	713	716	720	723	727	730	733	736	740	743
2,163	746	749	753	756	759	762	765	768	771	774
2,164	777	779	782	784	787	789	792	794	797	800
2,165	802	805	808	811	814	817	820	823	825	828
2,166	831	833	836	838	841	844	846	849	851	853
2,167	855	858	860	862	864	867	869	871	873	876
2,168	878	881	884	887	889	892	895	897	900	902
2,169	905	908	911	913	916	918	921	923	926	928
2,170	931	933	936	938	940	943	945	947	950	952
2,171	954	957	959	962	964	967	969	972	974	977
2,172	980	983	985	988	991	993	996	999	1,001	1,004
2,173	1,007	1,009	1,011	1,014	1,017	1,019	1,021	1,024	1,026	1,029
2,174	1,032	1,034	1,036	1,039	1,041	1,044	1,046	1,048	1,051	1,054
2,175	1,056	1,059	1,061	1,063	1,066	1,069	1,071	1,074	1,077	1,079
2,176	1,082	1,084	1,087	1,089	1,092	1,094	1,096	1,099	1,101	1,103
2,177	1,106	1,108	1,110	1,113	1,115	1,117	1,119	1,122	1,124	1,127
2,178	1,129	1,132	1,135	1,137	1,140	1,143	1,146	1,148	1,151	1,154
2,179	1,157	1,159	1,162	1,165	1,168	1,170	1,173	1,176	1,178	1,181
2,180	1,184	1,187	1,189	1,192	1,195	1,198	1,200	1,203	1,206	1,209
2,181	1,211	1,214	1,217	1,220	1,223	1,226	1,229	1,232	1,235	1,238
2,182	1,241	1,245	1,248	1,252	1,255	1,258	1,261	1,264	1,267	1,271
2,183	1,274	1,277	1,280	1,283	1,286	1,289	1,292	1,295	1,298	1,301
2,184	1,304	1,307	1,310	1,313	1,316	1,319	1,321	1,324	1,327	1,329
2,185	1,332	1,335	1,337	1,340	1,342	1,345	1,348	1,350	1,353	1,356
2,186	1,358	1,361	1,363	1,366	1,369	1,371	1,374	1,377	1,380	1,382
2,187	1,385	1,388	1,391	1,393	1,396	1,399	1,401	1,404	1,407	1,409
2,188	1,412	1,415	1,417	1,420	1,423	1,426	1,429	1,432	1,435	1,438
2,189	1,441	1,443	1,446	1,449	1,452	1,456	1,459	1,462	1,465	1,468
2,190	1,471	1,474	1,478	1,481	1,484	1,487	1,490	1,493	1,496	1,499
2,191	1,502	1,505	1,508	1,511	1,514	1,516	1,519	1,522	1,525	1,528
2,192	1,531	1,534	1,537	1,540	1,543	1,546	1,549	1,552	1,556	1,559
2,193	1,562	1,565	1,568	1,572	1,576	1,579	1,582	1,585	1,589	1,592
2,194	1,595	1,599	1,602	1,606	1,610	1,613	1,616	1,620	1,623	1,626
2,195	1,630	1,634	1,637	1,640	1,644	1,648	1,652	1,656	1,660	1,664
2,196	1,667	1,671	1,675	1,679	1,684	1,688	1,692	1,696	1,700	1,703
2,197	1,707	1,710	1,714	1,717	1,720	1,724	1,727	1,730	1,734	1,738
2,198	1,741	1,745	1,748	1,752	1,755	1,758	1,762	1,765	1,768	1,772
2,199	1,776	1,780	1,784	1,787	1,791	1,794	1,797	1,801	1,804	1,807

Appendix B (continued)

Alan Henry Reservoir

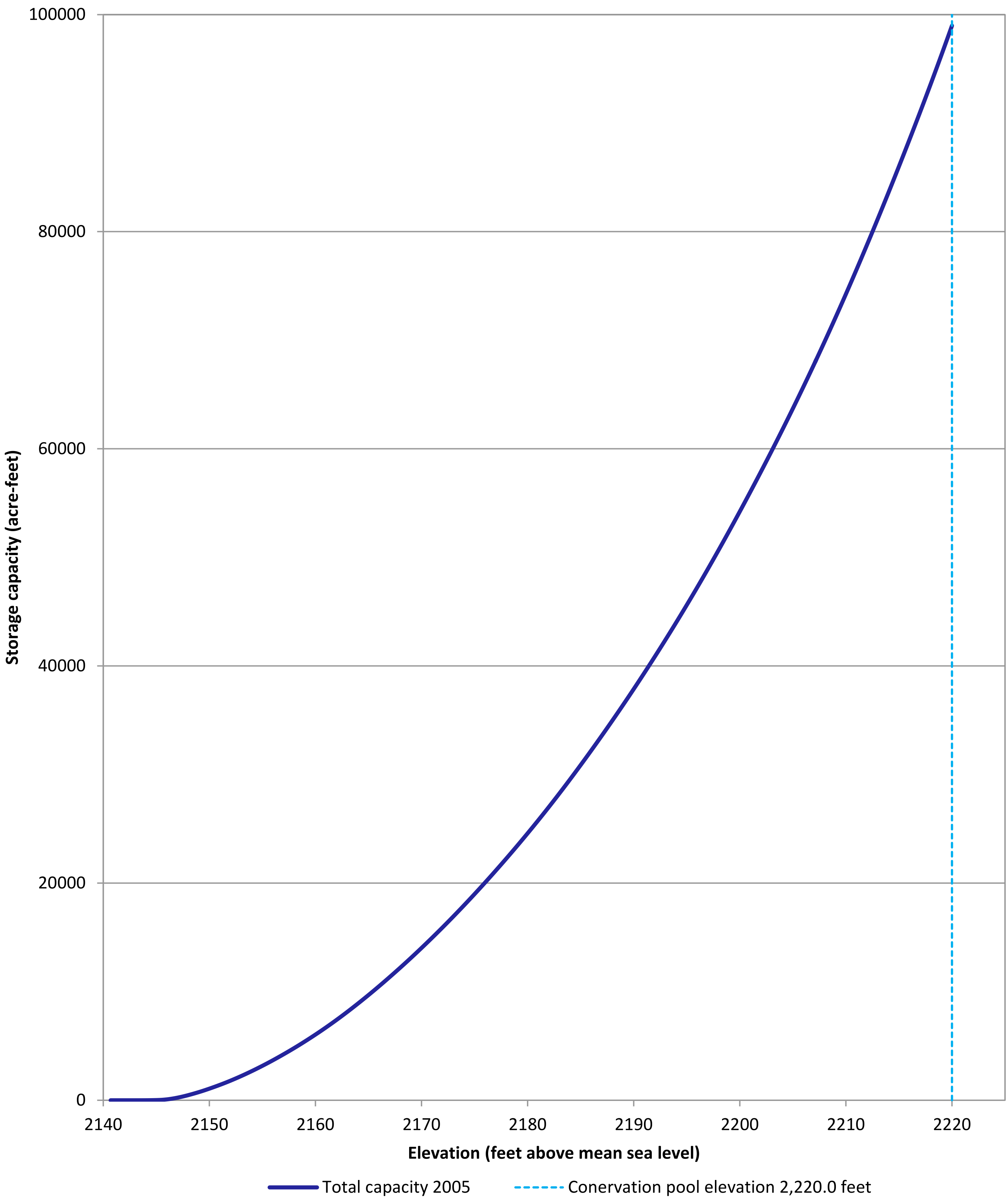
RESERVOIR AREA TABLE

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

July 2005 Survey re-calculated November 2016
Conservation Pool Elevation 2,220.0 feet NGVD29

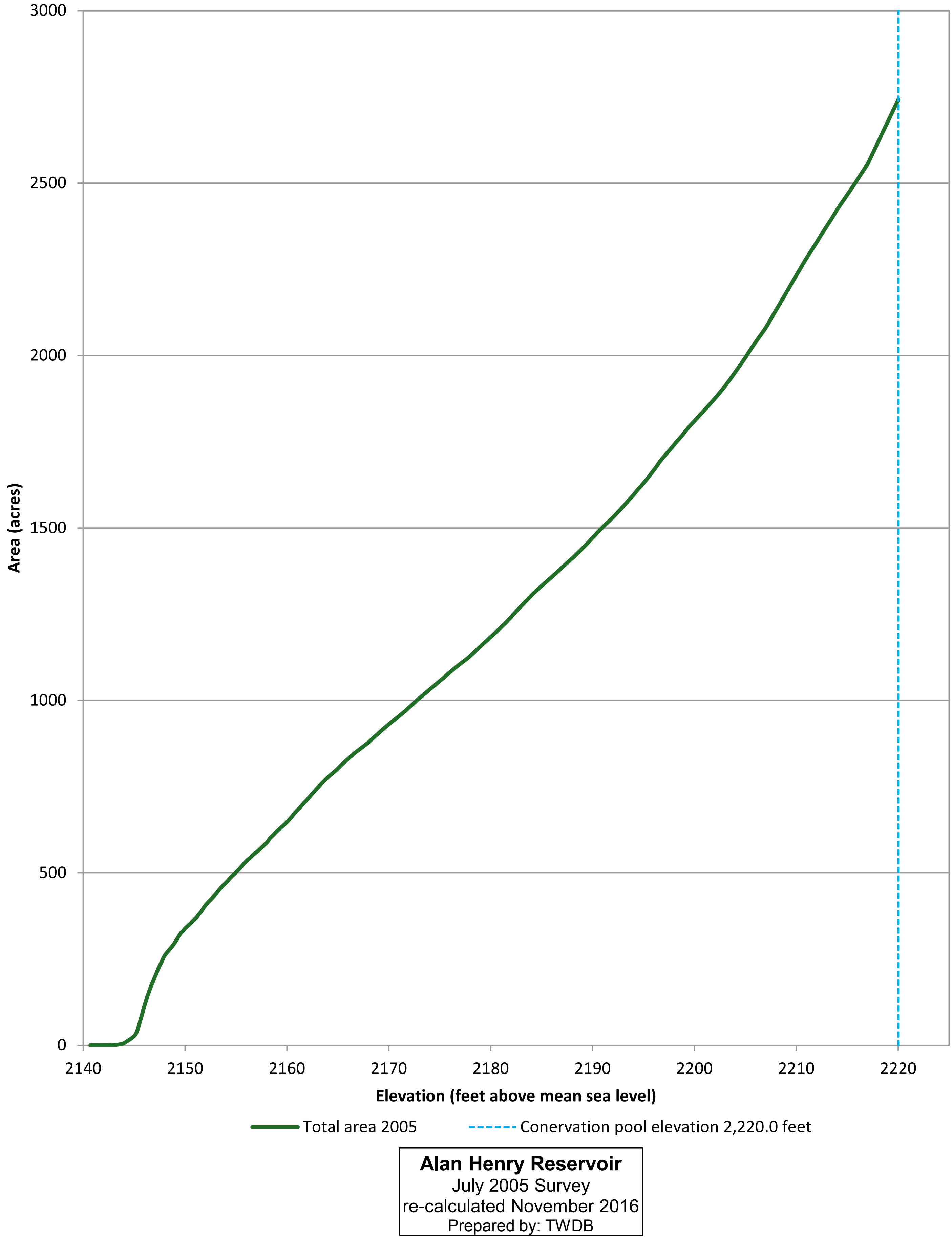
ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2,200	1,810	1,813	1,817	1,820	1,823	1,826	1,829	1,833	1,836	1,839
2,201	1,842	1,846	1,849	1,852	1,855	1,859	1,862	1,865	1,869	1,872
2,202	1,875	1,879	1,882	1,886	1,889	1,893	1,896	1,900	1,904	1,907
2,203	1,911	1,915	1,919	1,923	1,927	1,931	1,935	1,939	1,943	1,947
2,204	1,952	1,956	1,960	1,964	1,968	1,972	1,977	1,981	1,986	1,990
2,205	1,994	1,999	2,003	2,008	2,013	2,017	2,021	2,026	2,030	2,034
2,206	2,039	2,043	2,047	2,051	2,055	2,059	2,063	2,068	2,072	2,076
2,207	2,081	2,085	2,090	2,095	2,101	2,106	2,111	2,116	2,121	2,126
2,208	2,131	2,136	2,141	2,146	2,151	2,156	2,161	2,166	2,171	2,177
2,209	2,182	2,187	2,192	2,197	2,202	2,207	2,212	2,217	2,222	2,227
2,210	2,232	2,237	2,242	2,247	2,252	2,257	2,262	2,267	2,273	2,277
2,211	2,282	2,287	2,292	2,296	2,301	2,306	2,310	2,315	2,319	2,324
2,212	2,328	2,333	2,338	2,343	2,348	2,353	2,357	2,362	2,366	2,371
2,213	2,375	2,380	2,385	2,389	2,394	2,398	2,403	2,408	2,413	2,418
2,214	2,422	2,427	2,431	2,436	2,440	2,444	2,449	2,453	2,457	2,462
2,215	2,466	2,470	2,475	2,479	2,483	2,488	2,492	2,497	2,501	2,506
2,216	2,510	2,515	2,519	2,524	2,528	2,533	2,537	2,541	2,546	2,550
2,217	2,555	2,561	2,567	2,574	2,580	2,586	2,592	2,599	2,605	2,611
2,218	2,617	2,623	2,630	2,636	2,642	2,648	2,654	2,661	2,667	2,673
2,219	2,679	2,685	2,692	2,698	2,704	2,710	2,716	2,723	2,729	2,735
2,220	2,741									

Note: Areas between elevations 2,217.0 and 2,220.0 feet linearly interpolated



Alan Henry Reservoir
July 2005 Survey
re-calculated November 2016
Prepared by: TWDB

