Bathymetric Survey of Select Dissolved Oxygen Impaired Reservoirs FY 2021

PROJECT 03 FY20/21 §106 I-00640019

PREPARED BY:
OKLAHOMA WATER RESOURCES BOARD

PREPARED FOR:
OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

Final
August 2021

This page is intentionally left blank.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

TABLE OF EQUATIONS

Bathymetric Survey of Select Dissolved Oxygen Impaired Reservoirs FY 2021

INTRODUCTION

Project

The Oklahoma Water Resources Board (OWRB) was contracted by the Oklahoma Department of Environmental Quality (ODEQ) to conduct hydrographic surveys on three Oklahoma reservoirs listed on the state's 303(d) list as impaired for dissolved oxygen. These reservoirs include Atoka Lake and Dave Boyer (Walters) Lake. The purpose of this project is to produce current elevation-area-capacity tables, to allow for volumetric determination of dissolved oxygen for beneficial use assessment.

Reservoirs

Atoka Lake

Atoka Lake is located on North Boggy Creek, a tributary of the Muddy Boggy Creek. It is located in Atoka County, approximately 3 miles northeast of the City of Atoka, as shown in **Figure 1**. The dam (NID ID: OK00092) was completed in 1964, and the reservoir (Waterbody ID: 410400080020) is owned by the City of Oklahoma City. The dam is located at 34° 26' 43.7" N 096° 04' 60.0" W in Sec. 30-T1S-R12E. Atoka's designated beneficial uses include Agriculture, Aesthetics, Fish and Wildlife Propagation, Recreation, and Public and Private Water Supply. Atoka Lake is also designated as a Sensitive Water Supply (OAC, 785:45, Appendix A).

Atoka Lake was in the final stages of a dam and spillway rehabilitation construction project during the survey period. When finished the project will result in a higher spillway crest elevation (590.5 ft NAVD88) as well as a higher top of dam elevation (607.5 ft NAVD88) (Freese and Nichols, 2020).

Dave Boyer (Walters) Lake

Dave Boyer Lake is located on Walters Creek a minor tributary of East Cache Creek. It is located in Cotton County, approximately 2 miles northwest of the City of Walters, as shown in **Figure 2**. The dam (NID ID: OK00560) was originally completed in 1936, and the reservoir (Waterbody ID: 220200030120) is owned by the City of Walters. The dam is located at 34° 22' 34.3" N 098° 20' 01.4" W in Sec. 22-T2S-R11W. Dave Boyer's designated beneficial uses include Agriculture, Aesthetics, Fish and Wildlife Propagation, Recreation, and Public and Private Water Supply. Dave Boyer Lake is also designated as a Sensitive Water Supply (OAC, 785:45, Appendix A).

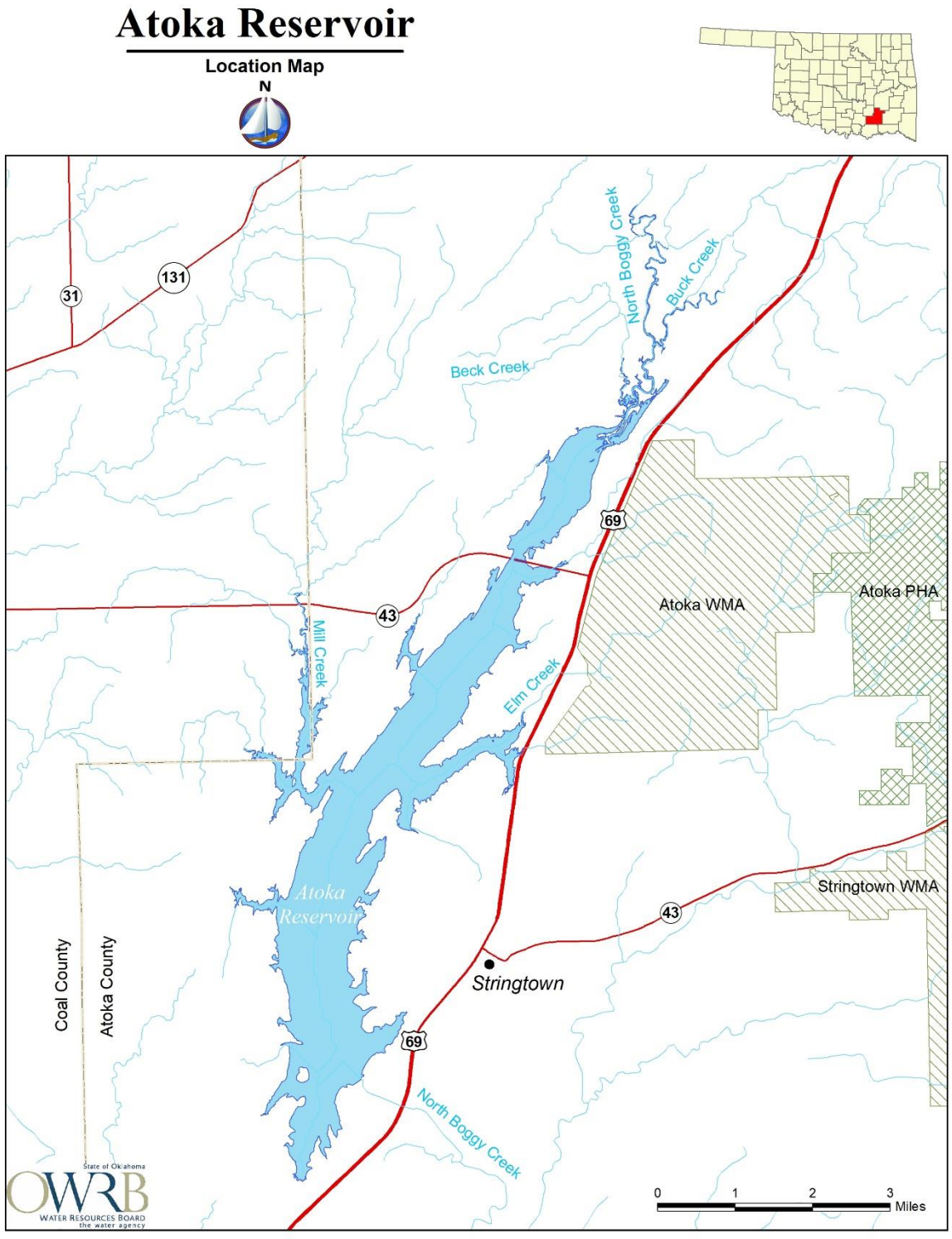


Figure 1: Location map for Atoka Lake

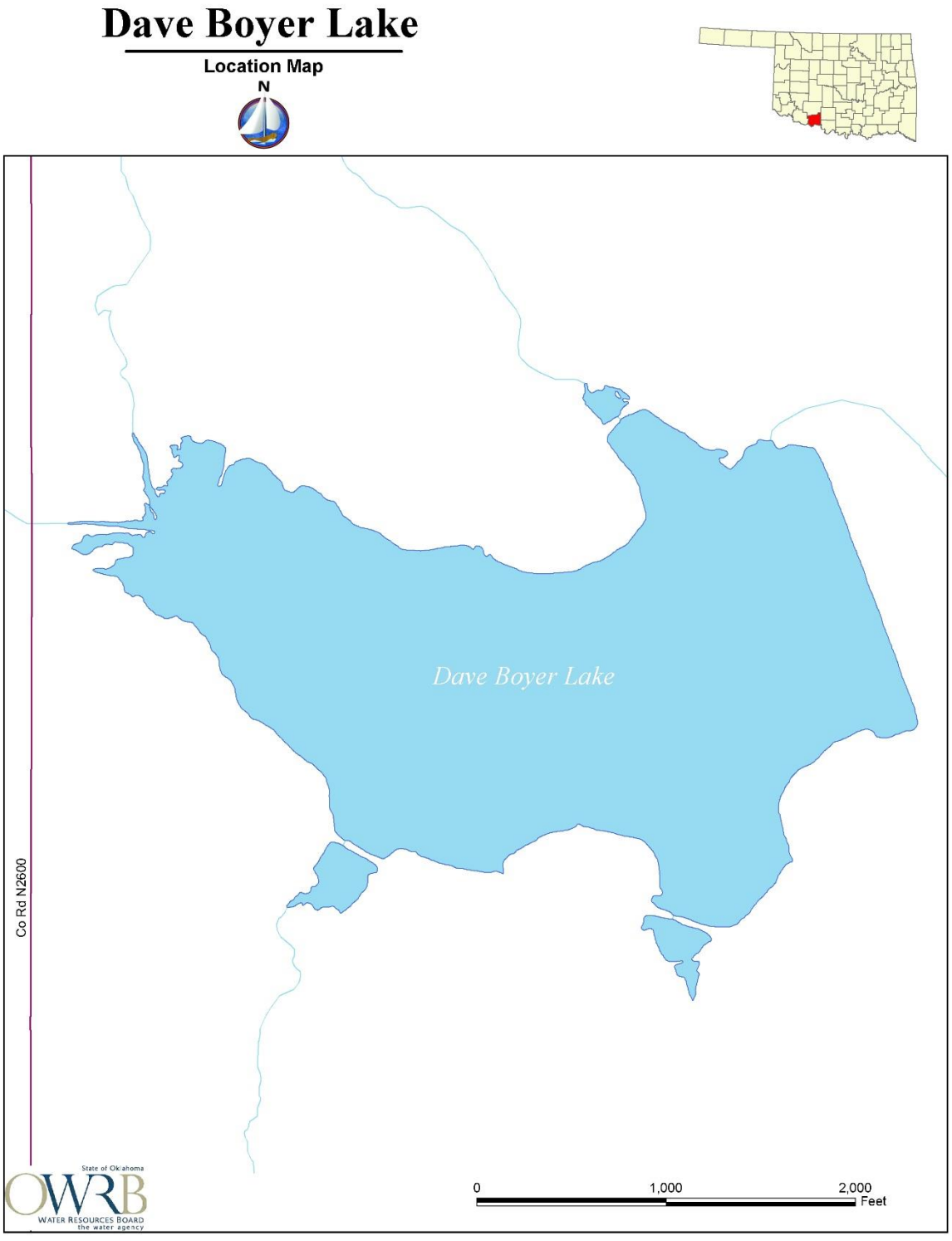


Figure 2: Location map of Dave Boyer Lake

HYDROGRAPHIC SURVEYING PROCEDURES

The process of surveying a reservoir uses a combination of Geographic Positioning Systems (GPS) and acoustic depth sounding technologies incorporated into a hydrographic survey vessel. As the survey vessel travels across the lake's surface, the echosounder gathers multiple depth readings every second. Depth readings are stored on the survey vessel's on-board computer along with positional data generated from the vessel's GPS receiver. The collected data files are downloaded daily from the computer and edited upon returning to the office. During editing, data "noise" is removed or corrected, and depth readings are converted to elevation readings based on the water level elevation recorded on the day the survey was performed. The edited data sets are then thinned to manageable sizes using Hypack's "Sounding Selection-Sort Program" using a 1 sort radius. Using ArcGIS, accurate estimates of area-capacity can then be determined for the lake by building a three-dimensional model of the reservoir from the sorted data set. The process of completing a hydrographic survey includes four steps: pre-survey planning, field survey, data processing, and model construction.

Pre-Survey Planning

Boundary File

Atoka Lake

The shoreline boundary for Atoka Lake was derived from six USGS 1-meter and one 1/3 arc-second DEM LiDAR data files downloaded from the National Map data download site[1]. The six USGS 1-meter LiDAR raster file TIFFs were combined into one file and then used to generate contours for most of the lake. The 1/3 arc-second LiDAR raster file was used for a small portion of the western side of the lake not covered by the 1-meter data. The NRCS Contour Tool v10x, which utilizes the ArcGIS Spatial Analyst extension, was used to generate 0.5 ft contours from the LiDAR file. A lake boundary line shapefile was created from the 590.5 ft contour line; this elevation was most representative of Atoka Reservoir at normal pool elevation (590.5 ft). A small amount of editing of this line was needed to adjust it to reflect the reconstructed dam spillway. Design drawings with control point data were georeferenced and used to edit the boundary at the dam. This boundary file was verified using both orthophotos and measured elevation readings. For development of the area/capacity table values for the flood and surcharge pools 0.5 ft contours were selected from the LiDAR derived data described up above which best represented those elevations. A surcharge boundary line shapefile was created from the 607.5 ft contour line; this elevation being most representative of the Atoka Reservoir surcharge elevation (607.5ft).

Dave Boyer Lake

The shoreline boundary for Dave Boyer Lake was derived from 2-meter DEM LiDAR data downloaded from OKMaps[2]. The LiDAR raster file TIFF was clipped, and contours were generated.

[1] https://apps.nationalmap.gov/downloader/#/

[2] https://okmaps.org/ogi/search.aspx

The NRCS Contour Tool v10x, which utilizes the ArcGIS Spatial Analyst extension, was used to generate 0.5 ft contours from the LiDAR file. A lake boundary line shapefile was created from the 1012.0 ft contour line; this elevation was most representative of Dave Boyer Lake at or near normal pool elevation (1012.2 ft). This boundary file was verified using both orthophotos and measured elevation readings. For development of the area/capacity table values for the flood and surcharge pools 0.5 ft contours were selected from the LiDAR derived data as described in the previous paragraph, which best represented those elevations. A flood pool boundary line shapefile was created from the 1013.5 ft contour line; this elevation being most representative of the Dave Boyer Lake flood pool elevation (1013.4 ft). A surcharge boundary line shapefile was created from the 1018.5 ft contour line; this elevation being most representative of the surcharge elevation (1018.5 ft).

Hypack Set-up

Hypack software from Xylem, Inc. was used to assign geodetic parameters, import background files, and create virtual track lines (transect and crosscheck) (Hypack, 2019). The geodetic parameters assigned were ellipsoid World Geodetic System of 1984 (WGS-84) in State Plane North American Datum of 1983 (NAD-83) Zone OK-3501 Oklahoma North or OK-3502 Oklahoma South, depending on location of the reservoir in regard to Highway Interstate 40 (I40). The distance and depth units used were US Survey Feet. The vertical datum was set to the North American Vertical Datum of 1988 (NAVD88), and any measurements in the National Geodetic Vertical Datum of 1929 (NGVD29) were converted using the National Geodetic Survey (NGS) VERTCON tool[3].

Survey transects were spaced according to the size and shape of each individual lake in order to maintain a high level of accuracy and coverage (**Table 1**). The survey transects within the digitized reservoir boundary ran perpendicular to the original stream channels and tributaries. Stream lines were placed along the center of channels in areas deemed too small for transect coverage, as well as perpendicular to transect lines down the center of any major lake arms. These stream lines were used for data collection in difficult to navigate areas as well as quality control (QC) purposes. Additional track lines set perpendicular to the transect lines were added to be used for QC cross check statistics if needed.

Table 1: Summary of track line coverage for all lakes surveyed.

Track Line Coverage				
Lake	Line Spacing	Transect Lines	Stream Lines	Additional QC Lines
Atoka Lake	300 ft	245	20	4
Dave Boyer Lake	100 ft	39	0	10

[3] http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html

Field Survey

Lake Elevation Acquisition

The lake elevations for all surveys were obtained by collecting positional data over a period of time. Data collection was done using a Trimble Zephyr Geodetic Antenna connected to Trimble 5700 receiver controlled using Trimble TSC1 survey controller (Trimble, 2008). Data was then uploaded to the On-line Positioning Users Service[4] (OPUS) website. The National Geodetic Survey (NGS) operates the OPUS to provide GPS users with easier access to the National Spatial Reference System (NSRS). OPUS allows users to submit their GPS data files to NGS, where the data is processed to determine a position using NGS computers and software. Each data file that is submitted is processed with respect to at least three Continuously Operating Reference Stations (CORS). All collection and processing of elevation data followed methods covered in full detail in the OWRB Standard Operating Procedures (SOP) for lake elevation measurement found in the approved project Quality Assurance Project Plan (QAPP) (OWRB, 2021).

Method

The procedures followed by the OWRB during the hydrographic surveys adhere to U.S. Army Corps of Engineers (USACE) standards EM 1110-2-1003 (USACE, 2013) as stated in the approved project QAPP (OWRB, 2021). The quality assurance and quality control (QA/QC) procedures for equipment calibration and operation, field survey, data processing, and accuracy standards are presented in the following sections and covered in more detail in the approved project QAPP (OWRB, 2021).

Technology

The Hydro-survey vessels were a 16-ft aluminum hull boat, powered by a single 40-horsepower outboard motor for Dave Boyer; and an 18-ft aluminum hull boat, powered by a single 115-horsepower outboard motor for Atoka. Equipment used to conduct the survey included: a rugged notebook computer running Hypack's 2019 survey data collection software (Hypack, 2019), Knudsen 1614 Echo Sounder (Knudsen, 2010), with a depth resolution of 0.1 ft, Hemisphere R131 receiver with differential global positioning system (DGPS) correction (Hemisphere, 2013), a Valeport SWiFT SVP (Sound Velocity Profiler) (Valeport, 2020). All field equipment was used in accordance with their corresponding manuals.

Survey

A two-man survey crew was used throughout the duration of the project. Data collection began at the dam and moved upstream. The survey crew followed the parallel transects created during the pre-survey planning while collecting depth soundings and positional data. In areas of the lake that were too narrow for pre-planned transect lines; stream lines were followed, using both straight and with a zigzag pattern to collect data. These areas included small tributaries as well as the upstream section of the reservoir. Similar to the shoreline data collection procedure, upstream data was collected until depths were too shallow for the boat to navigate and/or an obstruction prevented travel past a certain point. All lake surveys followed the aforementioned

[4] https://www.ngs.noaa.gov/OPUS

procedure for survey data collection. Survey dates and water level elevations can be found in **Table 2**.

Table 2: Summary of water elevations measured or recorded for all survey dates.

Survey Dates and Water Elevations		
Lake	Date	Water Elevations (NAVD88)
Atoka Lake	04/19/2021	586.3 ft
	04/20/2021	586.2 ft
	04/21/2021	586.1 ft
	05/05/2021	591.3 ft
	05/06/2021	591.1 ft
Dave Boyer Lake	01/26/2021	1013.0 ft

Quality Assurance/Quality Control

Sound Velocity

The hydrographic surveys followed the quality control procedures presented in the approved QAPP (OWRB, 2021) and summarized in **Table 3**. While on board the Hydro-survey vessel, the Knudsen 1614 Echo Sounder was calibrated using both a SWiFT SVP and/or a bar-check setup. The sound velocimeter measures the speed of sound (SOS) at incremental depths throughout the water column. The factors that influence the SOS—depth, temperature, and salinity—are all taken into account. Deploying the unit involved lowering the probe into the water to the calibration depth mark to allow for acclimation and calibration of the depth sensor. The unit was then gradually lowered at a controlled speed to a depth just above the lake bottom, and then was raised to the surface. The unit collected sound velocity measurements in feet/seconds at regular increments on both the deployment and retrieval phases. The data was then reviewed for any discrepancies, which were subsequently edited out of the sample. Sound velocity profiles are used to calibrate collected raw depth readings during the editing process.

Table 3: Summary of Relevant Minimum Performance Standards (MPS) and Quality Assurance (QA) Practices for the Hydrographic Survey (USACE, 2002&2013).

Minimum Performance Standards and Quality Assurance Practices for the Hydrographic Survey		
Repeatability (Bias)	0.3 ft	0.5 ft
Standard Deviation (± ft at 95%)	± 0.8 ft	
Resultant Elevation/Depth Accuracy (95%) (15>d<40 ft)	± 2.0 ft	
Horizontal Positioning System Accuracy (95%)	5 m (16 ft)	
Minimum Survey Coverage Density	Not to Exceed 500 ft (150 m)	
Quality Control and Assurance Criteria	--	
➢ Bar-check	1/project	
➢ Sound Velocity QC calibration	2/day	
➢ Squat Test	1/year	
➢ Position calibration QC check	1/project	
From the **2002** version of EM 1110-2-1003	From the **2013** version of EM 1110-2-1003	

Bar-Check

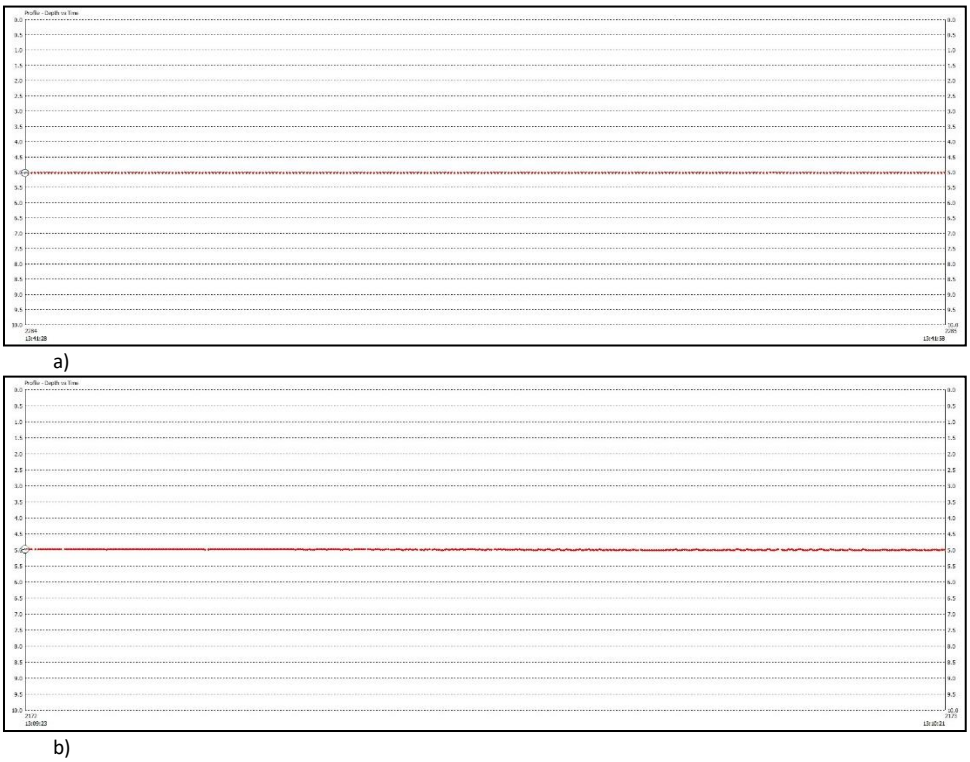
The bar-check procedure adheres to USACE methods (USACE, 2013). The setup consists of a steel plate lowered using chains measured and marked in five ft increments. The setup is lowered initially to a depth of 5 ft from the surface of the water. Taking the 5 ft depth and subtracting the unmodified depth from the echosounder provides the static draft or depth of the transducer in reference to the water's surface. This offset was measured and recorded by the Knudsen echosounder using its Bar-Check Mode where the SOS at five 5 ft depth is also entered. The bar-check setup is then lowered to 25 ft to check for variations. Data is collected at both 5 ft and 25 ft depths and processed with the correlating sound velocity profile to validate calibration. Bar-check echograms can be found in **Figure 3**. **Table D- 1** containing Static draft, average SOS, as well as SOS set in the echosounder for all survey dates can be found in **APPENDIX D:** Additional Survey Data Tables.

Cross-Line Check

Depth observations contain both random errors (σ Random Error) and systematic biases (σ Bias). Biases are often referred to as systematic or external errors and may contain observational oversight. A constant error in tide or stage would be an example of a bias. Biases are reduced as much a possible by using the quality control measures discussed previously. Random errors are those errors present in the measurement system that cannot be easily minimized by additional calibration. Examples include echo sounder resolution, water sound velocity variations, tide/staff gage reading resolution, etc. The precision of the observations is a measure of the closeness of a set of measurements--or their internal agreement. Accuracy relates to the closeness of measurements to their true or actual value.

Accuracy and precision were assessed utilizing a cross-line check method referenced in the approved QAPP (OWRB, 2021). The cross-line check was performed by collecting depth readings

along survey track lines perpendicular to, and intersecting the survey transect lines. Hypack's Cross Check Statistics program was used to assess vertical accuracy and confidence measures of the recorded depths at the points where the lines intersected. This program tabulates and statistically analyzed the depth differences between overlapping points of single beam data. The program provides a report calculating the standard deviation and mean difference. **Table D- 2** contains the results of the cross-line checks; include the number of Quality Control (QC) intersections, arithmetic mean (Bias), and the standard deviation (Random Error) for all reservoirs and can be found in **APPENDIX D:** Additional Survey Data Tables.



a)

b)

Figure 3: Digital Echogram of Bar-checks for All Lakes Surveyed a) Atoka Lake 04/16/2021 b) Dave Boyer (Walters) Lake 01/26/2021

Depth Accuracy Calculation

Mean difference and the standard deviation can be used to calculate the Root Mean Square (RMS) error using **Equation 1**. The RMS error estimate is used to compare relative accuracies of estimates that differ substantially in bias and precision (USACE, 2002). According to the recommended standards in the approved QAPP, RMS at the 95% confidence level should not exceed a tolerance of $\pm$ 2.0 ft for reservoir surveys (OWRB, 2021). This simply means that on average, 19 of every 20 observed depths will fall within the specified accuracy tolerance.