Appendix C: Capacity curve



Appendix D: Area curve

Appendix E

Alan Henry Reservoir

RESERVOIR VOLUME TABLE

TEXAS WATER DEVELOPMENT BOARD — August 2017 Survey

VOLUME IN ACRE-FEET — Conservation Pool Elevation 2,220.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2,144	0	0	0	0	0	0	0	0	0	0
2,145	0	0	0	0	0	0	0	0	0	0
2,146	0	0	0	1	1	1	1	2	2	3
2,147	4	5	7	8	11	14	17	22	29	37
2,148	46	56	69	82	97	113	130	148	167	187
2,149	208	230	253	276	301	326	352	379	406	434
2,150	462	491	520	550	581	611	642	674	706	738
2,151	770	803	836	870	904	939	974	1,009	1,044	1,080
2,152	1,117	1,153	1,190	1,227	1,264	1,302	1,339	1,377	1,416	1,454
2,153	1,493	1,533	1,572	1,612	1,652	1,693	1,734	1,775	1,817	1,859
2,154	1,901	1,944	1,987	2,031	2,075	2,120	2,165	2,211	2,257	2,303
2,155	2,350	2,397	2,444	2,492	2,540	2,588	2,637	2,686	2,735	2,784
2,156	2,835	2,885	2,936	2,987	3,038	3,090	3,141	3,193	3,246	3,298
2,157	3,351	3,404	3,457	3,511	3,565	3,619	3,673	3,727	3,782	3,836
2,158	3,891	3,946	4,002	4,058	4,114	4,170	4,227	4,283	4,340	4,397
2,159	4,455	4,513	4,571	4,630	4,688	4,747	4,807	4,866	4,926	4,987
2,160	5,047	5,108	5,169	5,230	5,291	5,353	5,415	5,477	5,540	5,603
2,161	5,666	5,729	5,793	5,857	5,921	5,986	6,050	6,115	6,181	6,247
2,162	6,313	6,380	6,447	6,514	6,582	6,650	6,718	6,787	6,855	6,925
2,163	6,994	7,064	7,134	7,204	7,275	7,346	7,417	7,488	7,560	7,631
2,164	7,704	7,776	7,848	7,921	7,994	8,067	8,141	8,215	8,289	8,363
2,165	8,438	8,513	8,588	8,664	8,740	8,816	8,892	8,969	9,046	9,123
2,166	9,200	9,278	9,356	9,435	9,513	9,592	9,671	9,750	9,829	9,909
2,167	9,989	10,069	10,150	10,231	10,312	10,394	10,476	10,558	10,641	10,723
2,168	10,807	10,890	10,974	11,058	11,142	11,226	11,311	11,396	11,482	11,567
2,169	11,653	11,739	11,826	11,913	11,999	12,087	12,174	12,262	12,350	12,438
2,170	12,526	12,615	12,704	12,793	12,883	12,973	13,063	13,153	13,243	13,334
2,171	13,425	13,517	13,608	13,700	13,792	13,885	13,978	14,070	14,164	14,257
2,172	14,351	14,445	14,539	14,634	14,729	14,824	14,919	15,015	15,111	15,207
2,173	15,304	15,400	15,497	15,595	15,692	15,790	15,888	15,986	16,085	16,183
2,174	16,282	16,382	16,481	16,581	16,681	16,781	16,882	16,982	17,083	17,185
2,175	17,286	17,388	17,490	17,592	17,694	17,797	17,900	18,003	18,107	18,210
2,176	18,314	18,418	18,522	18,627	18,732	18,837	18,943	19,048	19,154	19,260
2,177	19,367	19,474	19,580	19,688	19,795	19,903	20,011	20,119	20,228	20,336
2,178	20,445	20,555	20,664	20,774	20,884	20,994	21,105	21,216	21,327	21,439
2,179	21,550	21,663	21,775	21,887	22,000	22,113	22,227	22,341	22,455	22,569
2,180	22,684	22,799	22,914	23,030	23,145	23,262	23,378	23,495	23,612	23,729
2,181	23,846	23,964	24,082	24,201	24,320	24,439	24,558	24,678	24,798	24,918
2,182	25,039	25,160	25,281	25,403	25,525	25,647	25,770	25,892	26,016	26,139
2,183	26,263	26,387	26,511	26,636	26,760	26,886	27,012	27,137	27,264	27,390
2,184	27,517	27,644	27,772	27,899	28,027	28,156	28,285	28,413	28,543	28,672
2,185	28,802	28,932	29,062	29,193	29,324	29,455	29,587	29,719	29,851	29,983
2,186	30,116	30,249	30,382	30,516	30,649	30,784	30,918	31,053	31,188	31,323
2,187	31,459	31,595	31,731	31,868	32,004	32,142	32,279	32,417	32,555	32,693
2,188	32,832	32,971	33,111	33,250	33,390	33,530	33,671	33,812	33,953	34,094
2,189	34,236	34,378	34,520	34,663	34,806	34,949	35,093	35,236	35,380	35,524
2,190	35,669	35,814	35,959	36,105	36,250	36,396	36,543	36,689	36,836	36,983
2,191	37,131	37,279	37,427	37,575	37,724	37,873	38,023	38,172	38,322	38,472
2,192	38,623	38,774	38,925	39,077	39,229	39,381	39,534	39,687	39,840	39,993
2,193	40,147	40,301	40,455	40,610	40,765	40,920	41,076	41,232	41,388	41,544
2,194	41,701	41,859	42,016	42,174	42,332	42,490	42,649	42,808	42,968	43,127
2,195	43,287	43,448	43,608	43,769	43,930	44,092	44,254	44,416	44,579	44,741
2,196	44,905	45,068	45,231	45,396	45,560	45,724	45,890	46,055	46,220	46,386
2,197	46,552	46,719	46,885	47,052	47,220	47,387	47,556	47,724	47,893	48,062
2,198	48,232	48,402	48,572	48,743	48,914	49,086	49,258	49,430	49,603	49,777
2,199	49,951	50,125	50,300	50,475	50,651	50,827	51,005	51,182	51,360	51,538

Appendix E (continued)

Alan Henry Reservoir

RESERVOIR VOLUME TABLE

TEXAS WATER DEVELOPMENT BOARD — August 2017 Survey

VOLUME IN ACRE-FEET — Conservation Pool Elevation 2,220.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2,200	51,717	51,896	52,075	52,255	52,435	52,616	52,797	52,978	53,160	53,341
2,201	53,524	53,707	53,889	54,073	54,256	54,441	54,625	54,810	54,995	55,181
2,202	55,367	55,553	55,740	55,928	56,115	56,304	56,492	56,682	56,871	57,061
2,203	57,252	57,443	57,634	57,826	58,018	58,210	58,403	58,596	58,789	58,983
2,204	59,177	59,372	59,567	59,762	59,957	60,154	60,350	60,547	60,744	60,942
2,205	61,139	61,338	61,536	61,735	61,935	62,134	62,334	62,534	62,735	62,936
2,206	63,137	63,339	63,541	63,743	63,946	64,149	64,353	64,557	64,761	64,965
2,207	65,171	65,376	65,582	65,788	65,994	66,201	66,409	66,616	66,824	67,033
2,208	67,242	67,452	67,662	67,873	68,084	68,296	68,508	68,721	68,934	69,148
2,209	69,362	69,577	69,792	70,007	70,223	70,439	70,656	70,873	71,091	71,309
2,210	71,528	71,747	71,966	72,186	72,406	72,627	72,849	73,070	73,293	73,516
2,211	73,739	73,963	74,187	74,412	74,638	74,864	75,090	75,317	75,545	75,773
2,212	76,001	76,230	76,459	76,689	76,920	77,151	77,382	77,614	77,847	78,080
2,213	78,314	78,548	78,782	79,017	79,253	79,489	79,725	79,962	80,199	80,437
2,214	80,676	80,914	81,154	81,394	81,634	81,875	82,116	82,359	82,601	82,845
2,215	83,089	83,334	83,580	83,826	84,074	84,321	84,570	84,819	85,069	85,320
2,216	85,571	85,823	86,076	86,330	86,584	86,839	87,094	87,351	87,608	87,865
2,217	88,124	88,383	88,643	88,904	89,165	89,427	89,690	89,953	90,217	90,482
2,218	90,747	91,014	91,281	91,548	91,817	92,086	92,356	92,626	92,897	93,169
2,219	93,442	93,715	93,989	94,264	94,539	94,815	95,092	95,370	95,648	95,927
2,220	96,207									

Note: Capacities above elevation 2,202.0 feet calculated from interpolated and computed areas

Appendix F

Alan Henry Reservoir

RESERVOIR AREA TABLE

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

August 2017 Survey
Conservation Pool Elevation 2,220.0 feet NGVD29

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2,144	0	0	0	0	0	0	0	0	0	0
2,145	0	0	0	0	0	0	0	0	0	0
2,146	0	1	1	2	2	3	4	5	6	7
2,147	10	13	18	21	25	32	41	57	73	86
2,148	99	115	128	142	153	166	178	187	195	204
2,149	212	223	232	241	249	257	264	269	275	280
2,150	287	292	296	302	305	308	313	316	319	323
2,151	327	331	336	340	343	345	350	354	358	361
2,152	364	366	368	371	374	376	379	382	385	388
2,153	391	394	398	402	405	408	411	414	418	421
2,154	426	430	436	440	445	450	454	458	462	465
2,155	469	472	475	477	481	484	488	491	494	498
2,156	503	506	509	512	514	517	519	522	524	527
2,157	529	532	534	536	538	540	542	544	546	549
2,158	551	553	556	559	562	564	566	569	571	574
2,159	577	580	583	586	589	592	595	598	601	603
2,160	606	608	611	613	616	619	621	624	627	629
2,161	632	635	638	641	644	647	650	653	656	660
2,162	665	669	672	676	678	681	684	687	690	693
2,163	696	699	702	704	707	709	712	714	718	720
2,164	723	725	727	729	731	734	737	740	743	746
2,165	748	752	754	757	759	762	764	768	771	773
2,166	776	779	781	784	786	788	791	793	796	799
2,167	802	805	808	811	815	818	821	824	827	830
2,168	833	836	838	841	844	846	849	852	855	858
2,169	860	863	866	869	871	873	876	878	881	883
2,170	886	888	891	894	896	899	902	904	907	909
2,171	912	915	917	920	923	926	929	932	935	937
2,172	939	941	944	947	950	953	955	958	961	963
2,173	966	969	971	974	976	979	981	984	986	989
2,174	991	994	997	999	1,001	1,004	1,006	1,009	1,011	1,014
2,175	1,016	1,018	1,021	1,023	1,025	1,028	1,030	1,032	1,035	1,037
2,176	1,040	1,043	1,045	1,048	1,050	1,053	1,055	1,058	1,061	1,063
2,177	1,066	1,068	1,071	1,073	1,076	1,078	1,081	1,084	1,086	1,089
2,178	1,092	1,094	1,097	1,100	1,102	1,105	1,108	1,111	1,114	1,116
2,179	1,119	1,122	1,124	1,127	1,130	1,133	1,136	1,139	1,142	1,145
2,180	1,149	1,151	1,154	1,157	1,160	1,162	1,165	1,168	1,171	1,174
2,181	1,177	1,180	1,183	1,186	1,189	1,192	1,195	1,198	1,202	1,205
2,182	1,209	1,212	1,215	1,218	1,221	1,224	1,227	1,230	1,233	1,236
2,183	1,238	1,242	1,245	1,248	1,251	1,255	1,258	1,261	1,264	1,267
2,184	1,270	1,273	1,276	1,279	1,282	1,285	1,288	1,291	1,294	1,297
2,185	1,300	1,303	1,306	1,308	1,311	1,314	1,317	1,319	1,322	1,325
2,186	1,328	1,331	1,334	1,337	1,340	1,343	1,346	1,349	1,352	1,355
2,187	1,358	1,361	1,364	1,367	1,370	1,374	1,377	1,380	1,383	1,386
2,188	1,389	1,392	1,395	1,398	1,401	1,404	1,407	1,410	1,413	1,416
2,189	1,419	1,421	1,424	1,427	1,430	1,433	1,436	1,439	1,442	1,445
2,190	1,447	1,450	1,453	1,456	1,459	1,462	1,465	1,468	1,471	1,474
2,191	1,477	1,480	1,483	1,486	1,489	1,492	1,495	1,499	1,502	1,505
2,192	1,508	1,512	1,515	1,518	1,521	1,524	1,527	1,530	1,533	1,536
2,193	1,539	1,542	1,545	1,548	1,551	1,554	1,558	1,561	1,564	1,567
2,194	1,570	1,573	1,576	1,580	1,583	1,586	1,589	1,592	1,596	1,599
2,195	1,602	1,605	1,608	1,611	1,614	1,617	1,620	1,623	1,626	1,629
2,196	1,632	1,635	1,638	1,641	1,645	1,648	1,651	1,654	1,657	1,660
2,197	1,663	1,666	1,669	1,672	1,676	1,679	1,683	1,687	1,691	1,695
2,198	1,699	1,703	1,706	1,710	1,714	1,718	1,722	1,726	1,732	1,736
2,199	1,741	1,746	1,751	1,756	1,761	1,768	1,773	1,777	1,781	1,785

Appendix F (continued)