Equation 1: Depth/Elevation Accuracy Calculation

$$RMS = \sqrt{\sigma^2_{Random error} + \sigma^2_{Bias}}$$

where:

Random error = standard deviation
Bias = mean difference
RMS = Root Mean Square error (68% confidence level)

and:

$$RMS\ (95\%)\ depth\ accuracy = 1.96 \times RMS(68\%)$$

All reservoirs resulted in an RMS of less than ± 2.0 ft with a 95% confidence level meeting the QAPP's MPS for reservoir surveys. The calculated 95% RMS for all reservoirs can be found in **Table 4**.

Table 4: Calculated Depth Accuracies for All Lakes Surveyed.

Calculated Depth Accuracy	
Reservoir	RMS at 95% Confidence
Atoka Lake	±0.79 ft
Dave Boyer (Walters) Lake	±0.15 ft

GPS

The GPS system is an advanced high-performance geographic data-acquisition tool that uses differential GPS (DGPS) to provide sub-meter positional accuracy on a second-by-second basis. Potential errors are reduced with DGPS because additional data from a reference GPS receiver at a known position are used to correct positions obtained during the survey. Prior to the survey, the settings on the Hemisphere R131 were checked to ensure correct configuration of the GPS receiver. These settings are discussed in more detail in the OWRB SOP for hydrographic surveying found in the approved project QAPP (OWRB, 2021).

Latency Test

A latency test was performed to determine the fixed delay time between the GPS and single beam echo sounder. The timing delay was determined by running reciprocal survey lines over a channel bank. The raw data files were downloaded into Hypack - LATENCY TEST program. The program varies the time delay to determine the "best fit" setting. Position latency in seconds was produced and adjustments were applied to the raw data using Hypack's Single Beam Editor Program, during data processing. **Table D- 1** contains all latency offsets for all survey dates and can be found in **APPENDIX D:** Additional Survey Data Tables.

Data Processing

After uploading the collected data to an OWRB desktop, each raw data file was reviewed using the Single Beam Editor program within Hypack. The Single Beam Editor program allows the user to assign equipment offsets, latency corrections, tide corrections, display the raw data profile, and review/edit all raw depth information. Raw data files are checked for gross inaccuracies that

occur during data collection. Data editing is covered in more detail in the approved project QAPP (OWRB, 2021).

The DGPS latency offset was applied. The Echosounder was corrected for the static vertical draft. These offsets were applied to all raw data sets. The SOS corrections were applied during editing of raw data using the sound velocity correction files created with the sound velocity tool.

An elevation correction file was produced using Hypack's Manual Tides program to account for variance in lake elevation at the time of data collection. The corrected depths were subtracted from the elevation reading to convert their depth in feet to an elevation within the Single Beam Editor program.

During the editing process any areas with unconsolidated bottom returns were manually digitized. This was done using the digital echogram of the data and Hypack's Digitize tool as seen in **Figure 4**. The bottom was digitized on the first return, which was verified as bottom surface using multiple manual measurements over various unconsolidated bottom areas. The measurements were performed using a lead weight on a measure chain while simultaneously collecting echograms, then comparing them to identify the depth to solid bottom.

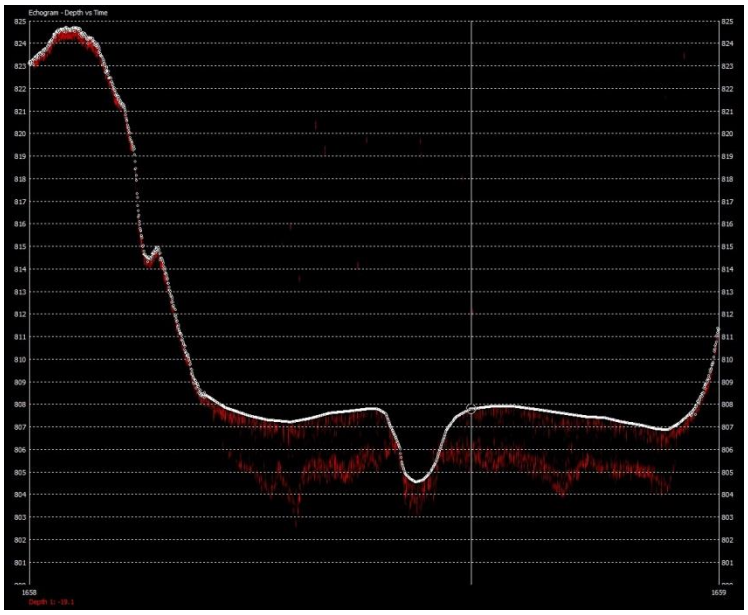


Figure 4: Example echogram showing results after manual bottom digitization

After editing the data for errors and correcting the spatial attributes (offsets and tide corrections), a data reduction scheme was utilized due to the large quantity of collected data. To accomplish this, the corrected data was sorted spatially at a 1 ft interval using the Sounding Selection program in Hypack. Resultant data was saved and exported as a xyz.txt file containing X and Y horizontal coordinates as well as Z elevations for all data points. The Hypack raw and corrected data files for all reservoirs are stored and available upon request.

GIS Application and Model Construction

Geographic Information Systems (GIS) software was used to process the edited XYZ data collected from the survey. The GIS software used was ArcGIS Desktop, version 10.2, from Environmental Systems Research Institute (ESRI). All GIS datasets created are in Oklahoma State Plane Coordinate System (North or South) referenced to the North American Datum 1983. Horizontal and vertical units are in feet. The edited data points in XYZ text file format were converted into a point feature class in an ArcGIS file geodatabase. The point feature class contains horizontal coordinates and elevation and depth values associated with each collected point.

Volumetric and area calculations were derived from a Triangulated Irregular Network (TIN) surface model. A TIN consists of connected data points that form a network of triangles representing the bottom surface of the lake. The TIN model was created within ArcGIS using the following datasets: 2, 5, or 10 ft contours derived from a raster file interpolated from the collected survey data points, lake boundary at normal pool elevation, and LiDAR data covering flood and surcharge pools. Lake area and cumulative volume were calculated by slicing the TIN horizontally into planes 0.1 ft thick. Area and cumulative volume of each slice are shown in **APPENDIX A: Area-Capacity Data.**

Contours, depth ranges, and the shaded relief maps were derived from a constructed DEM grid. This grid was created using the ArcGIS Topo to Raster Tool and had a spatial resolution of 1 ft. Contours lines were created at a 2, 5, or 10 ft interval using the ArcGIS contour tool. Contour lines were edited to allow for polygon topology improving accuracy and general smoothness of the lines. Lines were visually edited, paying close attention to the channel area, while also ensuring the lines matched the original data set. The contours were then converted to a polygon feature class and attributed to show 2, 5, or 10 ft depth ranges across the lake. All geographic datasets derived from the survey contain Federal Geographic Data Committee (FGDC) compliant metadata documentation. The metadata describes the procedures and commands used to create the datasets. The GIS metadata for all reservoirs are stored and available upon request, along with all GIS Data.

RESULTS

Atoka Lake

Results from the April 2021 OWRB survey indicate that Atoka Lake encompasses 5639.5 surface acres and contains a cumulative capacity of 117326.0 acre-ft at normal pool elevation of 590.5 ft (NAVD88). The mean depth for Atoka Lake is 20.8 ft, while the deepest point measured was 64.0 ft. Lake Maps can be found in **APPENDIX B: Atoka Lake Maps**.

Dave Boyer (Walters) Lake

Results from the January 2021 OWRB survey indicate that Dave Boyers Lake encompasses 153.7 surface acres and contains a cumulative capacity of 1283.1 acre-ft at normal pool elevation of 1012.2 ft (NAVD88). The average depth for Dave Boyer Lake is 8.3 ft, while the deepest point measured was 17.2 ft. Lake Maps can be found in **APPENDIX C: Dave Boyer (Walters) Lake Maps**.

SUMMARY and COMPARISON

Table 5 displays areas and volumes calculated at normal pool elevations for both design specifications and the current surveys. Percent change was then calculated for area, capacity, and average depth. Caution should be used when directly comparing between the design specifications and the current surveys conducted by the OWRB as different methods were used to collect the data and extrapolate capacity and area.

Table 5: Areas and Volumes calculated at normal pool elevations during design specifications and current survey periods for all lakes (OWRB, 1990).
***Values after dam/spillway rehabilitation project for Atoka in 2021.**

Feature	Survey Year		Change (%)
	Design Specifications	Current Survey	
Atoka Lake – April 2021			
Area (acres)	5,700	5,639.5	-1.1
Capacity (acre-ft)	125,000	117,326.0	-6.1
Mean depth (ft)	21.9	20.8	-5.1
Dave Boyer (Walters) – January 2021			
Area (acres)	125	153.7	+23.0
Capacity (acre-ft)	861	1,283.1	+49.0
Mean depth (ft)	6.9	8.3	+21.2

All current calculated changes are only estimations and can be verified by performing additional surveys. To make the most accurate comparison across surveys, it is the recommendation of the OWRB that additional/future surveys utilizing the current survey methods be conducted in 10 years. By using the current survey figures as a baseline, similarly performed future surveys would allow for accurate mean sedimentation rates to be determined.

Atoka Lake

The surface area of Atoka Lake shows an apparent decrease of 60.5 acres or 1.1%. The April 2021 survey shows that Atoka Lake had an apparent decrease in capacity of 7674.0 acre-ft or 6.1%. Average depth for the reservoir decreased 1.1 ft or 5.1%. Calculations were based on design specifications from the dam inspection report (Freese and Nichols, 2020) and as built drawings on record at the OWRB. The estimated average annual loss in capacity is 134.6 acre-ft or 0.1% over the 21-year life of the reservoir. Area and capacity values from a 2000 (OWRB, 2000) survey were not used for comparison, due to differences in coverage at the time of the 2000 survey, current availability of lidar, as well as modification made to the spillway and dam area (Freese and Nichols, 2020).

Dave Boyer (Walters) Lake

The surface area of Dave Boyer Lake shows an apparent increase of 28.72 acres or 23.0%. The January 2021 survey shows that Dave Boyer Lake had an apparent increase in capacity of 422.1

acre-ft or 49.0%. Average depth for the reservoir increased 1.5 ft or 21.2%. Calculations were done using values found in a Phase I report (USACE, 1978. Estimation of the average annual capacity loss was not calculated due to the increase in capacity, this increase in capacity may be attributed to updated survey methods and data availability.

REFERENCES

Freese and Nichols, Inc. 2020. *Atoka Dam 2020 Inspection*

Hemisphere GNSS Inc.. 2013. *R100 Series Receiver: User Guide*. Retrieved From https://hemispheregnss.com/Portals/0/TechnicalDocumentation/875-0173-000_H1%20(MNL,UG,R100)%20web.pdf

Hypack a Xylem Brand. 2019. *Hypack: User Manual*. Retrieved from http://www.hypack.com/File%20Library/Resource%20Library/Manuals/2019/2019-HYPACK-User-Manual.pdf

Knudsen Engineering Limited. 2010. *SounderSuite – USB: Software User Manual*. Retrieved from http://knudseneng.com/files/manuals/D101-04969-Rev2.0-SounderSuite-USBUserManual.pdf

Oklahoma Administrative Code *Title 785, Chapter 45 Oklahoma's Water Quality Standards, Appendix A.* Retrieved from http://www.owrb.ok.gov/util/rules/pdf_rul/current/Ch45.pdf

Oklahoma Water Resources Board (OWRB). 1990. *Oklahoma Water Atlas*

Oklahoma Water Resources Board (OWRB). 2002. *Impact of Concentrated Animal Feeding Operations on Oklahoma City's Water Supplies*

Oklahoma Water Resources Board (OWRB). 2021. *Quality Assurance Project Plan for Bathymetric Mapping of Selected Water Supply Reservoirs Impaired for Dissolved Oxygen FY 20/20 Section §106 I-00640019*. QTRAK #21-158

Trimble. (2008). *Trimble 5700 GPS Receiver: User Guide*. Retrieved from http://trl.trimble.com/docushare/dsweb/Get/Document-422396/R7GNSS-5700_364_UserGuide.pdf

U.S. Army Corps of Engineers (USACE). 1978. *Walters City Lake – Dam & Spillway – Phase I Inspection Report National Dam Safety Program*

U.S. Army Corps of Engineers (USACE). 2002. *Engineering and Design - Hydrographic Surveying, Publication EM 1110-2-1003, 3rd version*

U.S. Army Corps of Engineers (USACE). 2002. *Engineering Design: Hydrographic Surveying (EM 1110-2-1003)*; Chapter 3. Table 3-1: *Minimum Performance Standards for Corps of Engineers Hydrographic Surveys (Mandatory)*; Project Classification – Other General Surveys & Studies. Retrieved from www1.frm.utn.edu.ar/laboratorio_hidraulica/Biblioteca_Virtual/Hydrographic%20Surveying/c-3.pdf

U.S. Army Corps of Engineers (USACE). 2013. *Engineering and Design: Hydrographic Surveying (EM 1110-2-1003)*. Retrieved from www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-1003.pdf

Valeport. (2020). *SWiFT SVP & SWiFTplus Operating Manual*. Retrieved from https://www.valeport.co.uk/content/uploads/2020/03/SWiFT-SVP-SWiFTplus-Operating-Manual-0660879g.pdf

APPENDIX A: Area-Capacity Data

Table A- 1: Atoka Lake Area by 0.1 ft Increments.