Alan Henry Reservoir

RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD

AREA IN ACRES

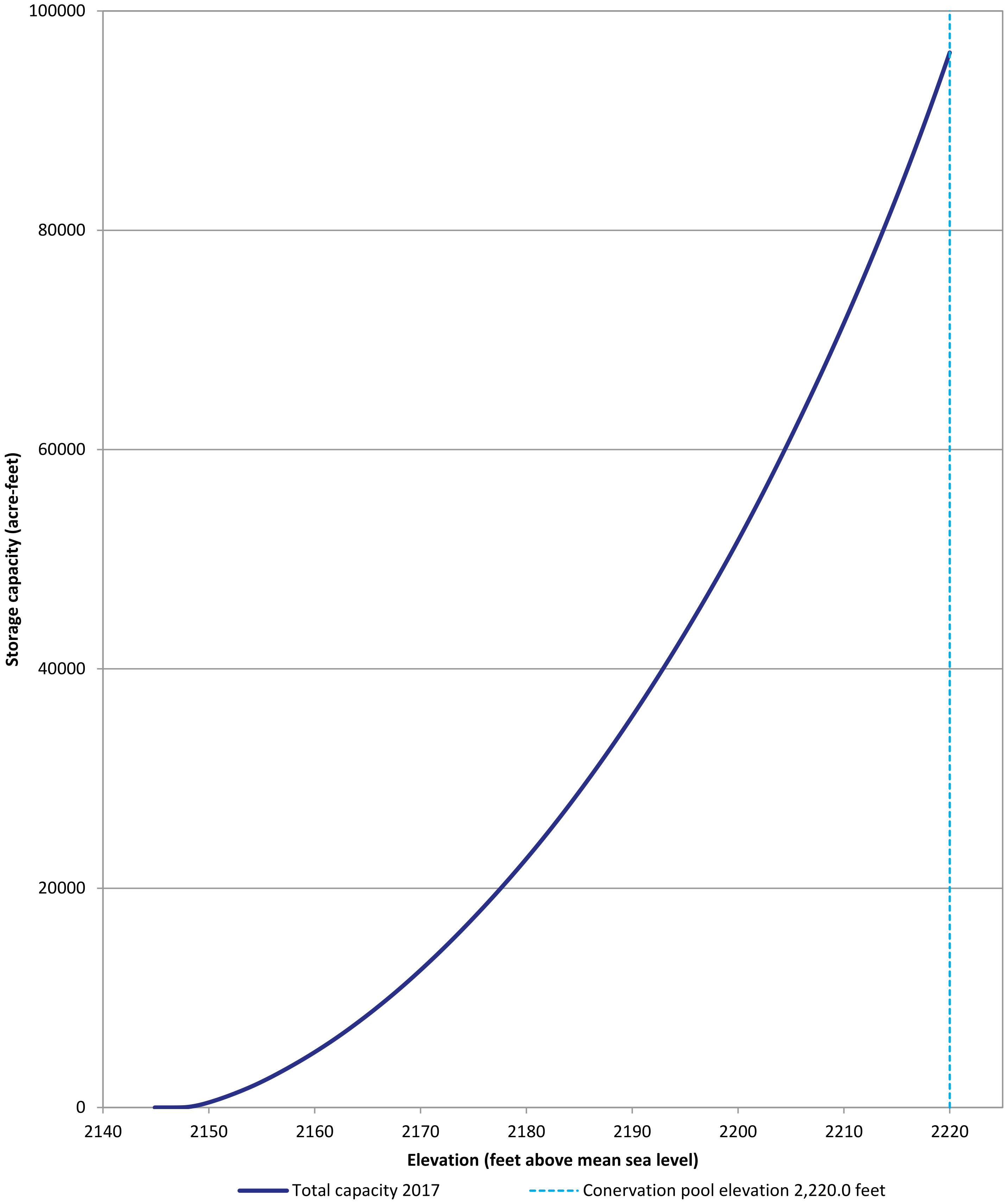
ELEVATION INCREMENT IS ONE TENTH FOOT

August 2017 Survey

Conservation Pool Elevation 2,220.0 feet NGVD29

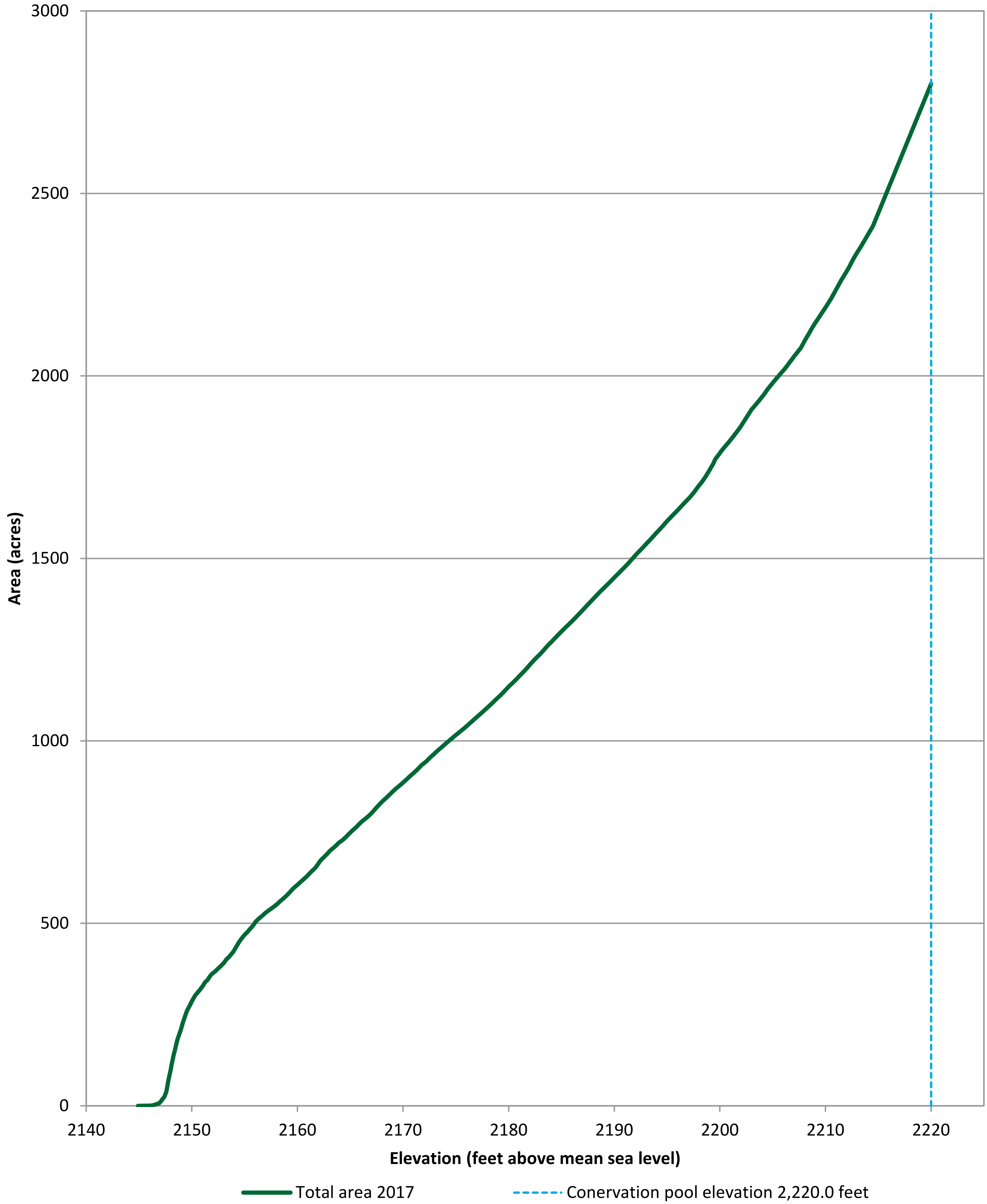
ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2,200	1,789	1,793	1,796	1,800	1,804	1,807	1,810	1,814	1,817	1,821
2,201	1,824	1,828	1,832	1,835	1,839	1,843	1,847	1,850	1,854	1,858
2,202	1,863	1,867	1,872	1,876	1,881	1,885	1,890	1,895	1,899	1,904
2,203	1,908	1,911	1,915	1,918	1,921	1,925	1,928	1,932	1,936	1,939
2,204	1,943	1,947	1,950	1,955	1,959	1,963	1,966	1,970	1,974	1,977
2,205	1,981	1,984	1,988	1,991	1,995	1,998	2,001	2,005	2,008	2,011
2,206	2,015	2,018	2,021	2,025	2,029	2,033	2,037	2,041	2,045	2,048
2,207	2,052	2,056	2,060	2,064	2,067	2,071	2,074	2,078	2,084	2,089
2,208	2,095	2,100	2,105	2,110	2,114	2,120	2,125	2,130	2,135	2,139
2,209	2,144	2,148	2,153	2,157	2,161	2,166	2,170	2,174	2,179	2,183
2,210	2,188	2,192	2,197	2,201	2,206	2,211	2,215	2,221	2,226	2,231
2,211	2,236	2,242	2,247	2,252	2,258	2,263	2,267	2,272	2,277	2,282
2,212	2,286	2,291	2,296	2,302	2,308	2,313	2,318	2,324	2,329	2,334
2,213	2,338	2,343	2,347	2,352	2,357	2,362	2,367	2,371	2,376	2,381
2,214	2,386	2,391	2,396	2,401	2,406	2,411	2,418	2,425	2,432	2,439
2,215	2,447	2,454	2,461	2,468	2,475	2,482	2,489	2,496	2,503	2,510
2,216	2,517	2,524	2,531	2,539	2,546	2,553	2,560	2,567	2,574	2,581
2,217	2,588	2,595	2,602	2,609	2,616	2,623	2,631	2,638	2,645	2,652
2,218	2,659	2,666	2,673	2,680	2,687	2,694	2,701	2,708	2,716	2,723
2,219	2,730	2,737	2,744	2,751	2,758	2,765	2,772	2,779	2,786	2,793
2,220	2,800									

Note: Areas between elevations 2,202.0 and 2,203.0 feet, 2,210.6 and 2,211.5 feet, and 2,214.5 and 2,220.0 feet linearly interpolated



Alan Henry Reservoir
August 2017 Survey
Prepared by: TWDB

Appendix G: Capacity curve



Alan Henry Reservoir
August 2017 Survey
Prepared by: TWDB

Appendix H: Area curve

Appendix I

Alan Henry Reservoir

Sediment range lines

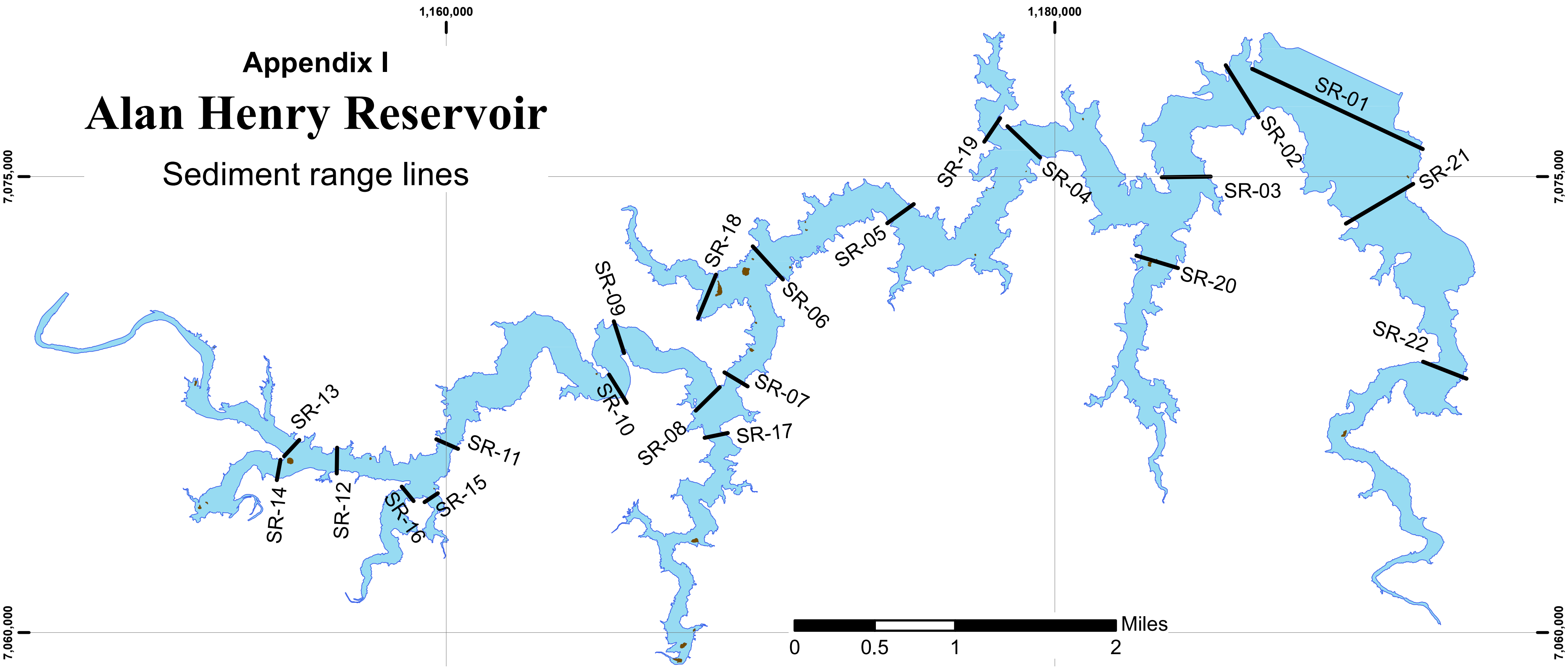
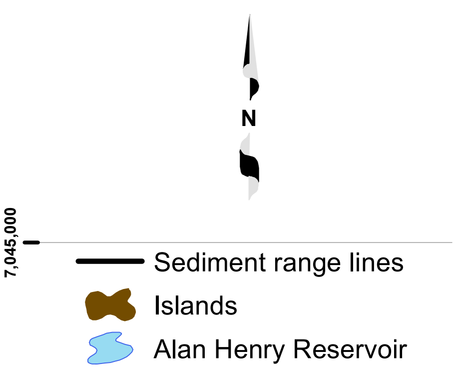


Table I1. Endpoint Coordinates for Alan Henry Reservoir Sediment Range Lines est. 2006 TWDB

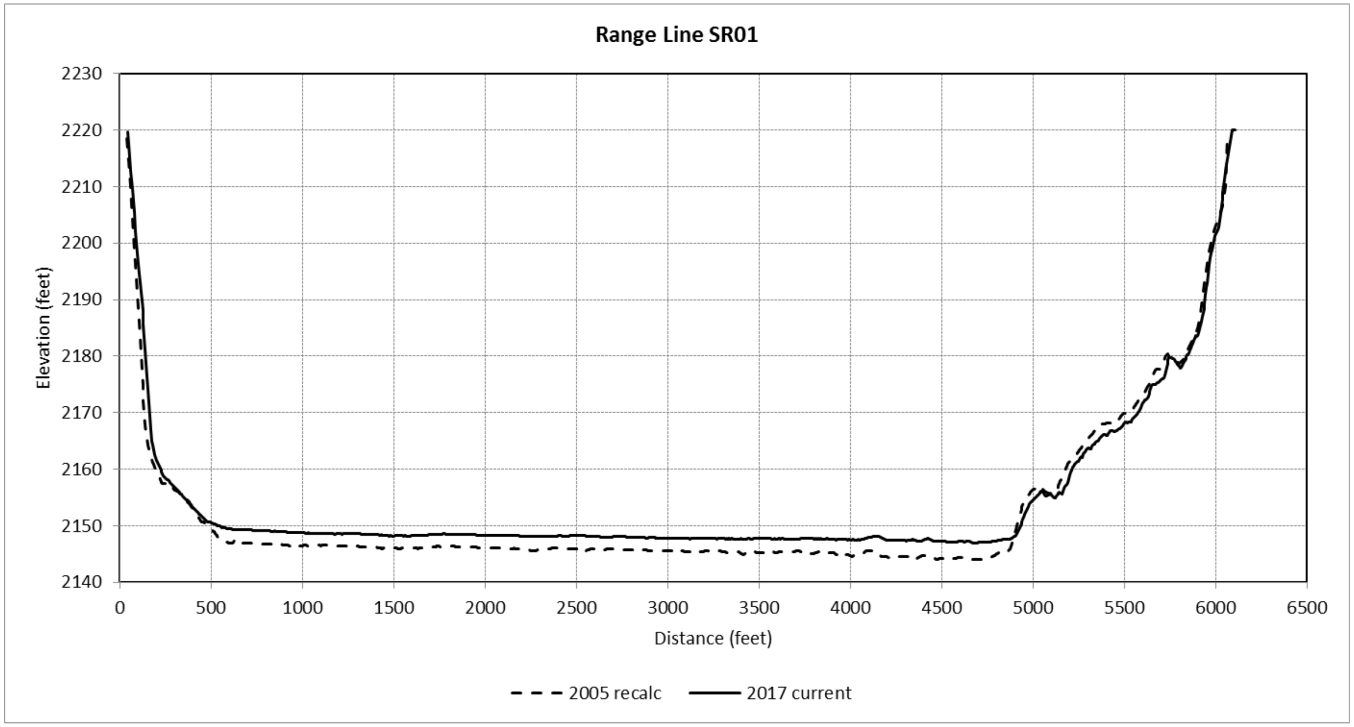
Range	L=Left R=Right	X	Y	Range	L=Left R=Right	X	Y
SR-01	L	1,186,496.61	7,078,530.17	SR-12	L	1,156,408.50	7,066,080.11
	R	1,192,103.32	7,075,896.94		R	1,156,390.35	7,065,227.15
SR-02	L	1,185,621.48	7,078,657.31	SR-13	R	1,155,164.27	7,066,335.75
	R	1,186,696.32	7,076,935.26		L	1,154,671.46	7,065,797.52
SR-03	L	1,183,518.04	7,074,970.51	SR-14	L	1,154,539.34	7,065,676.75
	R	1,185,124.52	7,074,993.62		R	1,154,428.86	7,065,015.73
SR-04	L	1,178,444.36	7,076,646.32	SR-15	L	1,159,281.89	7,064,288.26
	R	1,179,519.20	7,075,617.72		R	1,159,714.83	7,064,580.07
SR-05	L	1,175,362.45	7,074,088.81	SR-16	L	1,158,528.54	7,064,797.49
	R	1,174,489.72	7,073,461.61		R	1,158,919.52	7,064,328.31
SR-06	L	1,170,073.16	7,072,694.25	SR-17	L	1,168,491.38	7,066,407.58
	R	1,171,057.10	7,071,611.92		R	1,169,249.75	7,066,566.04
SR-07	L	1,169,145.71	7,068,555.06	SR-18	L	1,168,864.35	7,071,773.37
	R	1,169,903.47	7,068,093.87		R	1,168,277.21	7,070,341.25
SR-08	L	1,168,990.44	7,068,070.76	SR-19	L	1,178,201.82	7,076,913.64
	R	1,168,204.54	7,067,296.42		R	1,177,689.70	7,076,139.77
SR-09	L	1,165,500.11	7,070,231.99	SR-20	L	1,182,689.56	7,072,393.14
	R	1,165,846.83	7,069,191.82		R	1,184,048.14	7,071,988.37
SR-10	L	1,165,349.02	7,068,477.08	SR-21	L	1,189,574.40	7,073,446.48
	R	1,165,922.46	7,067,548.46		R	1,191,788.29	7,074,753.48
SR-11	L	1,159,664.19	7,066,359.72	SR-22	L	1,192,107.49	7,068,904.11
	R	1,160,375.44	7,066,040.02		R	1,193,541.66	7,068,353.95

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

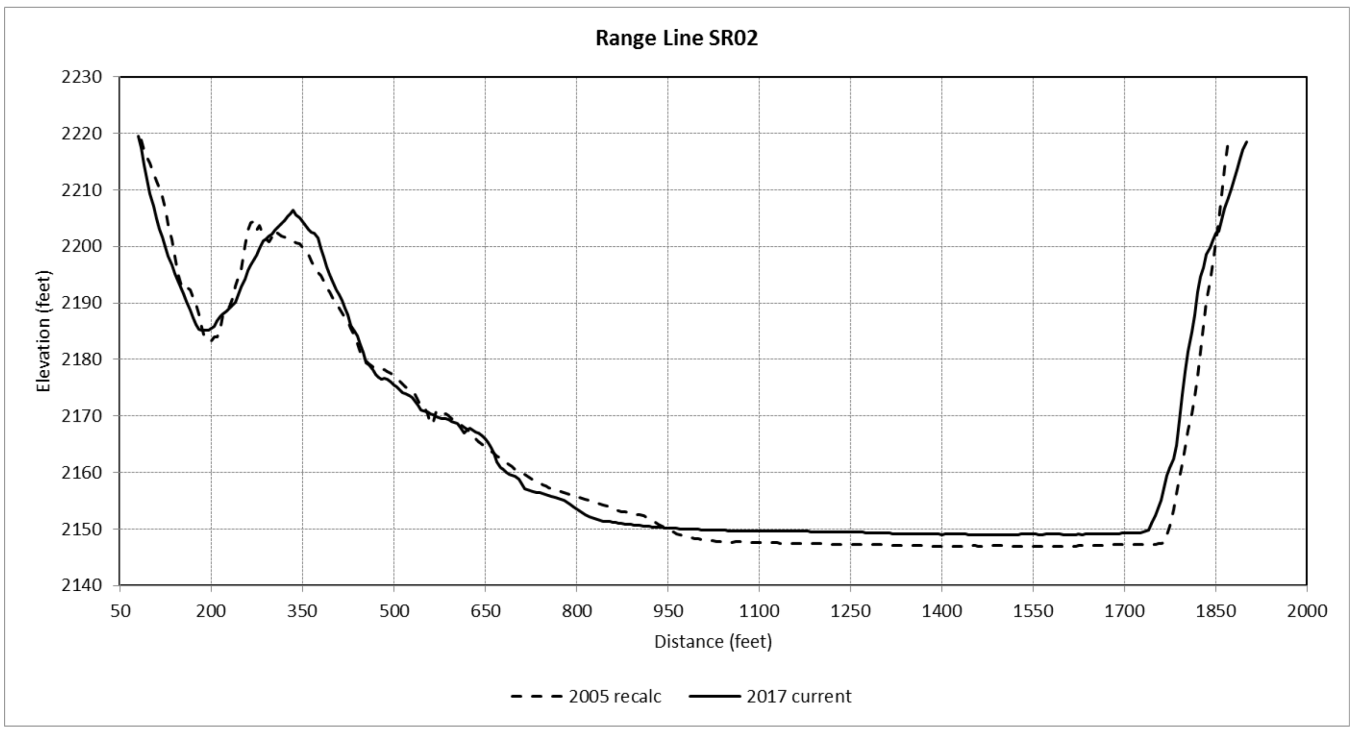


Texas Water Development Board

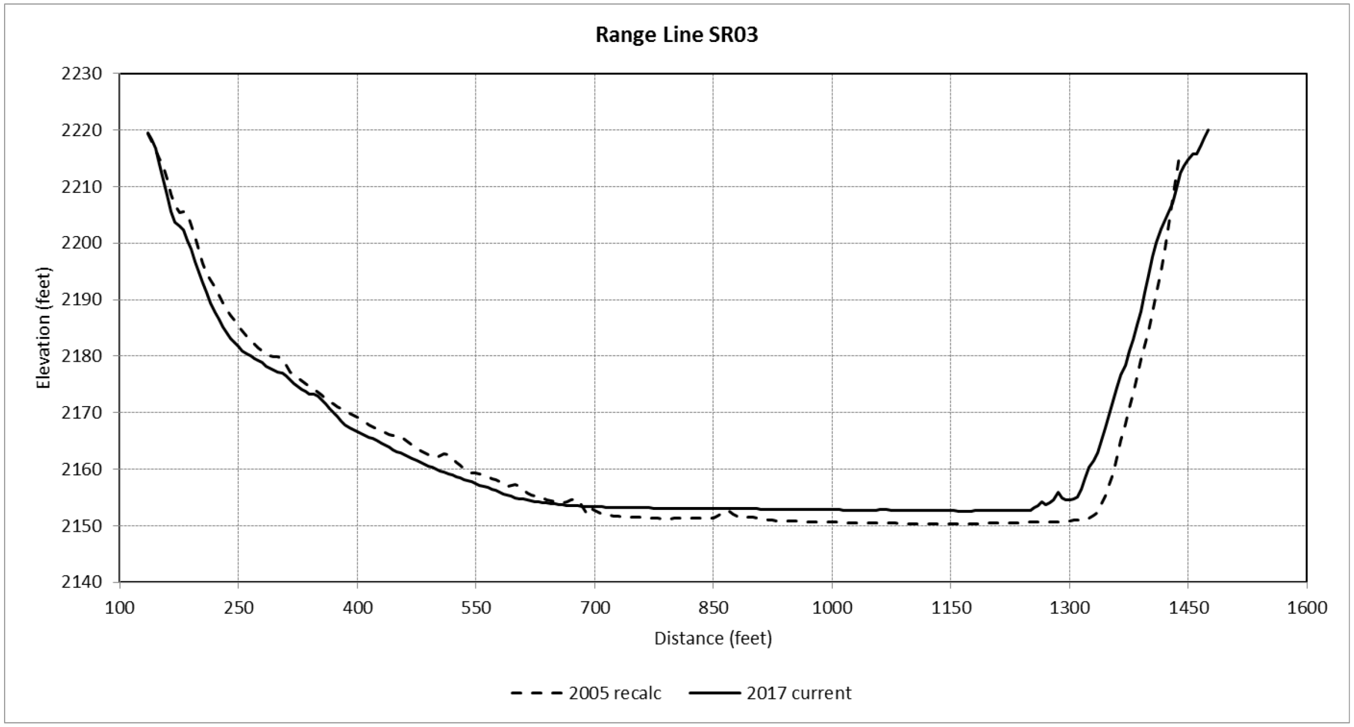
August 2017 Survey

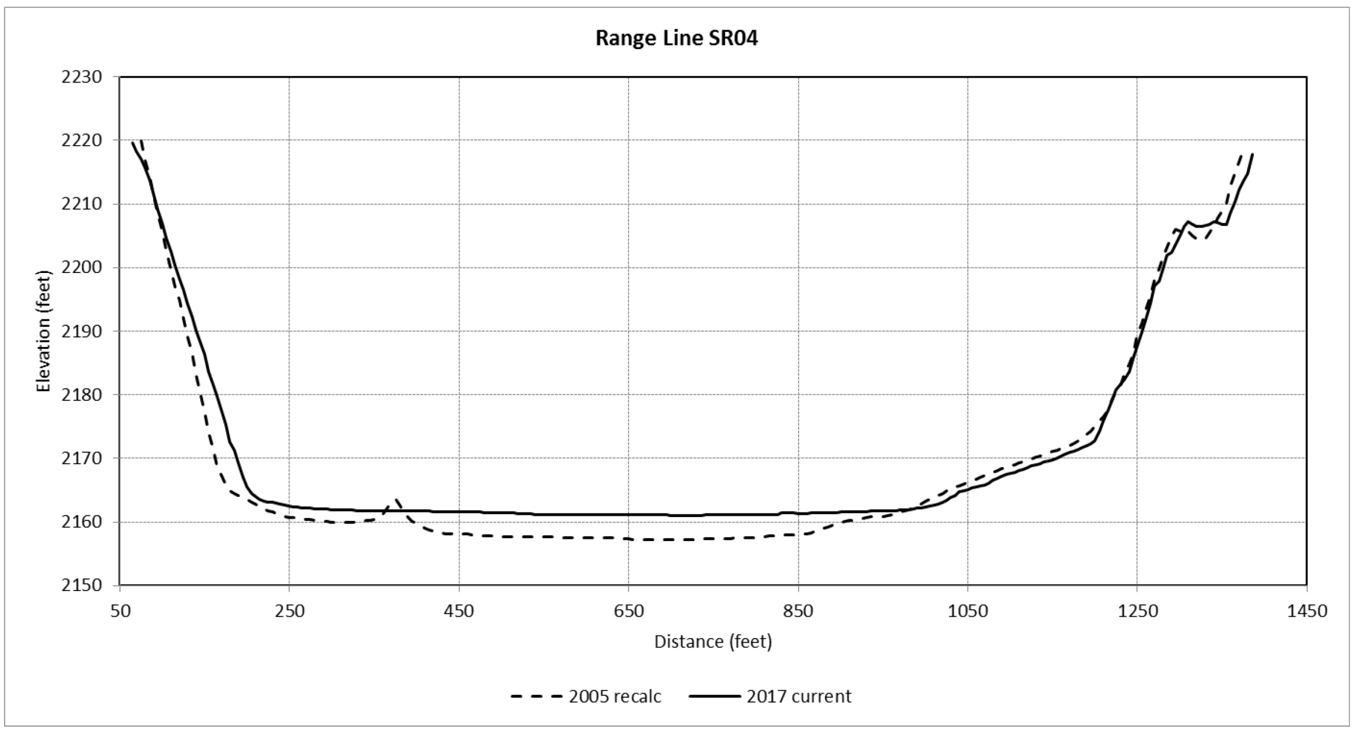


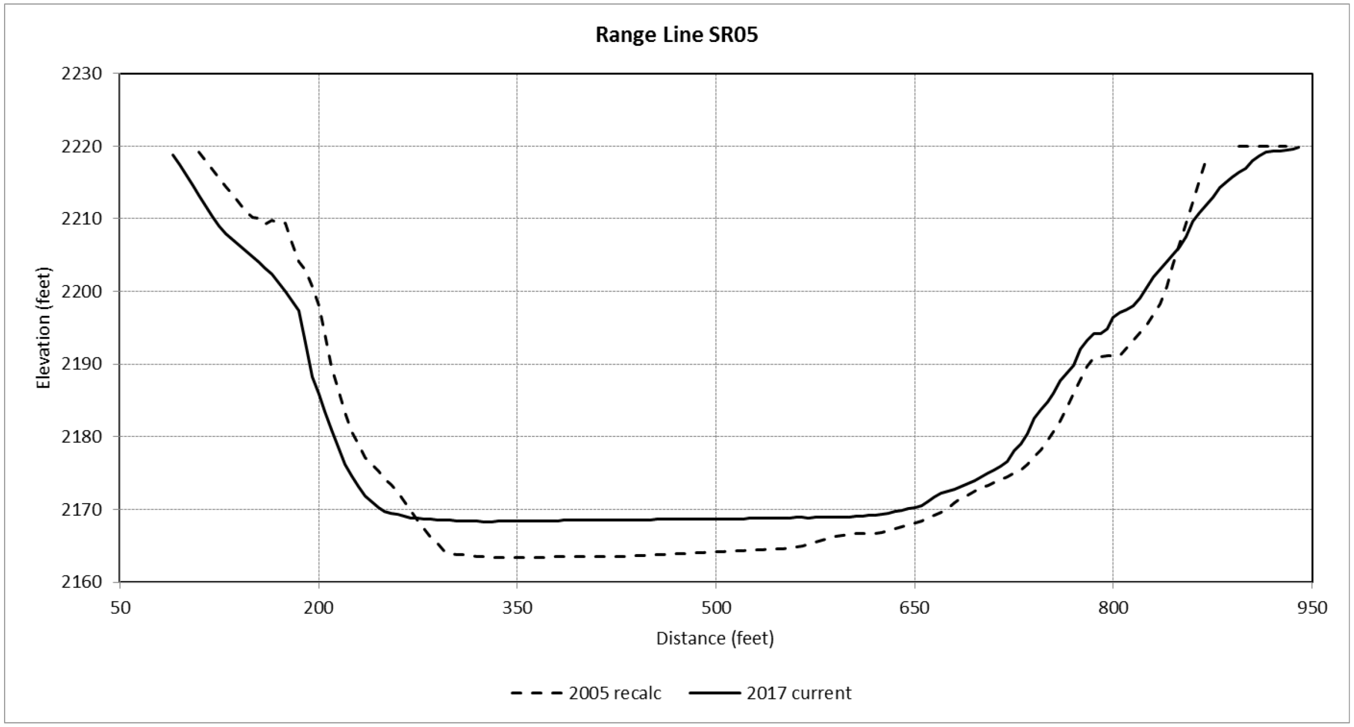
Range Line SR01
Elevation (feet)
Distance (feet)
2005 recalc
2017 current