Atoka Lake Area Table Area in Acres by 0.1 ft Elevation Increments 2021 Survey Oklahoma Water Resources Board										
Elevation in Feet	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
526			0.0000	0.0000	0.0000	0.0001	0.0078	0.0169	0.0272	0.0389
527	0.0519	0.0695	0.0917	0.1149	0.1400	0.1680	0.1976	0.2289	0.2631	0.2989
528	0.3370	0.3785	0.4231	0.4701	0.5188	0.5684	0.6216	0.6784	0.7389	0.8033
529	0.8724	0.9478	1.0320	1.1274	1.2329	1.3479	1.4738	1.6039	1.7447	1.8911
530	2.0414	2.1932	2.3487	2.5060	2.6637	2.8224	2.9814	3.1449	3.3091	3.4755
531	3.6430	3.8128	3.9866	4.1718	4.3619	4.5551	4.7520	4.9516	5.1532	5.3581
532	5.5659	5.7767	5.9916	6.2111	6.4357	6.6667	6.9030	7.1442	7.3897	7.6395
533	7.8937	8.1522	8.4146	8.6814	8.9524	9.2282	9.5082	9.7935	10.0831	10.3806
534	10.6837	10.9922	11.3055	11.6232	11.9457	12.2733	12.6059	12.9445	13.2892	13.6416
535	14.0020	14.3715	14.7497	15.1395	15.5433	15.9562	16.3798	16.8122	17.2529	17.7036
536	18.1688	18.6542	19.1652	19.6926	20.2415	20.8116	21.4031	22.0166	22.6714	23.3745
537	24.1158	24.9123	25.7664	26.6331	27.4942	28.4015	29.3482	30.3148	31.3029	32.3269
538	33.3745	34.4649	35.5693	36.6767	37.7965	38.9456	40.1167	41.3231	42.5990	43.9474
539	45.3978	46.9919	48.6130	50.3146	52.1476	53.9956	55.8135	57.6166	59.3730	61.0593
540	62.7185	64.3728	66.0615	67.7478	69.4709	71.2642	73.0869	74.9540	76.9062	78.8878
541	80.9702	83.1559	85.4916	87.9577	90.5438	93.2195	96.0709	98.9593	102.0287	105.3635
542	108.8597	112.3760	116.1503	120.0166	124.0831	128.1474	132.0682	135.8908	139.7122	143.7044
543	147.9223	152.2476	156.6580	161.0360	165.4454	169.9990	174.5871	179.1228	183.5548	187.9822
544	192.6001	197.2852	201.9404	206.6903	211.5807	216.6306	221.7952	227.0983	232.4817	237.9842
545	244.0659	250.0798	256.2949	261.8697	267.5916	273.3759	279.2785	285.1005	290.7188	296.5896
546	302.4726	308.4906	314.7225	320.9904	327.6426	334.1768	340.2354	346.3295	352.8515	359.6990
547	366.7702	373.7150	381.0902	387.9919	395.4244	403.7729	412.3655	421.4722	430.3662	439.2558
548	447.8742	456.2254	464.9055	473.2251	482.4695	492.6254	501.6895	510.7880	518.8189	526.9601
549	536.0578	544.1991	551.6144	558.1179	564.6113	571.2607	577.7722	584.8110	591.7289	598.6881
550	606.2162	613.2438	620.3319	627.5787	634.7161	642.2075	649.5787	657.1569	664.8999	672.7633
551	680.7762	688.9497	697.3193	705.3177	713.4380	721.8534	730.1150	738.3835	746.9002	756.0454
552	765.7329	775.0824	784.6379	794.1512	804.0902	814.2362	824.4811	834.3326	843.3825	853.0730
553	863.2227	873.3370	883.9190	894.1964	905.0354	915.6458	925.5143	935.5819	946.0717	958.1504
554	970.1641	980.7023	991.4090	1002.5972	1013.0683	1023.8260	1034.1828	1045.4078	1055.5705	1065.1313
555	1074.7256	1084.5015	1094.9011	1105.3257	1115.6684	1125.9361	1135.8103	1145.8937	1155.8006	1165.9598
556	1176.3747	1185.7747	1194.6712	1203.1840	1212.3431	1221.8241	1230.8611	1240.4939	1249.4249	1258.0587
557	1266.5920	1274.9895	1283.3578	1291.6174	1300.0890	1309.1662	1317.8964	1327.2517	1336.1714	1344.8137
558	1353.9296	1363.1658	1372.5829	1381.8689	1390.4231	1399.5174	1408.1943	1417.1297	1426.1603	1435.5679
559	1445.5703	1455.4080	1465.7449	1476.0897	1486.6503	1497.9989	1508.7198	1519.5299	1529.9494	1541.0982
560	1551.5366	1561.5716	1571.5935	1581.0408	1590.5694	1599.7154	1608.8396	1618.7102	1629.5304	1640.9052
561	1652.6014	1662.4874	1672.1066	1681.7179	1691.5882	1702.4424	1713.6668	1725.2074	1736.7075	1748.2556
562	1759.6517	1769.9875	1779.9537	1789.8945	1800.2471	1811.0390	1821.6473	1832.5496	1843.5952	1854.2527
563	1864.9316	1875.4584	1886.0357	1896.5763	1907.2468	1918.0794	1929.0804	1940.2610	1951.2053	1962.7922
564	1974.0174	1984.9065	1996.0409	2007.7176	2019.5455	2031.1786	2042.5793	2054.0180	2065.0629	2076.4751
565	2088.2070	2099.4832	2111.6207	2123.4566	2136.3715	2150.0555	2162.5087	2175.2005	2188.0519	2201.4593
566	2214.4337	2226.2718	2238.9579	2250.6683	2261.7636	2273.9196	2286.2176	2299.6763	2311.8728	2323.7881

567	2335.7662	2346.4939	2357.9569	2369.4027	2381.3545	2392.7164	2404.7733	2416.7673	2427.5736	2438.2149
568	2449.5574	2462.1016	2475.0517	2486.5902	2498.8181	2510.4085	2521.7314	2532.9900	2544.2436	2556.7298
569	2570.4315	2582.5064	2594.9273	2607.0982	2618.6261	2629.7310	2639.8920	2649.5949	2658.9772	2668.6755
570	2678.3446	2688.4946	2699.0616	2709.6262	2720.0364	2731.2864	2743.9066	2757.5596	2769.3359	2780.9749
571	2792.5503	2803.4022	2814.3364	2825.6105	2836.6378	2847.7508	2859.5158	2871.8799	2884.8897	2898.4910
572	2912.1546	2925.7347	2941.0760	2955.4860	2970.8810	2985.0715	2998.4869	3013.7137	3027.5905	3042.9647
573	3057.2181	3070.7066	3085.0151	3098.2078	3111.2389	3123.7756	3135.5516	3147.6113	3159.8555	3172.5809
574	3186.3348	3198.3169	3209.6578	3220.8816	3232.0573	3243.6422	3255.2522	3268.3272	3281.3559	3293.9194
575	3306.3361	3318.6156	3331.2436	3343.9702	3356.6809	3369.3365	3381.5197	3394.4514	3407.3045	3420.3847
576	3433.6229	3446.3871	3459.6887	3472.2783	3485.2481	3498.0608	3509.7221	3521.6174	3533.0304	3544.7372
577	3557.0516	3569.1308	3582.4881	3594.9702	3607.5615	3620.5310	3633.3014	3646.4326	3659.1651	3672.1237
578	3684.9774	3697.8909	3711.0807	3723.8866	3737.0997	3751.4801	3765.2053	3778.8009	3791.7050	3804.5577
579	3817.7908	3831.0611	3844.5730	3857.4955	3869.7049	3881.0331	3892.3818	3903.9894	3915.5299	3927.0674
580	3938.8515	3950.8681	3963.2174	3976.0062	3988.7963	4001.8525	4014.7085	4027.9198	4041.1067	4054.3702
581	4068.0302	4081.5489	4095.5156	4109.2727	4122.7712	4136.8731	4151.1669	4166.6414	4181.1722	4195.1661
582	4209.2768	4223.4037	4237.9636	4252.2851	4267.7632	4284.3221	4300.5345	4317.0576	4333.6504	4353.8806
583	4413.1523	4428.4041	4443.2032	4457.5027	4471.2992	4503.1585	4516.6842	4530.0140	4543.2260	4556.4786
584	4583.3057	4597.4629	4611.4345	4625.2628	4639.0172	4663.2648	4676.3116	4689.2394	4702.0797	4714.9034
585	4737.1490	4750.5000	4763.8929	4777.3418	4790.8845	4818.4824	4832.9609	4847.5511	4862.2594	4877.0845
586	4906.4713	4921.8236	4937.2210	4952.6710	4968.1741	4995.1908	5011.2207	5027.4086	5043.7573	5060.2672
587	5088.9328	5104.7087	5120.5624	5136.5020	5152.5394	5179.8643	5194.0649	5208.2958	5222.5588	5236.8568
588	5260.7312	5274.5277	5288.3457	5302.1960	5316.0855	5340.1739	5353.8523	5367.5630	5381.3059	5395.0812
589	5417.7321	5430.9289	5444.1324	5457.3427	5470.5598	5491.3307	5503.2197	5515.0993	5526.9695	5538.8303
590	5560.2810	5572.3162	5584.4065	5596.5521	5608.7527	5639.4711	5652.2441	5665.0304	5677.8300	5690.6428
591	5720.1383	5733.1532	5746.2336	5759.3796	5772.5911	5801.7299	5815.4536	5829.1938	5842.9505	5856.7237
592	5888.7154	5903.2820	5917.8371	5932.3808	5946.9130	5982.4646	5997.6163	6012.7618	6027.9012	6043.0343
593	6078.2195	6093.5667	6108.9067	6124.2395	6139.5653	6178.8893	6194.8836	6210.8224	6226.7056	6242.5332
594	6278.5552	6294.0449	6309.5114	6324.9547	6340.3749	6377.9724	6394.0519	6410.0645	6426.0103	6441.8893
595	6476.7803	6492.8171	6508.8491	6524.8765	6540.8990	6576.8758	6592.6003	6608.2854	6623.9313	6639.5378
596	6673.4406	6689.0250	6704.5551	6720.0307	6735.4520	6765.1131	6780.2241	6795.3074	6810.3630	6825.3909
597	6856.9786	6871.9348	6886.8772	6901.8056	6916.7202	6947.2843	6962.6136	6977.9085	6993.1692	7008.3956
598	7035.4702	7051.1082	7066.7487	7082.3916	7098.0371	7127.3900	7143.5653	7159.7535	7175.9547	7192.1689
599	7222.9145	7239.5305	7256.1486	7272.7690	7289.3915	7321.0744	7338.0518	7355.0206	7371.9808	7388.9324
600	7426.2445	7444.1415	7461.9784	7479.7553	7497.4723	7532.4560	7550.3709	7568.2319	7586.0391	7603.7925
601	7638.1363	7656.4776	7674.8288	7693.1900	7711.5611	7748.7773	7767.3616	7785.9165	7804.4420	7822.9383
602	7859.7635	7878.9113	7898.0736	7917.2503	7936.4415	7975.6006	7995.4137	8015.1473	8034.8014	8054.3761
603	8097.9813	8117.7206	8137.4965	8157.3088	8177.1576	8225.4635	8245.4516	8265.4103	8285.3397	8305.2398
604	8359.6750	8379.9863	8400.2320	8420.4122	8440.5269	8483.0517	8503.2117	8523.3499	8543.4663	8563.5607
605	8606.8768	8627.0948	8647.2324	8667.2897	8687.2668	8729.2958	8749.6759	8769.9336	8790.0689	8810.0818
606	8850.2160	8870.3357	8890.3689	8910.3157	8930.1761	8971.2910	8991.6464	9011.9872	9032.3133	9052.6247
607	9091.9302	9112.1269	9132.2944	9152.4327	9172.5420	9179.8849				

Table A- 2: Atoka Lake Capacity by 0.1 ft Increments.