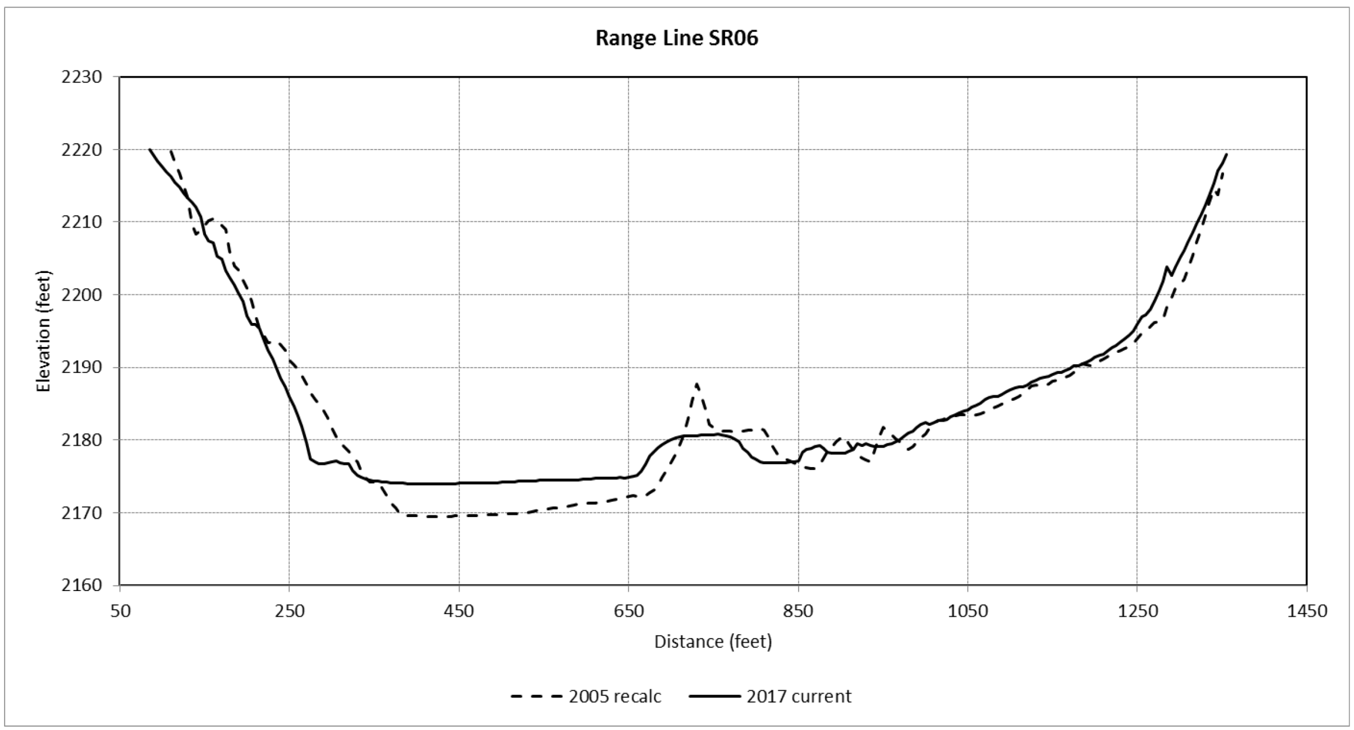


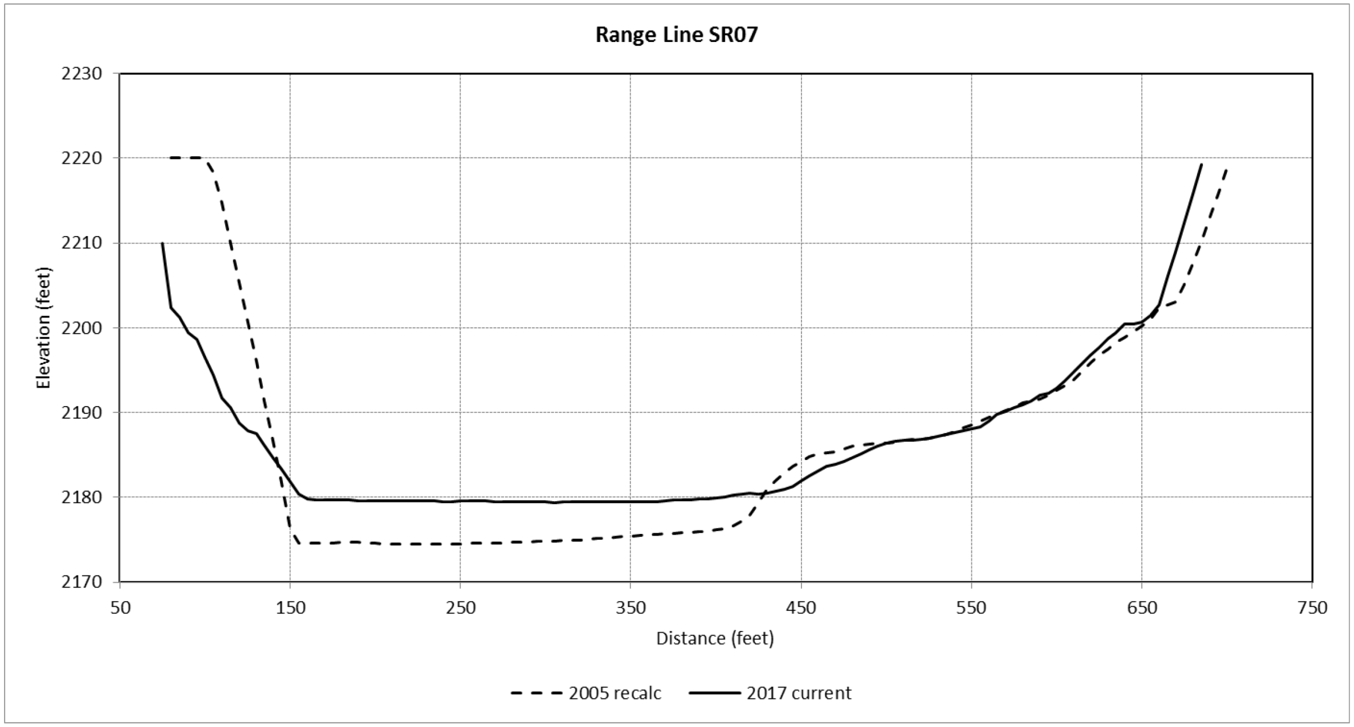
Range Line SR02
Elevation (feet)
Distance (feet)
2005 recalc
2017 current

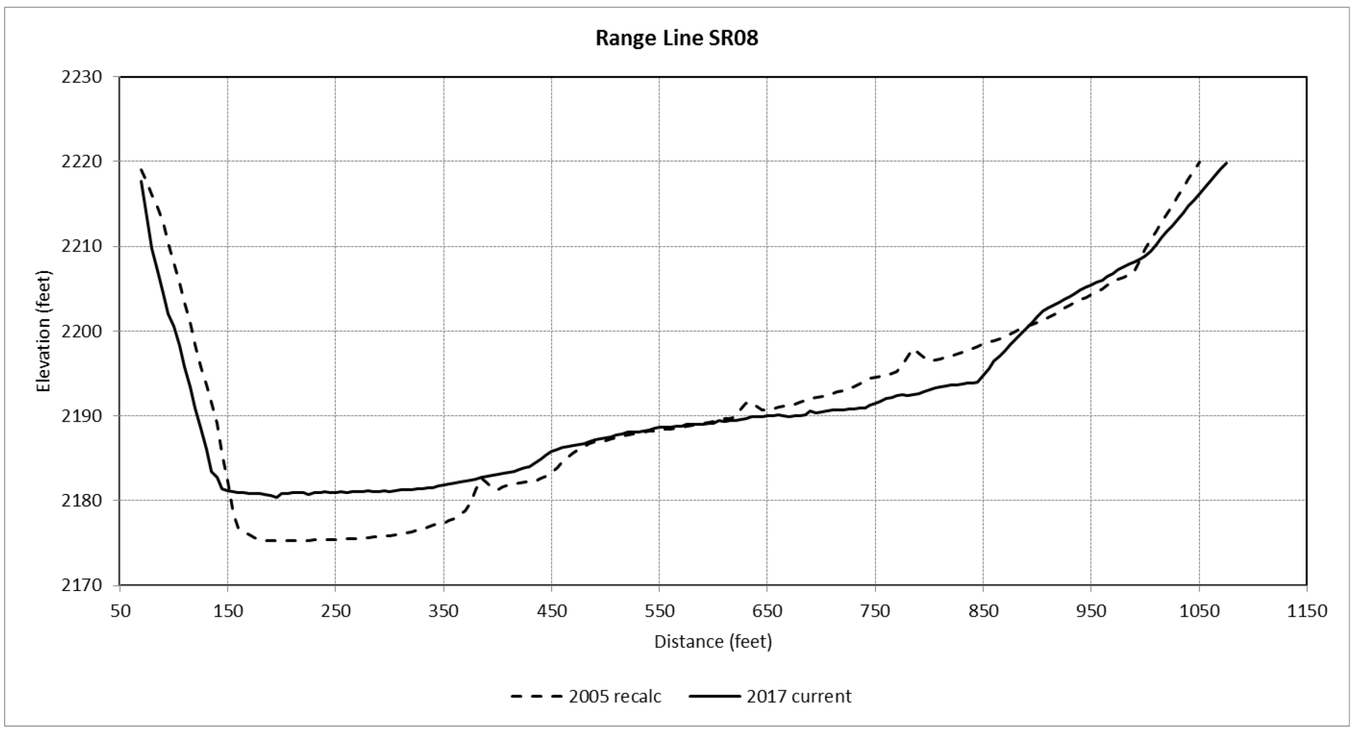

Range Line SR03
Elevation (feet)
2230
2220
2210
2200
2190
2180
2170
2160
2150
2140
100
250
400
550
700
850
1000
1150
1300
1450
1600
Distance (feet)
2005 recalc
2017 current

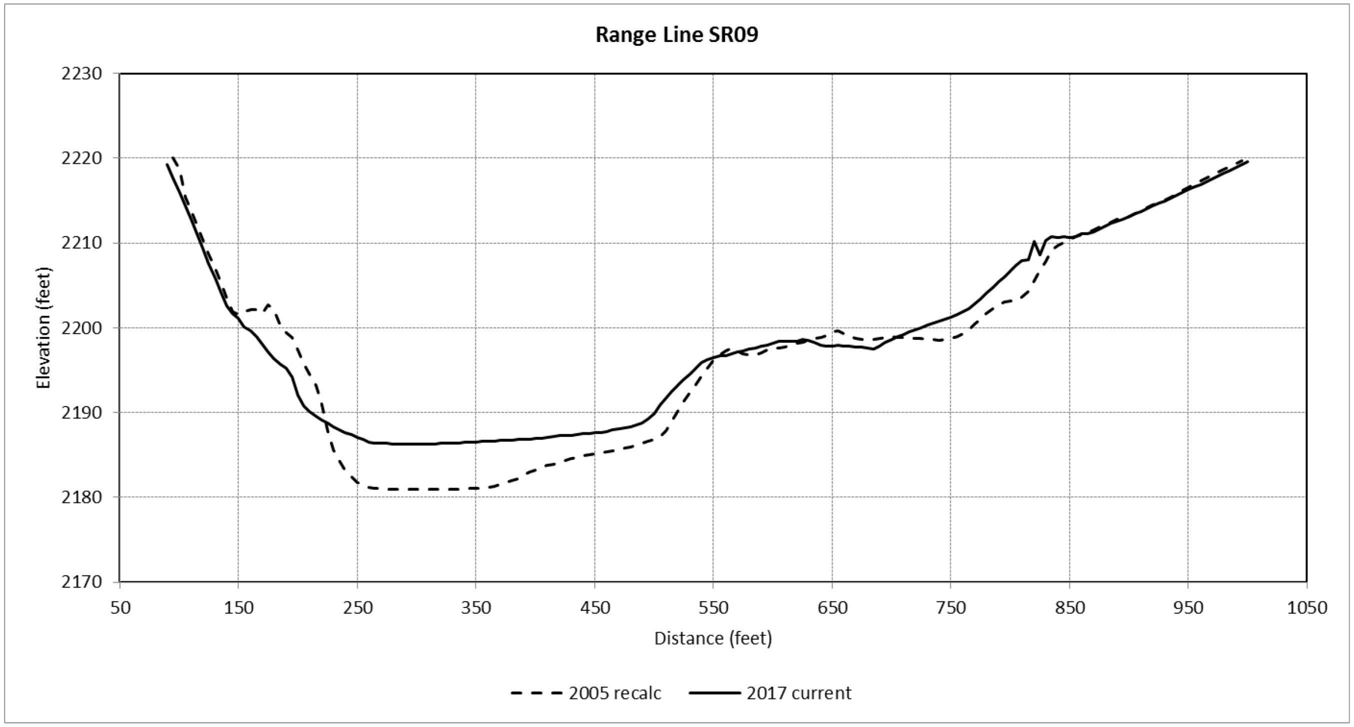

Range Line SR04
Elevation (feet)
2230
2220
2210
2200
2190
2180
2170
2160
2150
50
250
450
650
850
1050
1250
1450
Distance (feet)
2005 recalc
2017 current

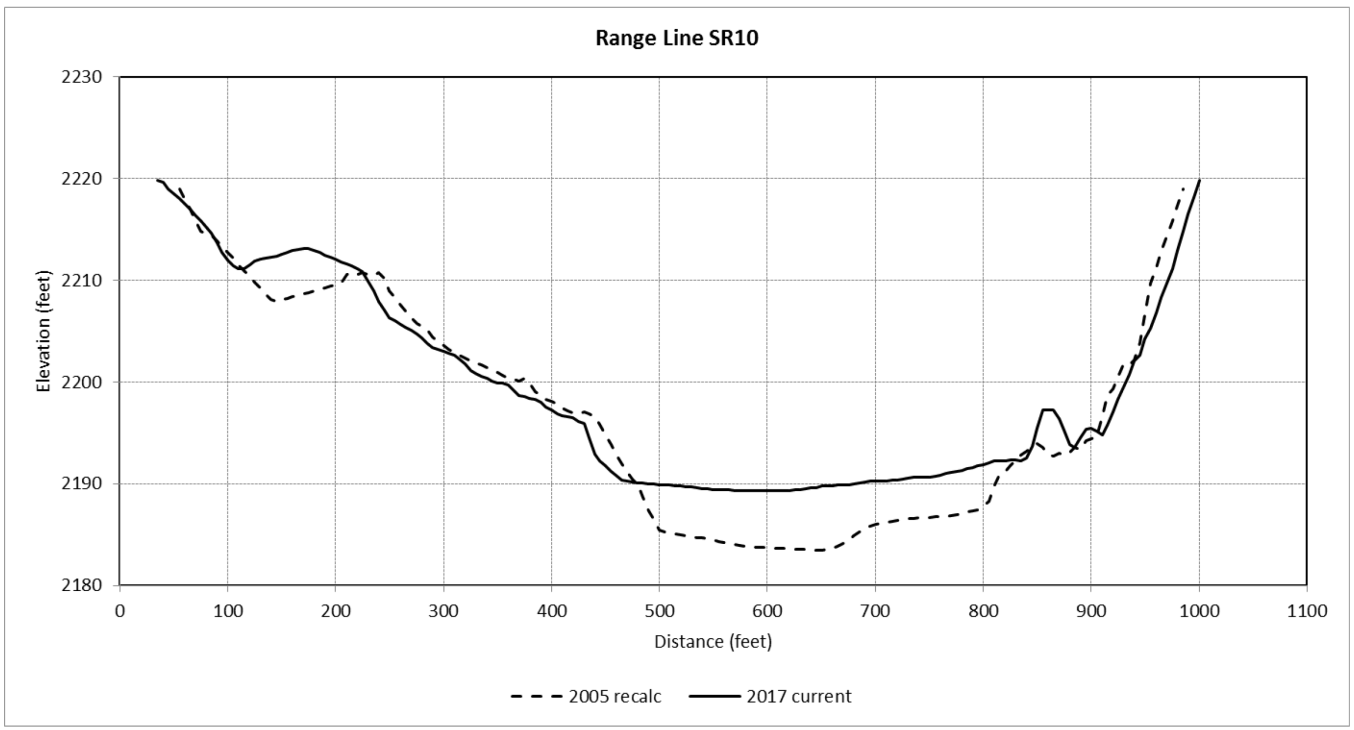

Range Line SR05
Elevation (feet)
Distance (feet)
2230
2220
2210
2200
2190
2180
2170
2160
50
200
350
500
650
800
950
2005 recalc
2017 current

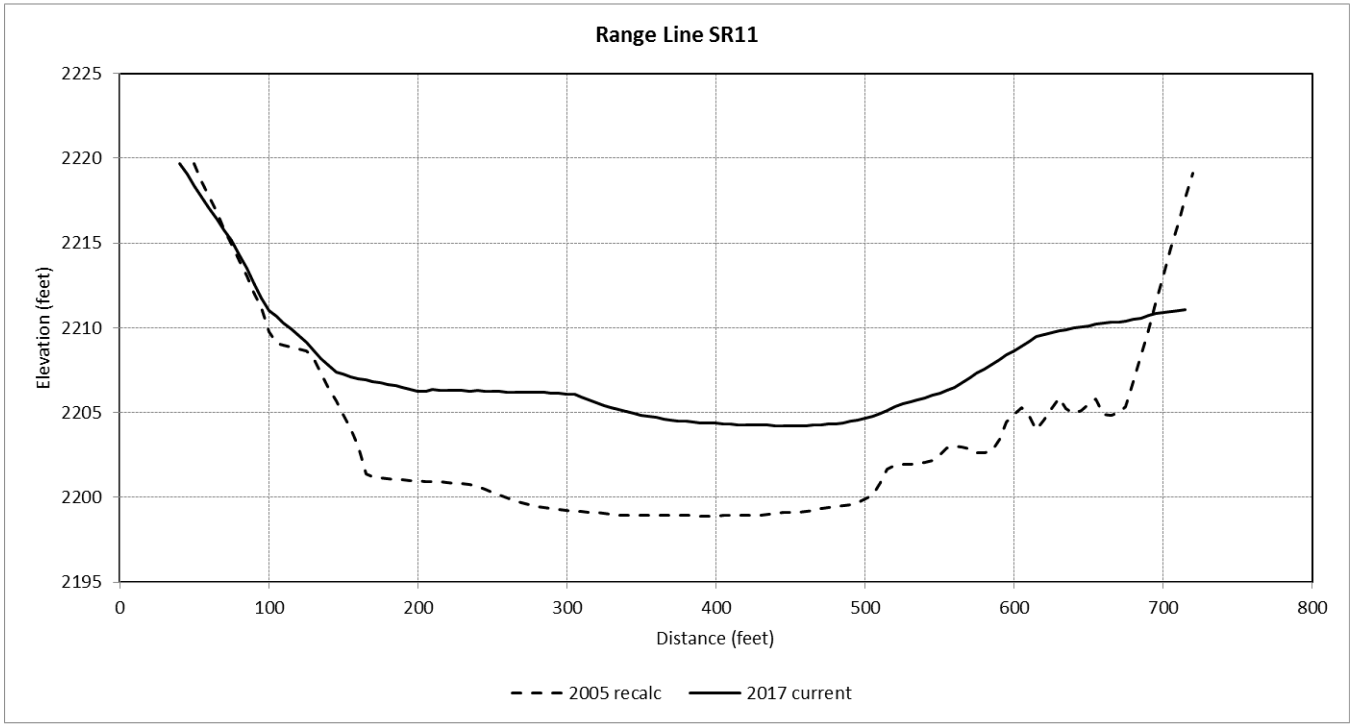

Range Line SR06
Elevation (feet)
Distance (feet)
2230
2220
2210
2200
2190
2180
2170
2160
50
250
450
650
850
1050
1250
1450
2005 recalc
2017 current

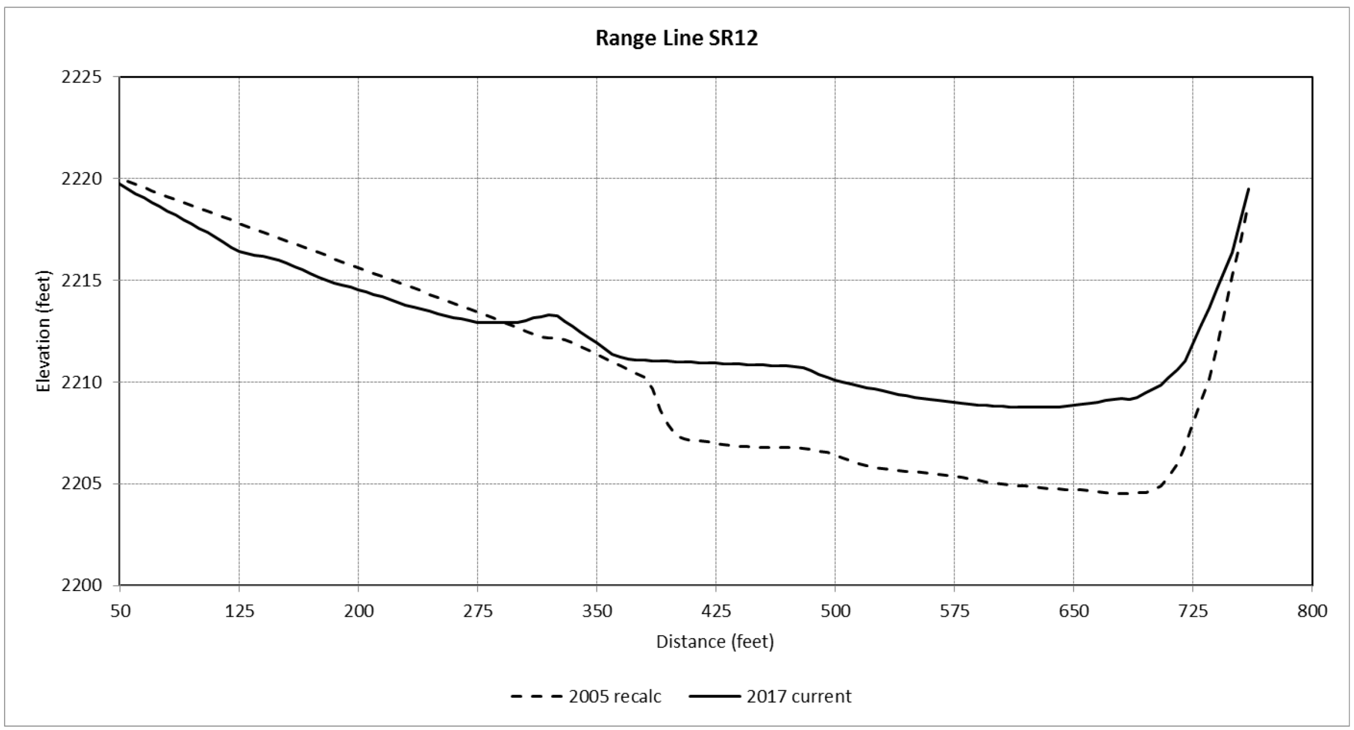

Range Line SR07
Elevation (feet)
2230
2220
2210
2200
2190
2180
2170
50
150
250
350
450
550
650
750
Distance (feet)
2005 recalc
2017 current

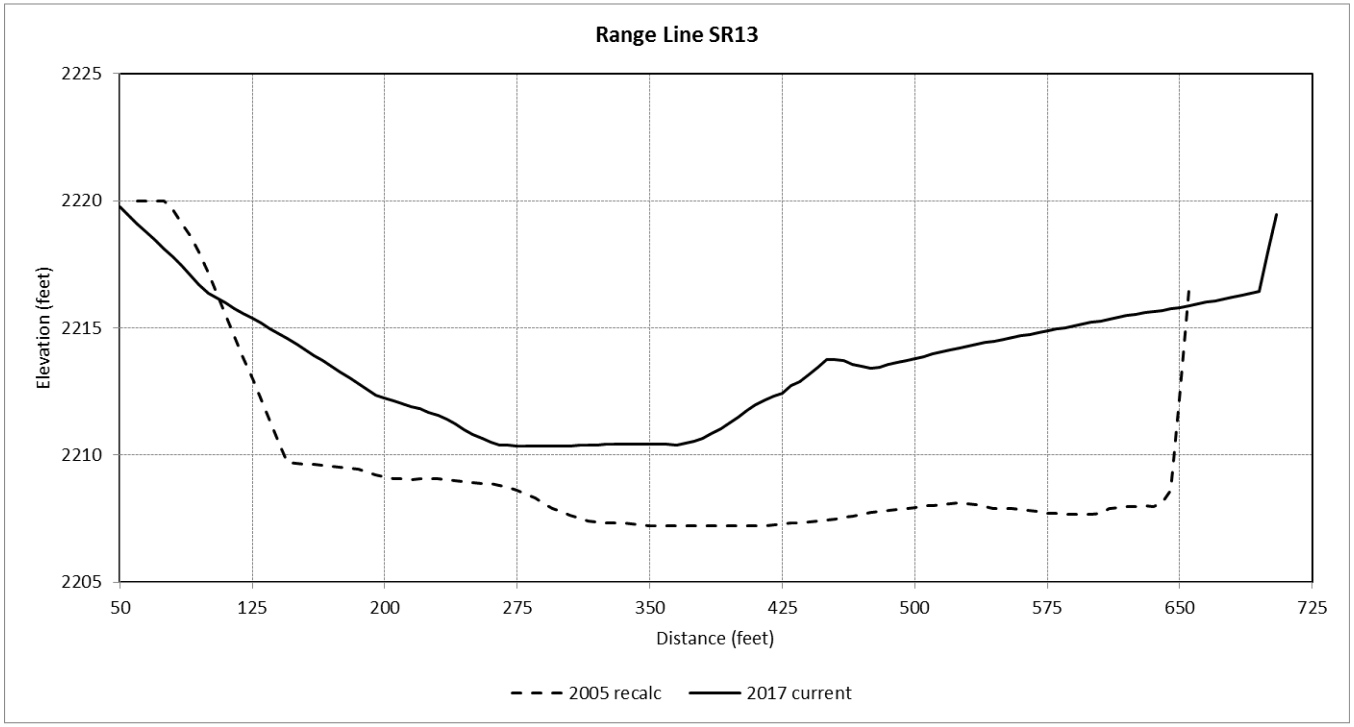

Range Line SR08
Elevation (feet)
2230
2220
2210
2200
2190
2180
2170
50
150
250
350
450
550
650
750
850
950
1050
1150
Distance (feet)
2005 recalc
2017 current

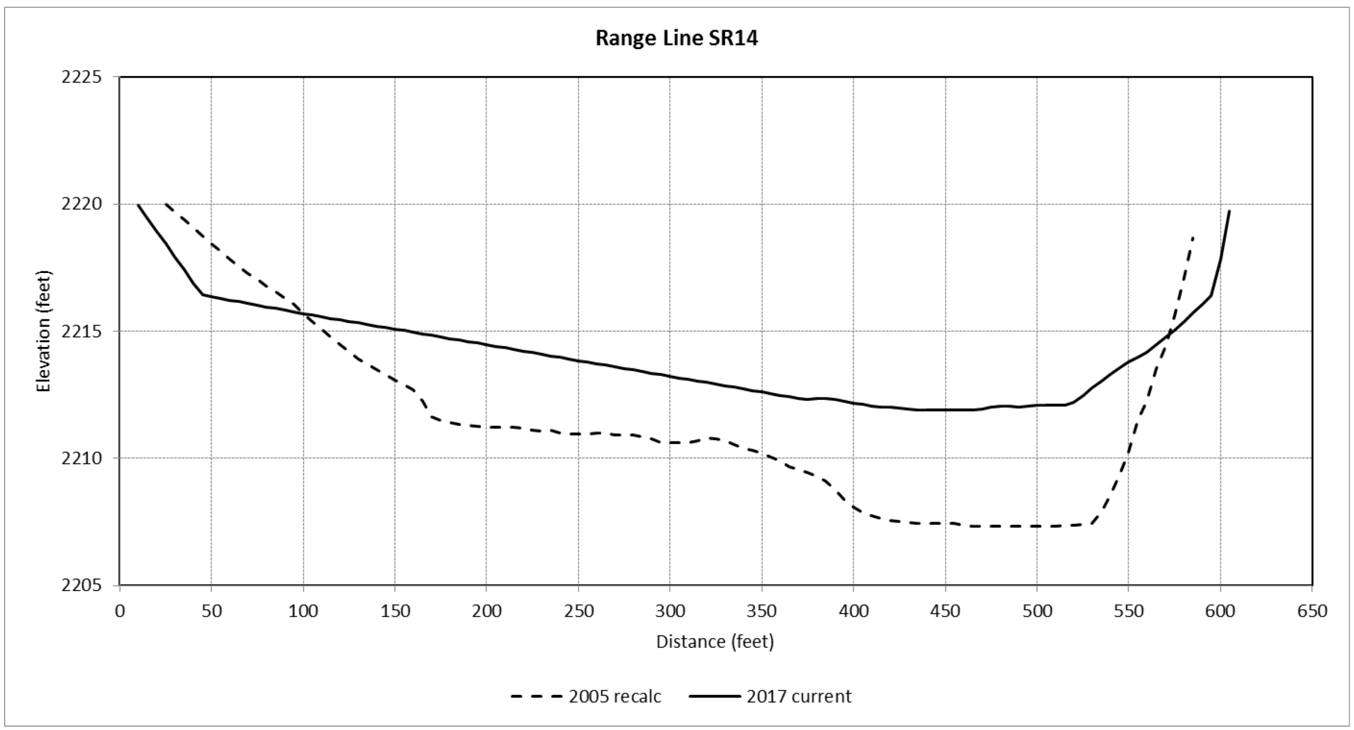

Range Line SR09
Elevation (feet)
2230
2220
2210
2200
2190
2180
2170
50
150
250
350
450
550
650
750
850
950
1050
Distance (feet)
2005 recalc
2017 current

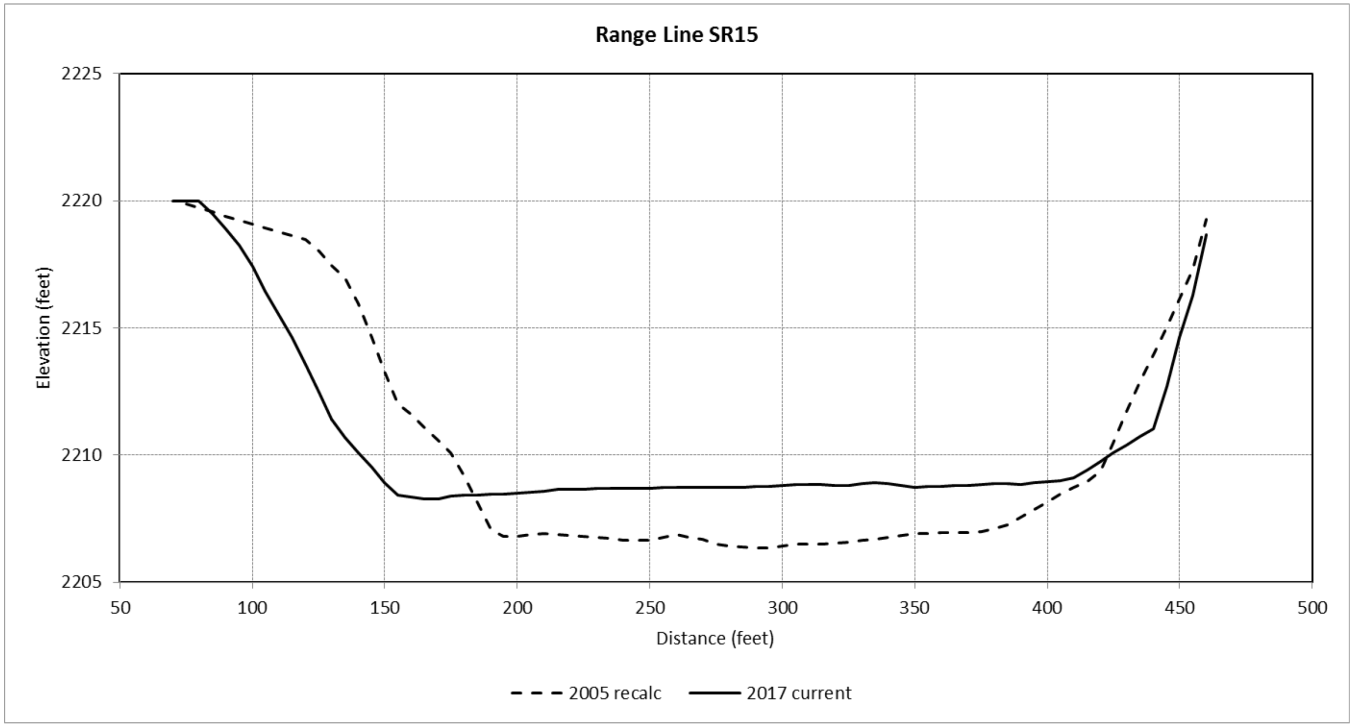

Range Line SR10
Elevation (feet)
2230
2220
2210
2200
2190
2180
0
100
200
300
400
500
600
700
800
900
1000
1100
Distance (feet)
2005 recalc
2017 current