Atoka Lake Capacity Table Volume in Acre-Feet by 0.1 ft Elevation Increments 2021 Survey Oklahoma Water Resources Board										
Elevation in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
526			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
527	0.01	0.01	0.02	0.03	0.04	0.05	0.06	0.08	0.10	0.13
528	0.16	0.19	0.22	0.26	0.31	0.36	0.41	0.47	0.54	0.61
529	0.68	0.77	0.86	0.96	1.07	1.18	1.31	1.45	1.61	1.78
530	1.96	2.15	2.37	2.59	2.84	3.09	3.37	3.66	3.96	4.29
531	4.63	4.98	5.36	5.75	6.15	6.58	7.03	7.49	7.98	8.48
532	9.01	9.55	10.12	10.71	11.32	11.95	12.61	13.28	13.99	14.71
533	15.46	16.24	17.04	17.87	18.73	19.61	20.52	21.45	22.42	23.41
534	24.44	25.49	26.57	27.69	28.83	30.01	31.22	32.47	33.75	35.06
535	36.40	37.79	39.20	40.66	42.15	43.69	45.26	46.88	48.54	50.24
536	51.99	53.78	55.62	57.52	59.46	61.46	63.51	65.62	67.79	70.02
537	72.33	74.70	77.15	79.68	82.30	85.01	87.81	90.69	93.67	96.76
538	99.94	103.22	106.61	110.12	113.73	117.45	121.29	125.24	129.31	133.51
539	137.84	142.30	146.92	151.70	156.65	161.77	167.08	172.57	178.24	184.09
540	190.11	196.30	202.65	209.18	215.87	222.73	229.76	236.98	244.38	251.98
541	259.77	267.76	275.96	284.39	293.07	301.99	311.18	320.64	330.39	340.44
542	350.81	361.52	372.58	384.01	395.82	408.02	420.64	433.65	447.04	460.82
543	474.99	489.58	504.59	520.03	535.92	552.24	569.01	586.24	603.93	622.06
544	640.64	659.67	679.17	699.13	719.56	740.47	761.88	783.80	806.25	829.22
545	852.75	876.85	901.56	926.88	952.79	979.27	1006.31	1033.94	1062.17	1090.96
546	1120.33	1150.28	1180.83	1211.99	1243.78	1276.21	1309.30	1343.02	1377.35	1412.30
547	1447.94	1484.26	1521.28	1559.02	1597.47	1636.64	1676.59	1717.39	1759.08	1801.67
548	1845.16	1889.52	1934.72	1980.78	2027.69	2075.47	2124.22	2173.93	2224.56	2276.05
549	2328.34	2381.50	2435.51	2490.31	2545.80	2601.95	2658.74	2716.19	2774.32	2833.14
550	2892.67	2952.91	3013.88	3075.56	3137.95	3201.07	3264.92	3329.51	3394.85	3460.95
551	3527.84	3595.52	3664.00	3733.32	3803.45	3874.39	3946.15	4018.75	4092.18	4166.43
552	4241.59	4317.67	4394.71	4472.70	4551.63	4631.55	4712.46	4794.40	4877.36	4961.25
553	5046.07	5131.88	5218.71	5306.57	5395.47	5485.45	5576.48	5668.54	5761.60	5855.67
554	5950.91	6047.34	6144.88	6243.49	6343.19	6443.98	6545.83	6648.73	6752.71	6857.76
555	6963.80	7070.79	7178.75	7287.71	7397.72	7508.77	7620.86	7733.95	7848.03	7963.11
556	8079.21	8196.32	8314.42	8433.45	8553.34	8674.12	8795.83	8918.46	9042.02	9166.52
557	9291.89	9418.13	9545.21	9673.13	9801.88	9931.46	10061.92	10193.27	10325.53	10458.70
558	10592.75	10727.70	10863.55	11000.34	11138.07	11276.69	11416.18	11556.56	11697.83	11839.99
559	11983.08	12127.14	12272.19	12418.24	12565.33	12713.47	12862.70	13013.04	13164.45	13316.92
560	13470.49	13625.12	13780.78	13937.44	14095.07	14253.66	14413.18	14573.60	14734.98	14897.39
561	15060.92	15225.62	15391.37	15558.10	15725.79	15894.46	16064.16	16234.96	16406.91	16580.01
562	16754.26	16929.68	17106.16	17283.66	17462.15	17641.66	17822.22	18003.85	18186.56	18370.36
563	18555.26	18741.21	18928.23	19116.30	19305.43	19495.63	19686.89	19879.25	20072.71	20267.28
564	20462.99	20659.84	20857.78	21056.83	21257.01	21458.39	21660.92	21864.61	22069.43	22275.39
565	22482.47	22690.70	22900.09	23110.63	23322.38	23535.41	23749.74	23965.37	24182.25	24400.42
566	24619.91	24840.70	25062.74	25286.01	25510.49	25736.11	25962.91	26190.91	26420.23	26650.80

567	26882.61	27115.59	27349.70	27584.92	27821.28	28058.83	28297.54	28537.41	28778.50	29020.72
568	29264.01	29508.38	29753.96	30000.86	30248.94	30498.24	30748.72	31000.33	31253.05	31506.91
569	31761.98	32018.34	32275.99	32534.86	32794.96	33056.26	33318.67	33582.15	33846.63	34112.06
570	34378.45	34645.80	34914.14	35183.51	35453.95	35725.44	35998.00	36271.76	36546.87	36823.21
571	37100.74	37379.41	37659.21	37940.09	38222.09	38505.21	38789.42	39074.78	39361.35	39649.19
572	39938.38	40228.92	40520.81	40814.16	41108.98	41405.34	41703.15	42002.33	42302.93	42605.00
573	42908.58	43213.60	43519.99	43827.77	44136.93	44447.41	44759.16	45072.12	45386.28	45701.65
574	46018.27	46336.23	46655.47	46975.87	47297.39	47620.04	47943.83	48268.77	48594.95	48922.43
575	49251.21	49581.22	49912.46	50244.96	50578.72	50913.77	51250.07	51587.61	51926.41	52266.49
576	52607.89	52950.58	53294.58	53639.89	53986.49	54334.38	54683.57	55033.96	55385.54	55738.27
577	56092.16	56447.23	56803.53	57161.12	57520.00	57880.13	58241.53	58604.22	58968.22	59333.50
578	59700.07	60067.92	60437.06	60807.51	61179.26	61552.32	61926.76	62302.59	62679.79	63058.32
579	63438.14	63819.26	64201.70	64585.47	64970.58	65356.98	65744.52	66133.19	66523.00	66913.98
580	67306.11	67699.41	68093.90	68489.60	68886.56	69284.82	69684.35	70085.18	70487.31	70890.76
581	71295.53	71701.66	72109.13	72517.98	72928.22	73339.83	73752.82	74167.22	74583.10	75000.49
582	75419.32	75839.54	76261.17	76684.24	77108.75	77534.76	77962.36	78391.61	78822.49	79255.03
583	79689.39	80129.86	80571.94	81015.52	81460.56	81907.00	82356.62	82807.61	83259.94	83713.61
584	84168.59	84626.21	85085.24	85545.69	86007.53	86470.74	86936.41	87403.39	87871.67	88341.23
585	88812.08	89285.13	89759.51	90235.23	90712.29	91190.71	91671.83	92154.40	92638.43	93123.92
586	93610.88	94100.76	94592.18	95085.13	95579.63	96075.67	96574.39	97074.71	97576.64	98080.20
587	98585.40	99093.50	99603.19	100114.45	100627.30	101141.75	101659.03	102177.73	102697.84	103219.39
588	103742.36	104267.74	104794.50	105322.65	105852.17	106383.09	106916.42	107451.12	107987.19	108524.64
589	109063.46	109604.57	110147.00	110690.76	111235.83	111782.23	112330.76	112880.49	113431.41	113983.51
590	114536.80	115092.23	115648.86	116206.69	116765.74	117326.01	117889.32	118453.90	119019.76	119586.91
591	120155.33	120726.70	121299.36	121873.33	122448.61	123025.21	123604.70	124185.55	124767.79	125351.39
592	125936.38	126524.52	127114.12	127705.18	128297.69	128891.65	129489.14	130088.14	130688.66	131290.70
593	131894.24	132501.30	133109.89	133720.01	134331.67	134944.86	135561.95	136180.63	136800.92	137422.80
594	138046.26	138673.34	139301.97	139932.15	140563.87	141197.14	141834.13	142472.73	143112.94	143754.74
595	144398.14	145045.01	145693.49	146343.58	146995.26	147648.55	148305.45	148963.92	149623.97	150285.58
596	150948.75	151615.32	152283.44	152953.12	153624.35	154297.12	154972.88	155650.15	156328.92	157009.21
597	157690.99	158375.94	159062.39	159750.33	160439.76	161130.69	161824.65	162520.15	163217.17	163915.73
598	164615.81	165318.57	166022.90	166728.79	167436.25	168145.27	168857.20	169570.75	170285.92	171002.70
599	171721.11	172442.57	173165.69	173890.47	174616.92	175345.03	176076.29	176809.24	177543.90	178280.25
600	179018.29	179760.02	180503.54	181248.85	181995.93	182744.79	183497.14	184251.28	185007.21	185764.93
601	186524.42	187287.32	188052.05	188818.61	189587.01	190357.25	191131.20	191907.01	192684.67	193464.19
602	194245.56	195030.58	195817.51	196606.36	197397.13	198189.81	198986.38	199784.93	200585.46	201387.95
603	202192.41	203001.23	203812.01	204624.77	205439.51	206256.24	207077.78	207901.33	208726.87	209554.41
604	210383.94	211218.89	212055.87	212894.88	213735.91	214578.96	215426.26	216275.57	217126.90	217980.24
605	218835.59	219695.27	220556.97	221420.68	222286.41	223154.14	224026.04	224899.99	225775.97	226653.98
606	227533.98	228418.00	229304.02	230192.06	231082.09	231974.12	232870.23	233768.38	234668.56	235570.77
607	236475.02	237383.20	238293.41	239205.63	240119.86	241036.11				

Table A- 3: Dave Boyer (Walters) Lake Area by 0.1 ft Increments.