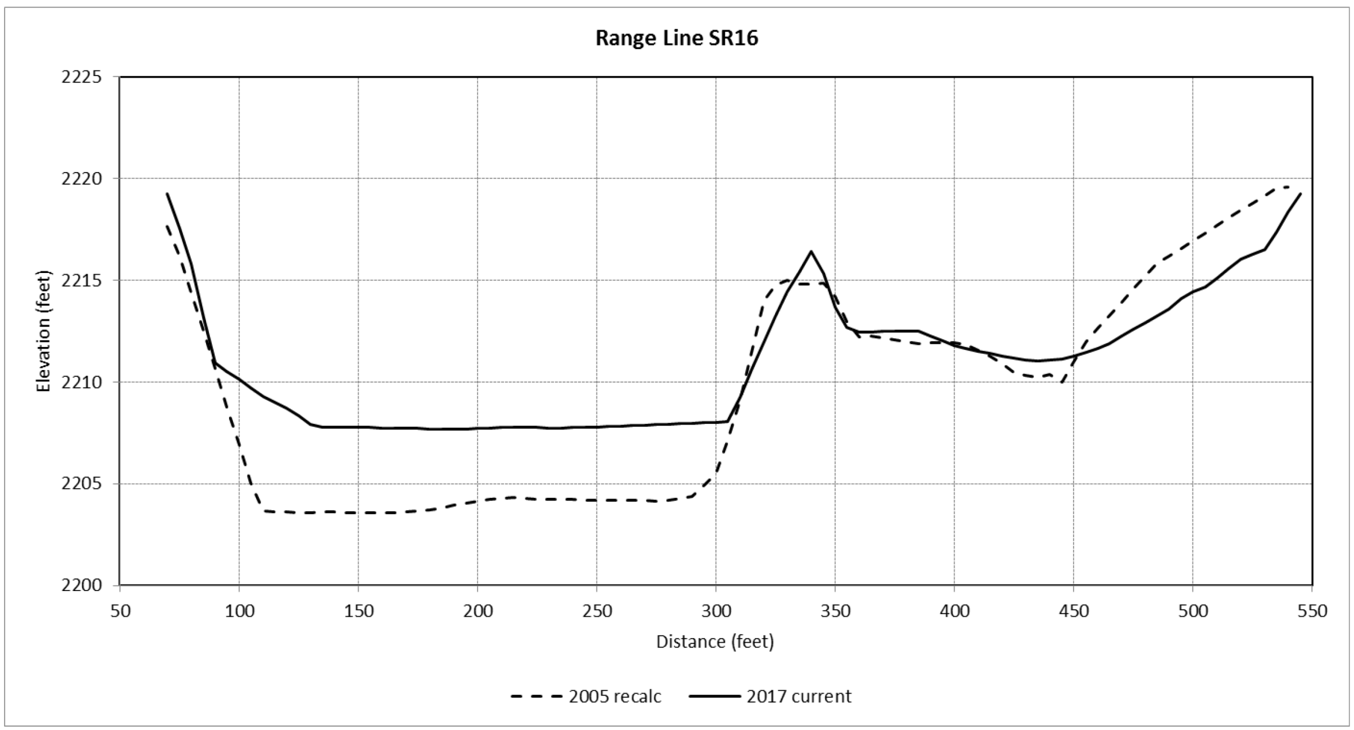

Range Line SR11
Elevation (feet)
2225
2220
2215
2210
2205
2200
2195
0
100
200
300
400
500
600
700
800
Distance (feet)
2005 recalc
2017 current

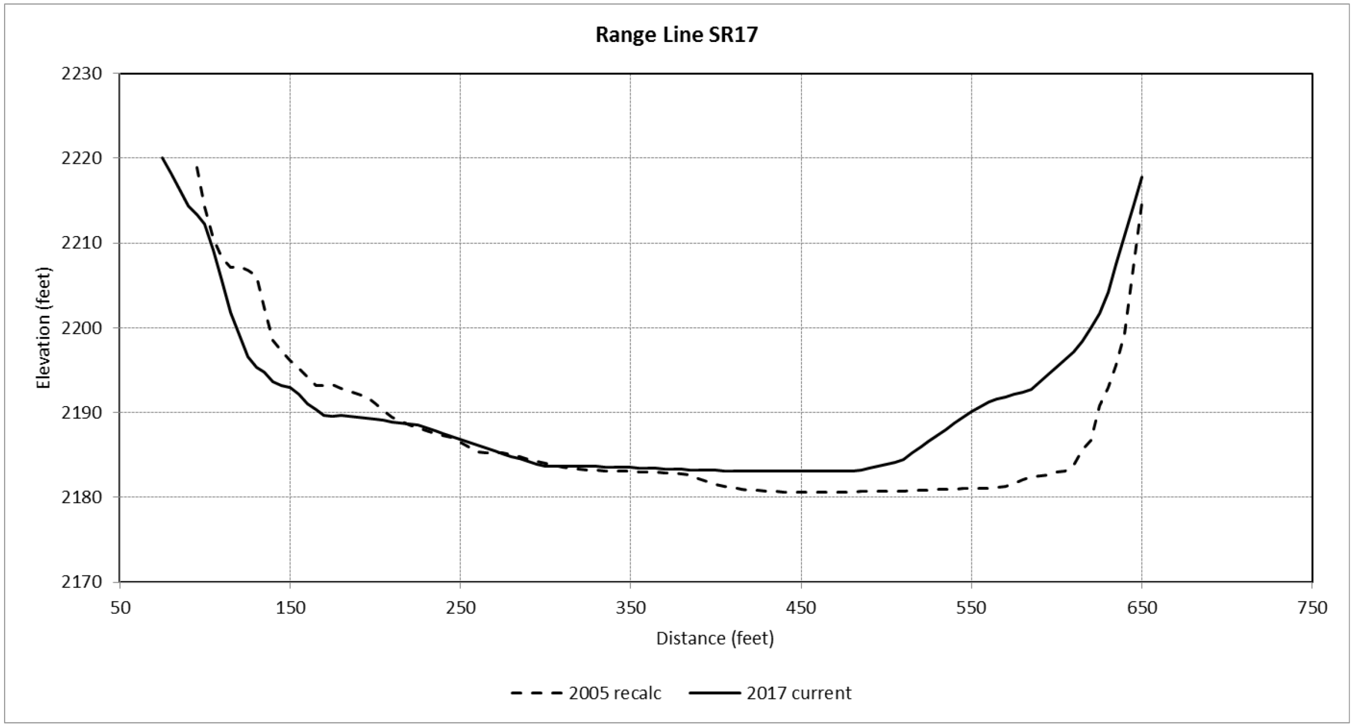

Range Line SR12
Elevation (feet)
2225
2220
2215
2210
2205
2200
50
125
200
275
350
425
500
575
650
725
800
Distance (feet)
2005 recalc
2017 current


Range Line SR13
Elevation (feet)
2225
2220
2215
2210
2205
50
125
200
275
350
425
500
575
650
725
Distance (feet)
2005 recalc
2017 current

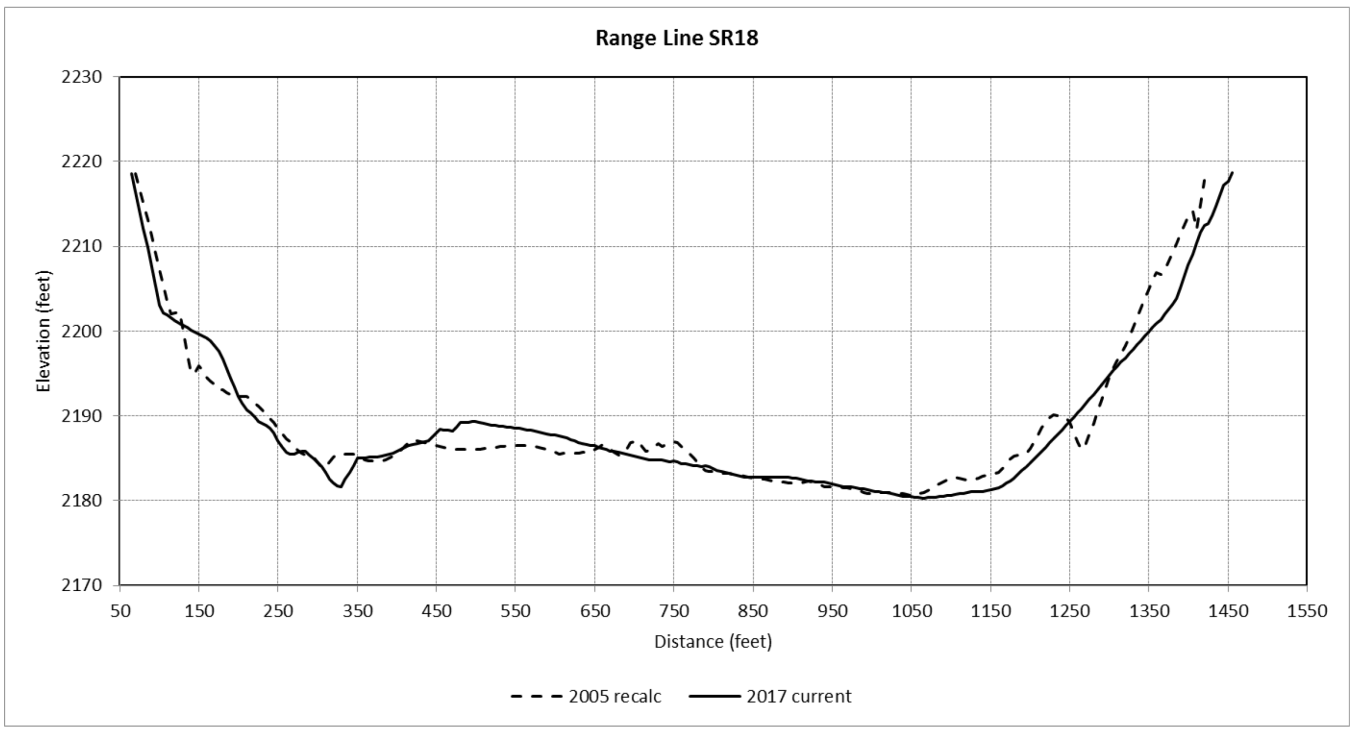

Range Line SR14
Elevation (feet)
2225
2220
2215
2210
2205
0
50
100
150
200
250
300
350
400
450
500
550
600
650
Distance (feet)
2005 recalc
2017 current


Range Line SR15
2225
2220
2215
2210
2205
Elevation (feet)
50
100
150
200
250
300
350
400
450
500
Distance (feet)
2005 recalc
2017 current

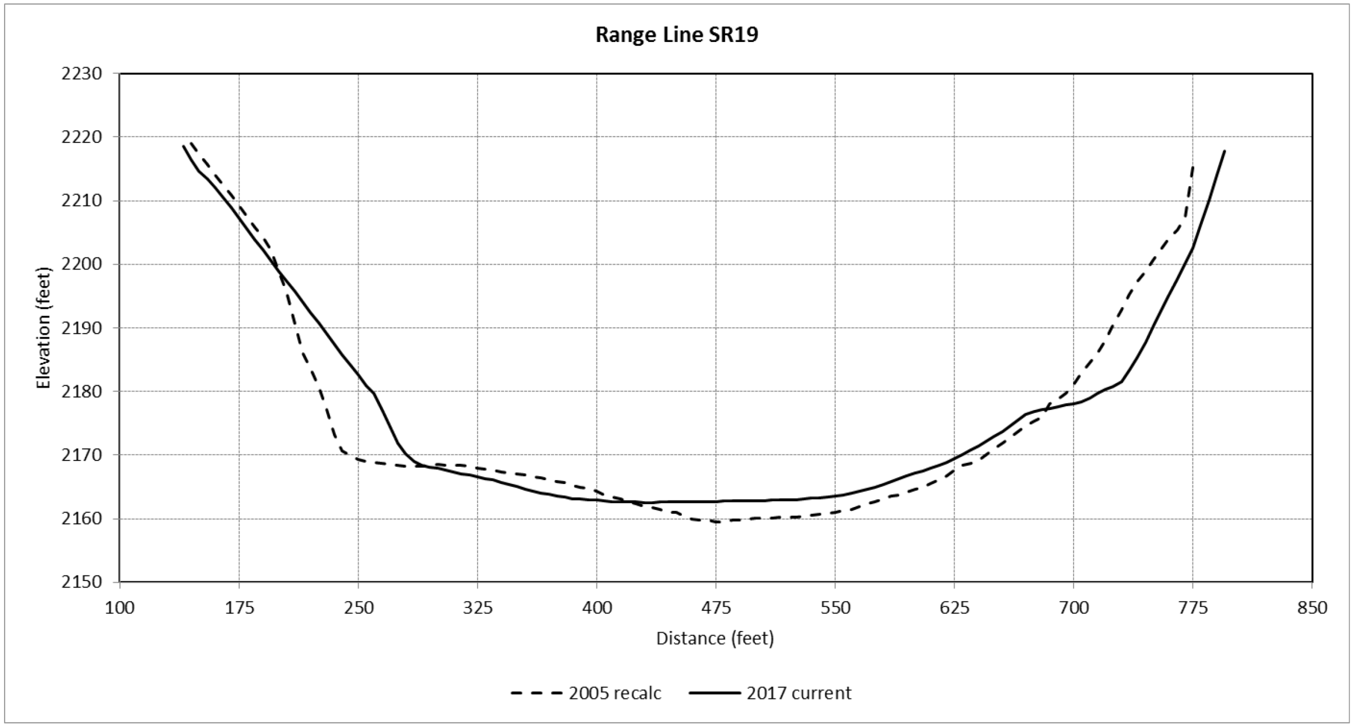

Range Line SR16
2225
2220
2215
2210
2205
2200
Elevation (feet)
50
100
150
200
250
300
350
400
450
500
550
Distance (feet)
2005 recalc
2017 current