Dave Boyer (Walters) Area Table Area in Acres by 0.1 ft Elevation Increments 2021 Survey Oklahoma Water Resources Board										
Elevation in Feet	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
994									0.0000	0.0000
995	0.0000	0.0003	0.0012	0.0025	0.0041	0.0061	0.0084	0.0110	0.0138	0.0170
996	0.0206	0.0252	0.0301	0.0356	0.0421	0.0503	0.0590	0.0690	0.0801	0.0911
997	0.1044	0.1217	0.1453	0.1821	0.2656	0.4659	0.6890	1.1543	1.5875	2.3682
998	3.6512	4.5547	6.5218	7.8541	10.3701	12.4450	14.1905	17.3547	19.8758	22.2532
999	24.8820	26.6402	28.8535	30.6299	32.7105	35.4511	37.2442	39.3748	40.6814	42.0139
1000	43.2966	44.2954	45.2711	46.2811	47.3941	48.5786	49.4121	50.5880	51.6747	52.7725
1001	54.1746	55.5275	56.5546	57.4748	58.3987	59.4617	60.4418	61.3305	62.1188	62.8879
1002	63.7727	64.5322	65.3285	66.1774	67.1239	68.4000	69.0566	69.7328	70.4565	71.2706
1003	72.6094	73.4048	74.2130	75.0806	76.0354	77.4541	78.1419	78.8304	79.5746	80.4263
1004	81.7593	82.5498	83.3373	84.1633	85.1284	86.7342	87.6873	88.6594	89.7237	91.0372
1005	92.9001	93.8862	94.8700	95.8756	97.0094	98.3852	99.2936	100.1712	101.0680	102.1612
1006	103.5618	104.4944	105.4375	106.4188	107.5255	109.0040	109.8783	110.7500	111.6783	112.7626
1007	114.4796	115.3425	116.1562	116.9588	117.7885	118.7461	119.4328	120.1074	120.7993	121.5765
1008	122.9918	123.6926	124.4070	125.1414	125.9496	127.0635	127.7832	128.5244	129.3216	130.2379
1009	131.6424	132.4019	133.1691	134.0419	134.9928	136.0884	136.7549	137.4153	138.0843	138.7847
1010	139.5712	140.1069	140.6510	141.2024	141.7648	142.5388	143.0666	143.5970	144.1337	144.6868
1011	145.5397	146.1024	146.6677	147.2390	147.8169	148.8155	149.4114	150.0169	150.6320	151.2566
1012	152.3941	153.0561	153.7251	154.4010	155.0840	156.3866	157.0987	157.8139	158.5323	159.2538
1013	160.7707	161.5619	162.3656	163.1817	164.0104	165.9262	166.8753	167.8310	168.7933	169.7622
1014	172.1446	173.1506	174.1609	175.1755	176.1944	178.5257	179.6067	180.6993	181.8034	182.9190
1015	184.8244	185.8542	186.8858	187.9191	188.9541	190.8875	191.8622	192.8350	193.8061	194.7753
1016	196.1641	197.1117	198.0590	199.0061	199.9531	201.9738	203.0163	204.0606	205.1067	206.1546
1017	208.4093	209.6212	210.8373	212.0575	213.2820	215.5815	216.7969	218.0158	219.2383	220.4642
1018	222.2255	223.3377	224.4527	225.5705	226.6911	227.0638				

Table A- 4: Dave Boyer (Walters) Lake Capacity by 0.1 ft Increments.

Dave Boyer (Walters) Capacity Table Volume in Acre-Feet by 0.1 ft Elevation Increments 2021 Survey Oklahoma Water Resources Board										
Elevation in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
994									0.0000	0.0000
995	0.0000	0.0000	0.0000	0.0001	0.0003	0.0006	0.0011	0.0018	0.0028	0.0040
996	0.0056	0.0074	0.0097	0.0125	0.0158	0.0196	0.0243	0.0297	0.0361	0.0436
997	0.0521	0.0619	0.0731	0.0865	0.1028	0.1252	0.1610	0.2186	0.3102	0.4457
998	0.6453	0.9394	1.3490	1.9024	2.6197	3.5662	4.7006	6.0321	7.5785	9.4430
999	11.5655	13.9220	16.4984	19.2644	22.2393	25.4190	28.8352	32.4701	36.3091	40.3124
1000	44.4496	48.7187	53.0984	57.5768	62.1545	66.8388	71.6365	76.5360	81.5394	86.6526
1001	91.8779	97.2212	102.7065	108.3118	114.0131	119.8068	125.6969	131.6922	137.7808	143.9532
1002	150.2040	156.5360	162.9515	169.4448	176.0203	182.6848	189.4909	196.3637	203.3031	210.3125
1003	217.3984	224.6148	231.9155	239.2963	246.7608	254.3164	262.0236	269.8034	277.6520	285.5721
1004	293.5720	301.7077	309.9233	318.2177	326.5928	335.0570	343.6778	352.3987	361.2159	370.1350
1005	379.1725	388.4102	397.7496	407.1874	416.7249	426.3690	436.1590	446.0430	456.0162	466.0783
1006	476.2389	486.5455	496.9483	507.4450	518.0379	528.7353	539.5858	550.5296	561.5612	572.6828
1007	583.9047	595.2988	606.7900	618.3657	630.0217	641.7595	653.5983	665.5073	677.4844	689.5297
1008	701.6478	713.9091	726.2431	738.6482	751.1255	763.6797	776.3487	789.0910	801.9062	814.7983
1009	827.7758	840.8983	854.1005	867.3788	880.7392	894.1907	907.7643	921.4063	935.1148	948.8897
1010	962.7330	976.6608	990.6447	1004.6826	1018.7753	1032.9236	1047.1507	1061.4309	1075.7641	1090.1505
1011	1104.5915	1119.1152	1133.6972	1148.3357	1163.0310	1177.7837	1192.6359	1207.5472	1222.5185	1237.5509
1012	1252.6452	1267.8518	1283.1242	1298.4632	1313.8695	1329.3437	1344.9469	1360.6211	1376.3667	1392.1840
1013	1408.0733	1424.1113	1440.2278	1456.4241	1472.7014	1489.0609	1505.6063	1522.2463	1538.9816	1555.8127
1014	1572.7405	1589.9048	1607.1695	1624.5351	1642.0019	1659.5703	1677.3693	1695.2758	1713.2910	1731.4161
1015	1749.6521	1768.0831	1786.6170	1805.2540	1823.9943	1842.8379	1861.8778	1881.0153	1900.2502	1919.5823
1016	1939.0114	1958.5804	1978.2442	1998.0027	2017.8560	2037.8039	2057.9493	2078.1988	2098.5526	2119.0109
1017	2139.5740	2160.3545	2181.2560	2202.2789	2223.4236	2244.6905	2266.1880	2287.8069	2309.5475	2331.4102
1018	2353.3953	2375.5623	2397.8405	2420.2300	2442.7311	2465.3442				

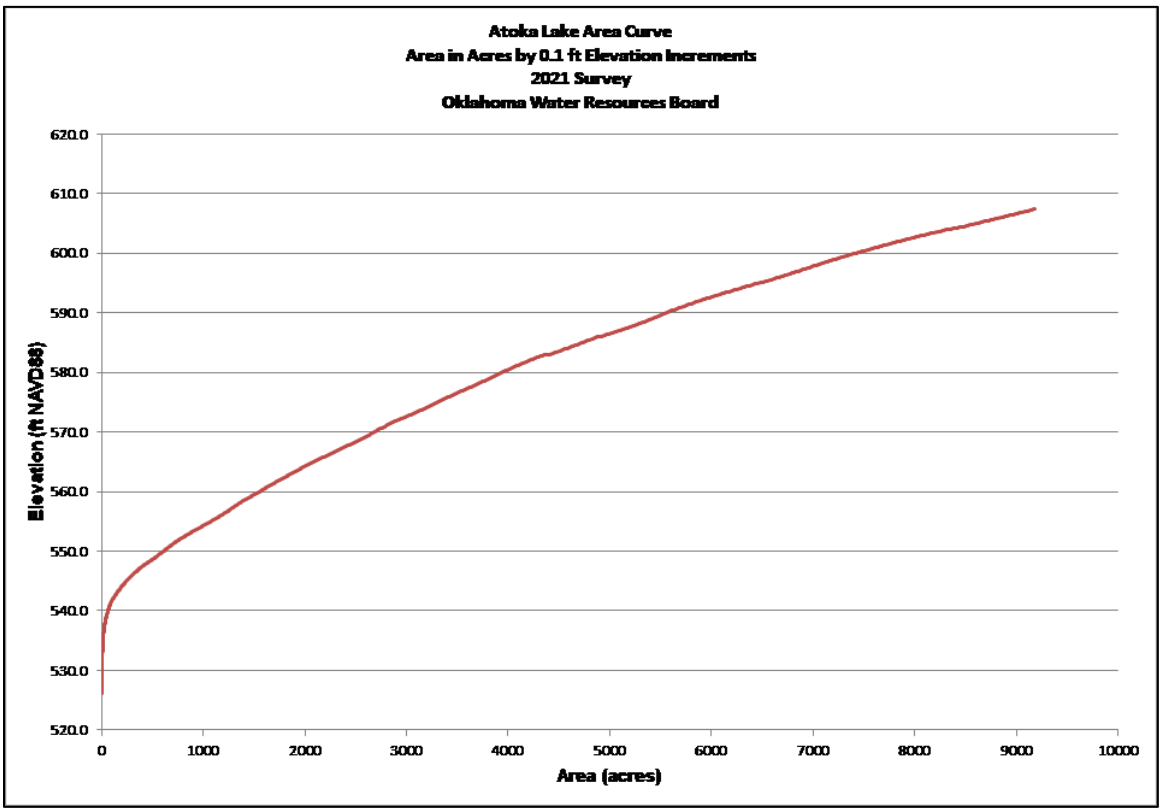


Figure A- 1: Area Curve for Atoka Lake.

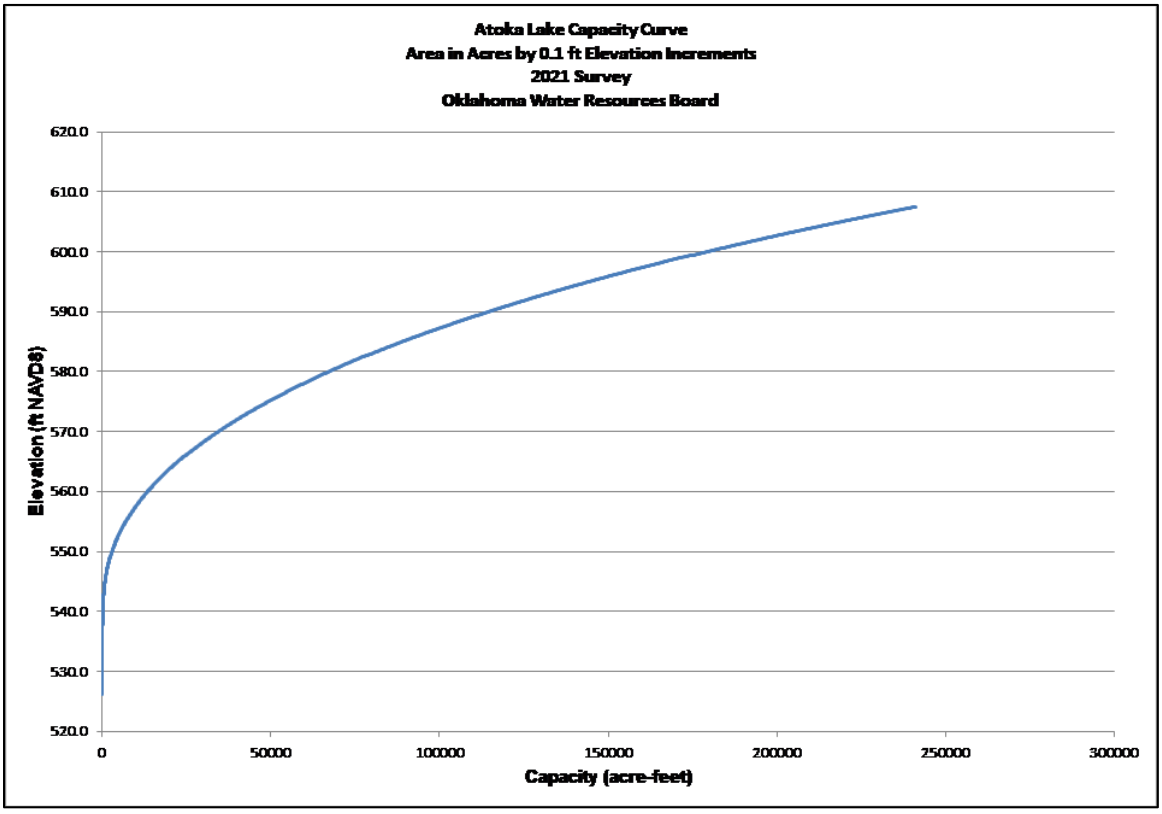


Figure A- 2: Cumulative Capacity Curve for Atoka Lake.

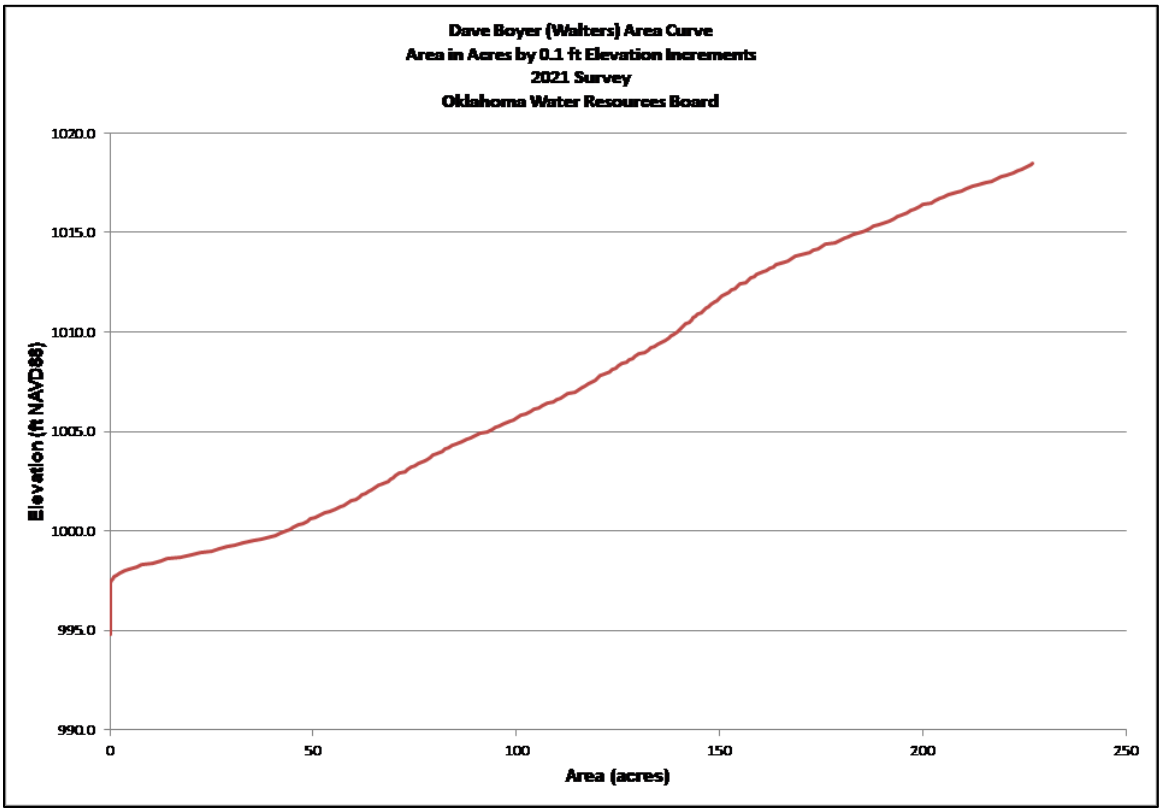


Figure A- 3: Area Curve for Dave Boyer (Walters) Lake.

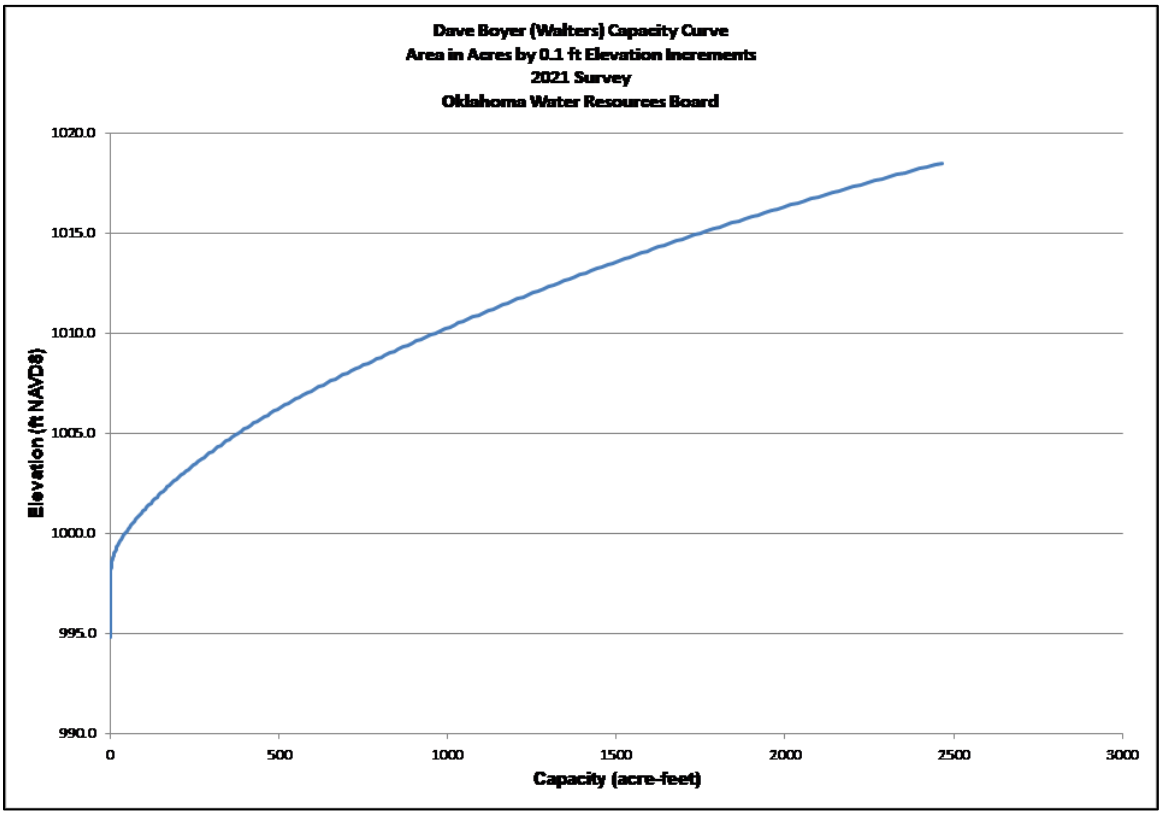


Figure A- 4: Cumulative Capacity Curve for Dave Boyer (Walters) Lake.

APPENDIX B: Atoka Lake Maps

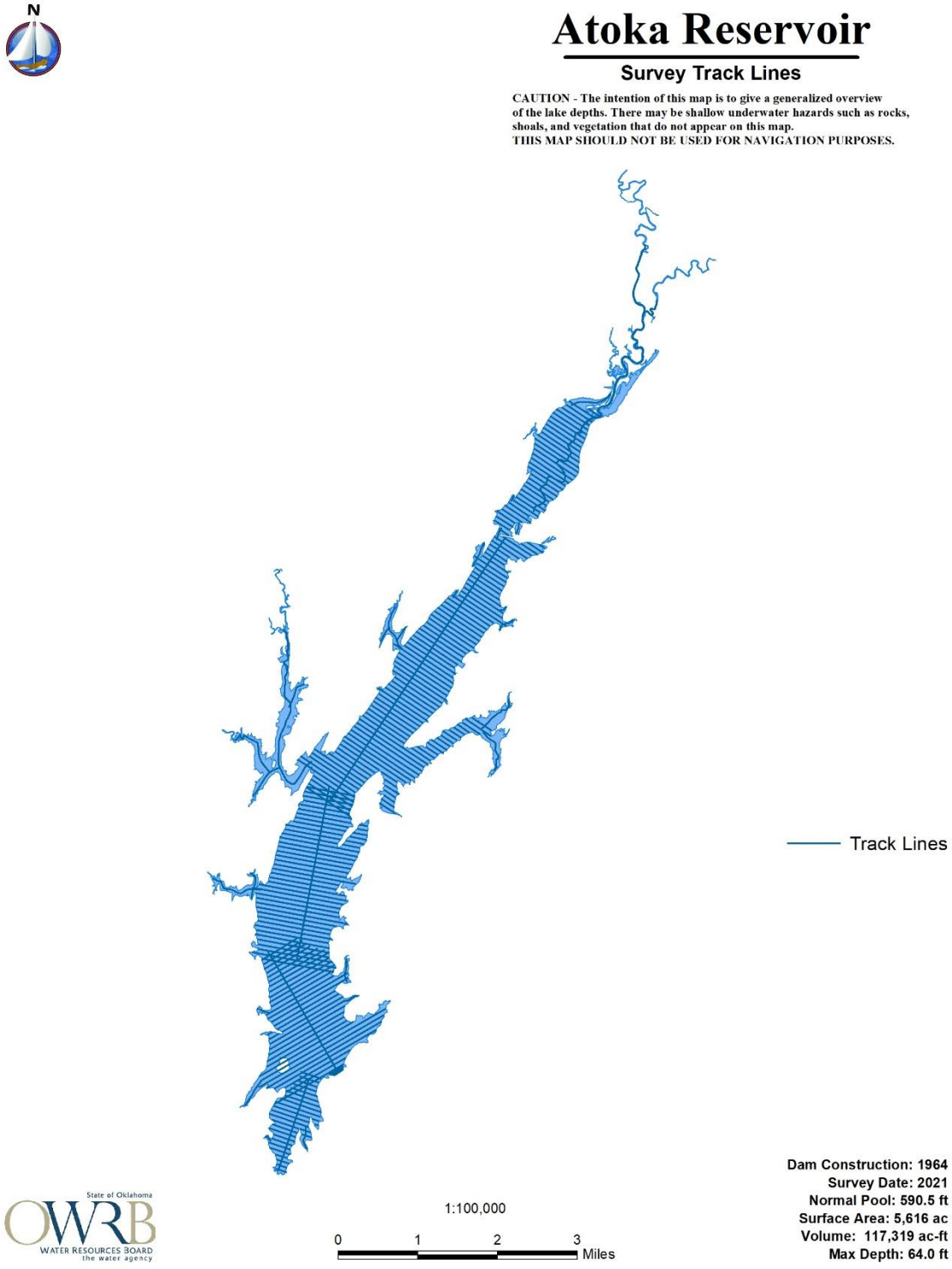


Figure B- 1: Atoka Lake Survey Track Lines.

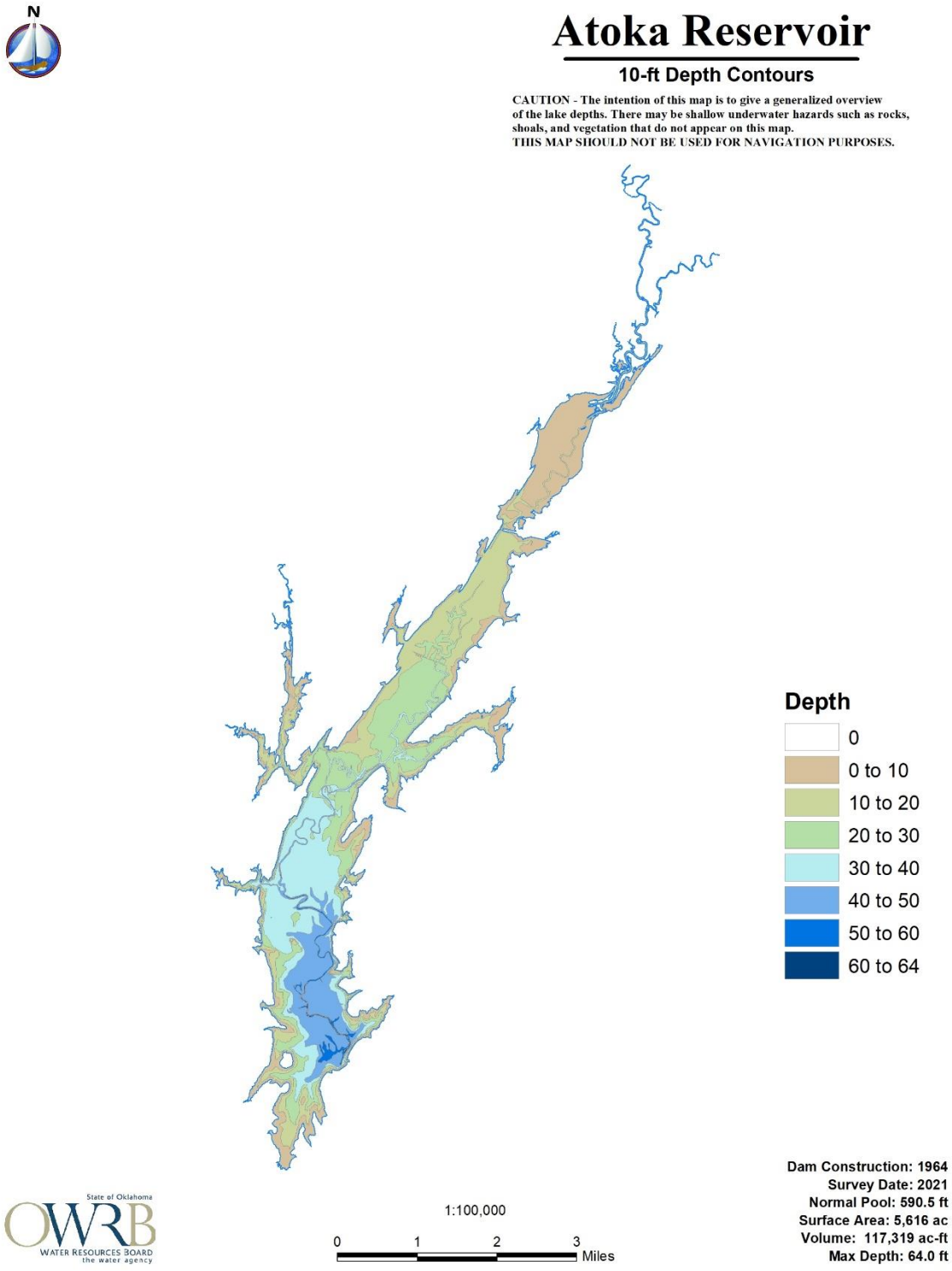


Figure B- 2: Atoka Lake Contour Map with 10 ft Intervals.