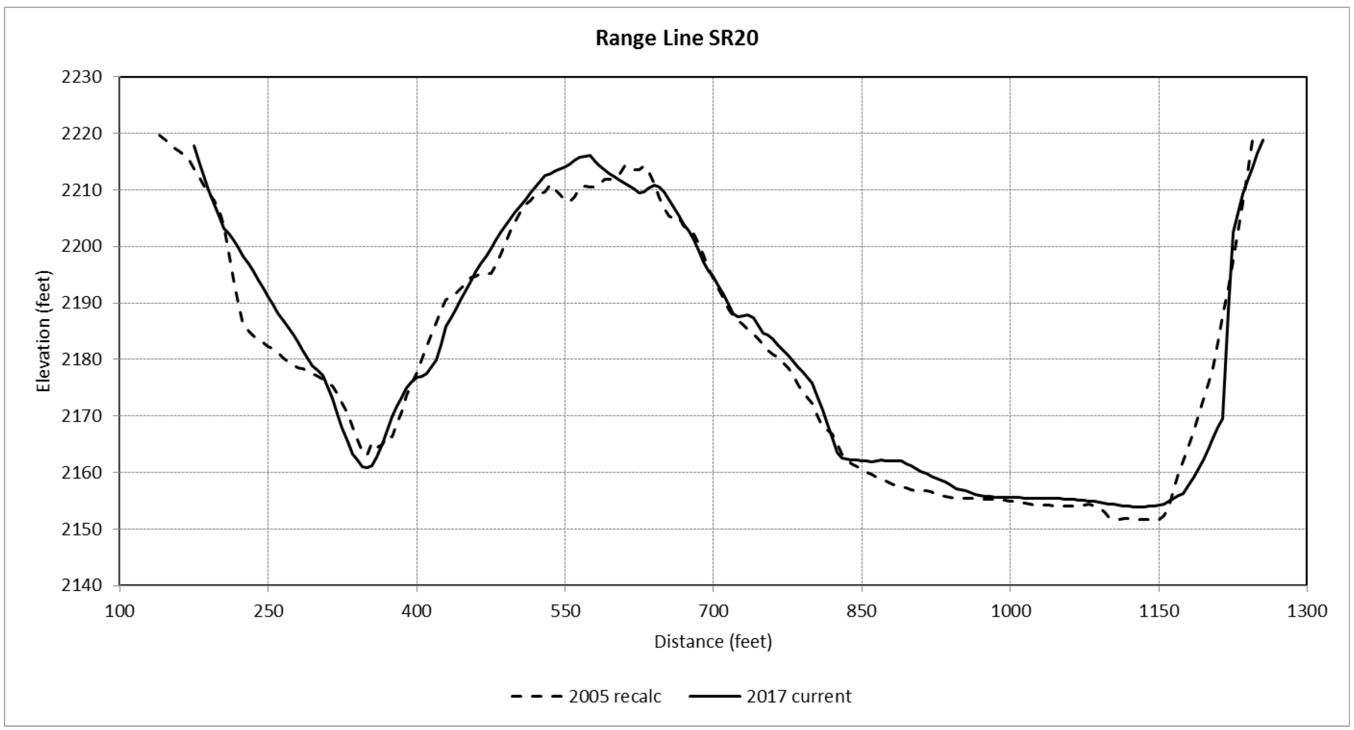
Range Line SR17
2230
2220
2210
2200
2190
2180
2170
Elevation (feet)
50
150
250
350
450
550
650
750
Distance (feet)
2005 recalc
2017 current



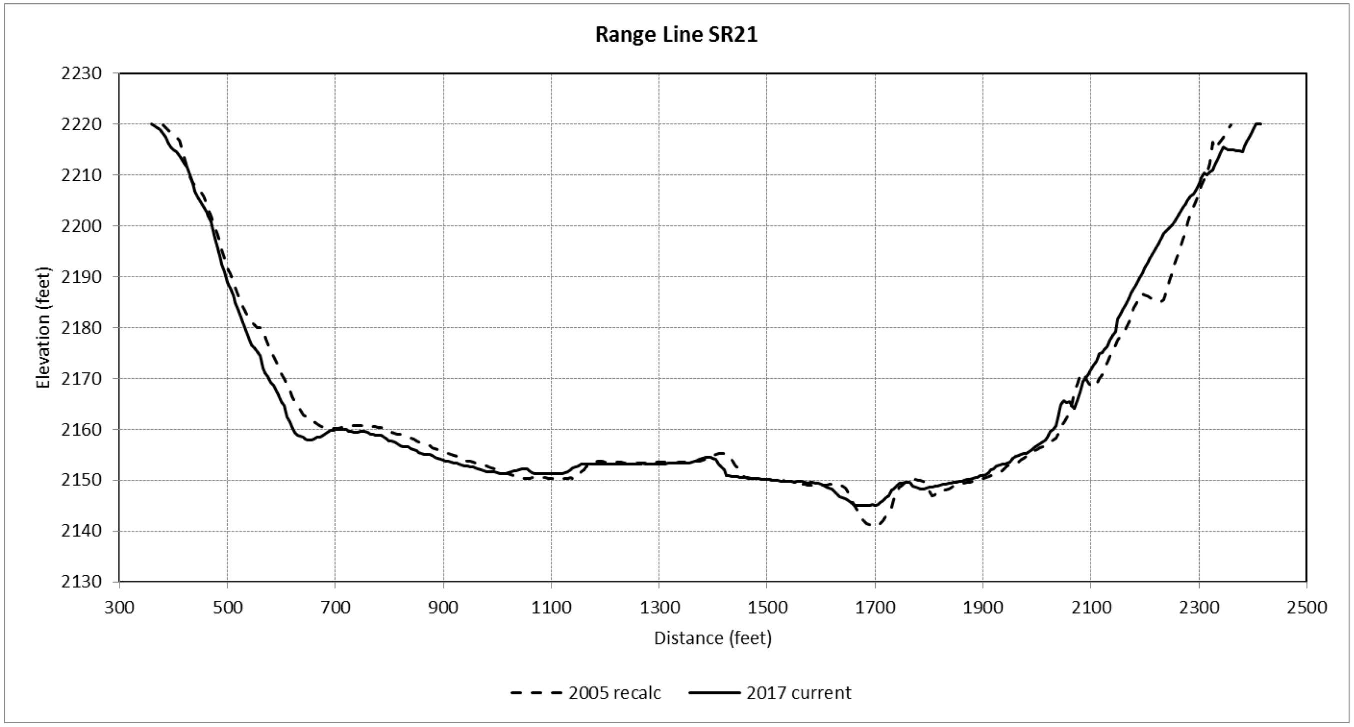
Range Line SR18
2230
2220
2210
2200
2190
2180
2170
Elevation (feet)
50
150
250
350
450
550
650
750
850
950
1050
1150
1250
1350
1450
1550
Distance (feet)
2005 recalc
2017 current



Range Line SR19
Elevation (feet)
Distance (feet)
2230
2220
2210
2200
2190
2180
2170
2160
2150
100
175
250
325
400
475
550
625
700
775
850
2005 recalc
2017 current



Range Line SR20
Elevation (feet)
Distance (feet)
2230
2220
2210
2200
2190
2180
2170
2160
2150
2140
100
250
400
550
700
850
1000
1150
1300
2005 recalc
2017 current


Range Line SR21
Elevation (feet)
2230
2220
2210
2200
2190
2180
2170
2160
2150
2140
2130
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
2500
Distance (feet)
2005 recalc
2017 current

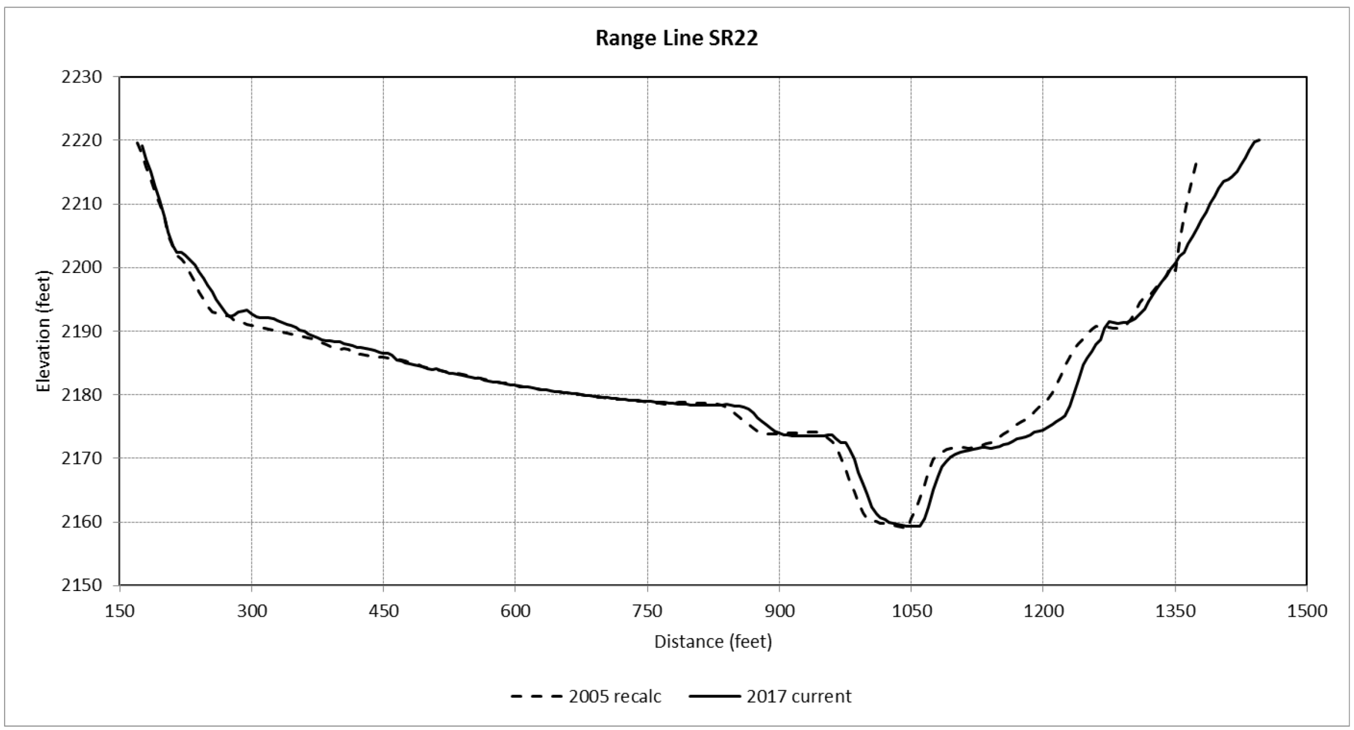

Range Line SR22
Elevation (feet)
2230
2220
2210
2200
2190
2180
2170
2160
2150
150
300
450
600
750
900
1050
1200
1350
1500
Distance (feet)
2005 recalc
2017 current

Figure 6

CONTOURS
(feet above mean sea level)

- 2215
- 2210
- 2205
- 2200
- 2195
- 2190
- 2185
- 2180
- 2175
- 2170
- 2165
- 2160
- 2155
- 2150

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

Kent County
Garza County

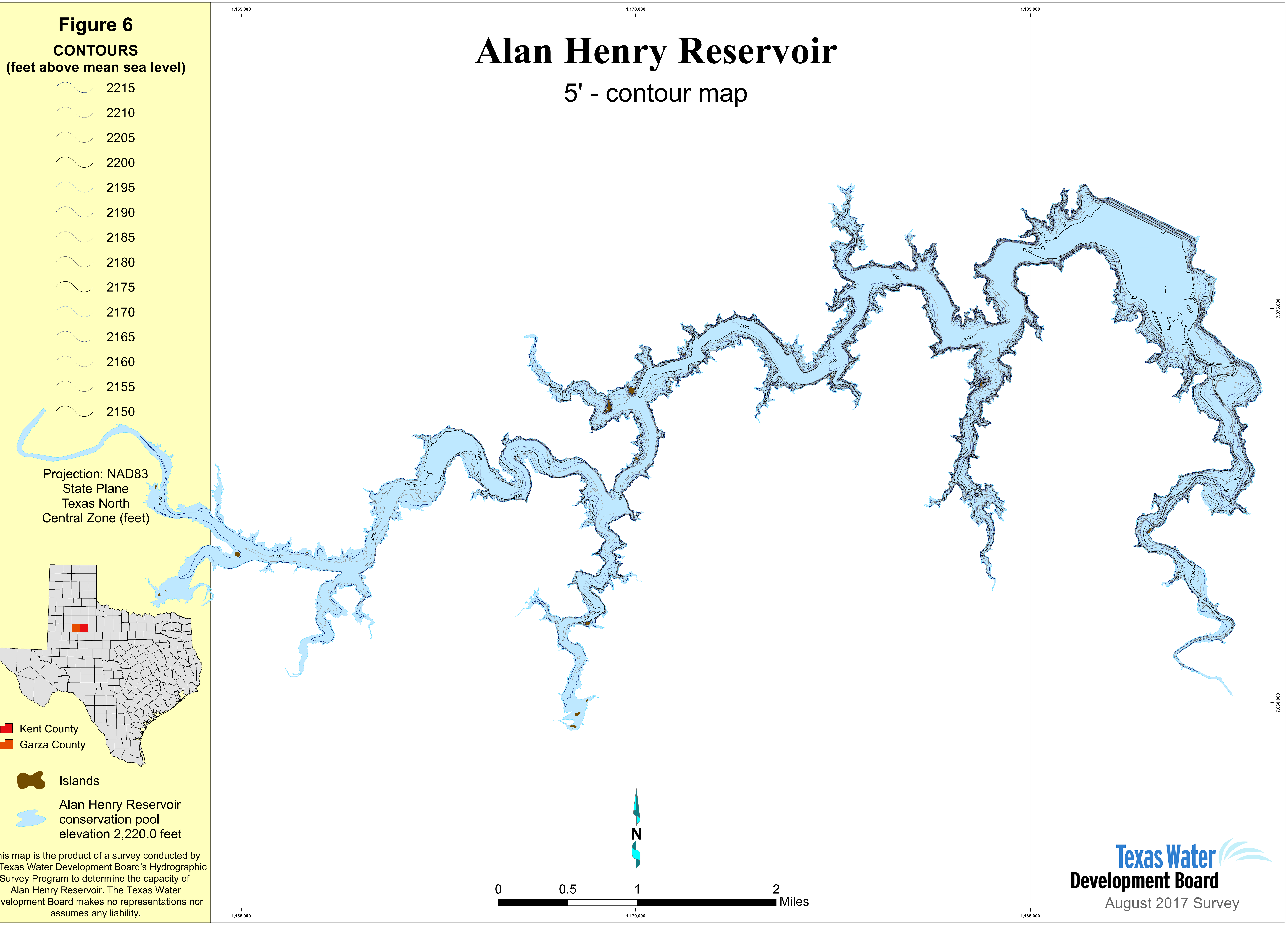
Islands

Alan Henry Reservoir
conservation pool
elevation 2,220.0 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 Alan Henry Reservoir. The Texas Water Development Board makes no representations nor assumes any liability.

Alan Henry Reservoir

5' - contour map



Texas Water Development Board

August 2017 Survey