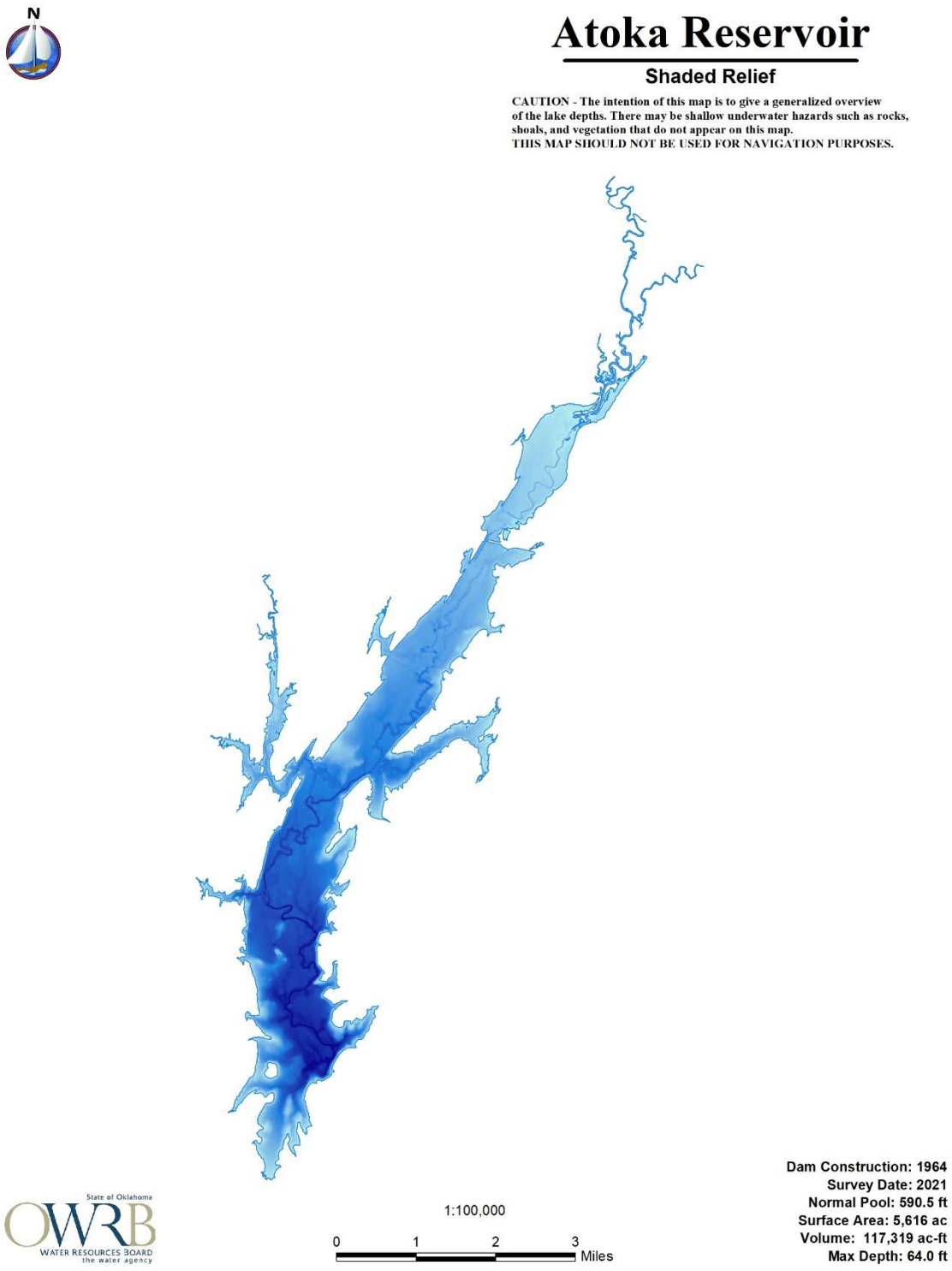


Figure B- 3: Atoka Lake Shaded Relief Map.

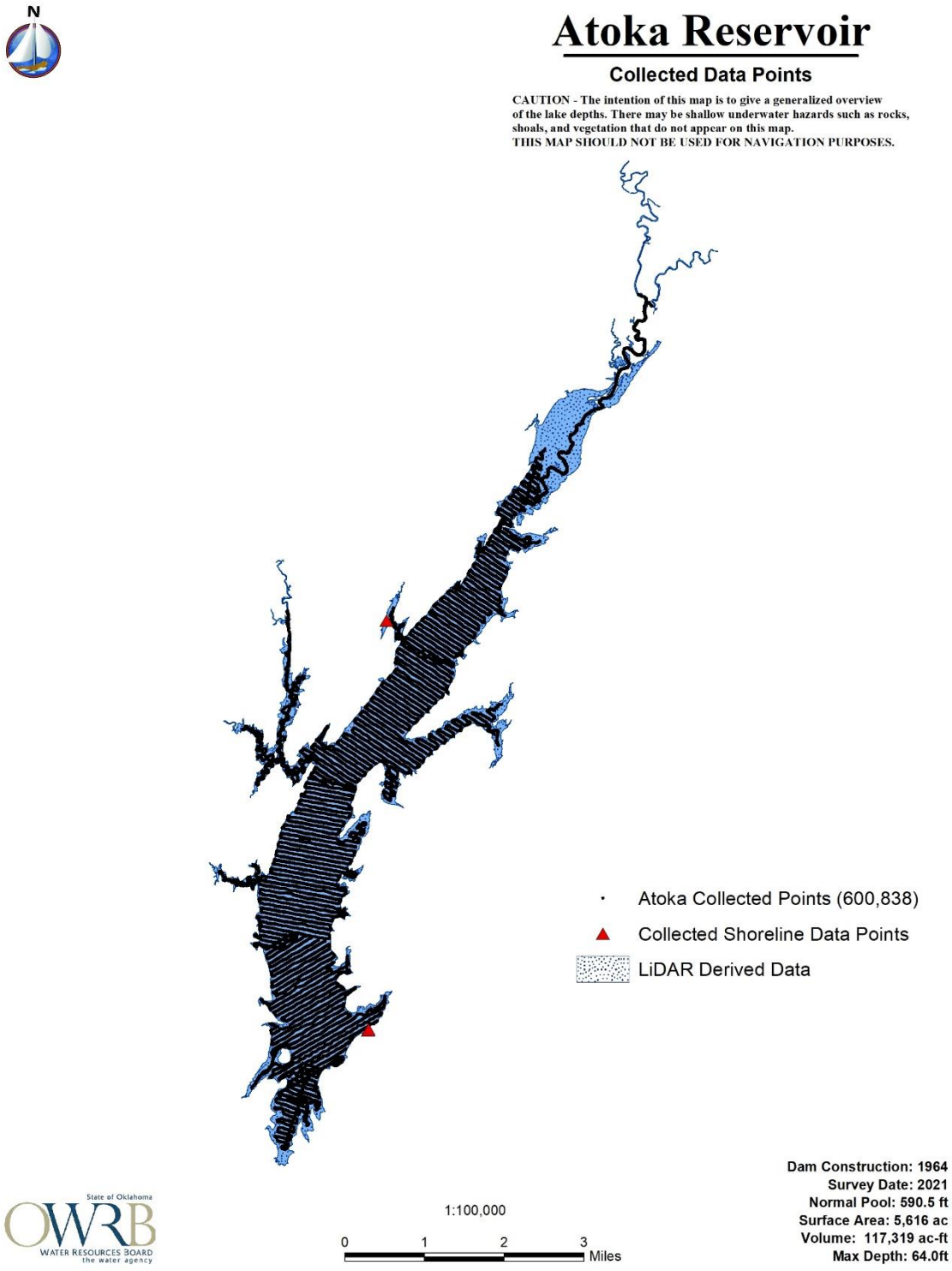


Figure B- 4: Atoka Lake Collected Data Points Map.

APPENDIX C: Dave Boyer (Walters) Lake Maps

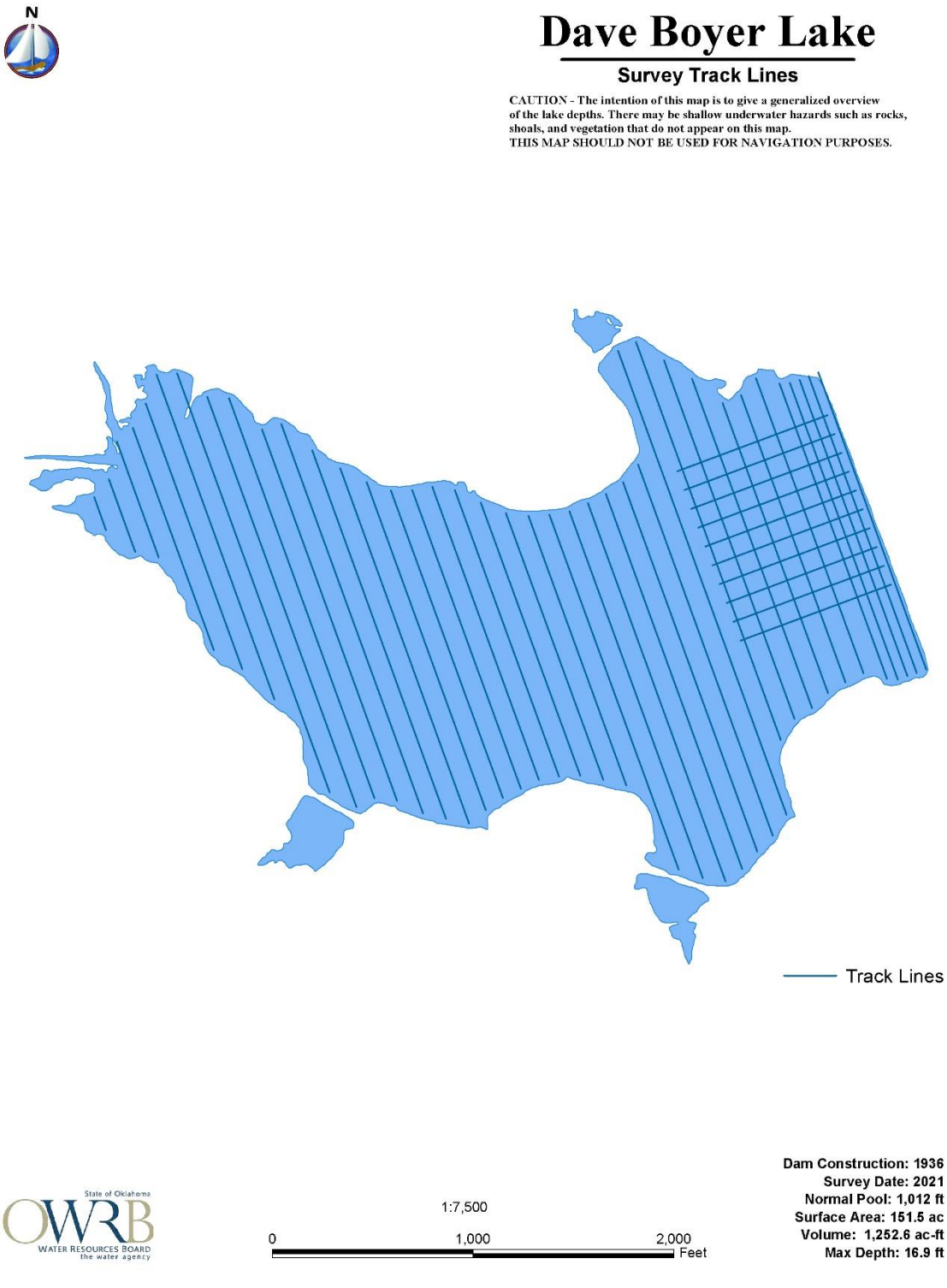


Figure C- 1: Dave Boyer (Walters) Lake Survey Track Lines Map.

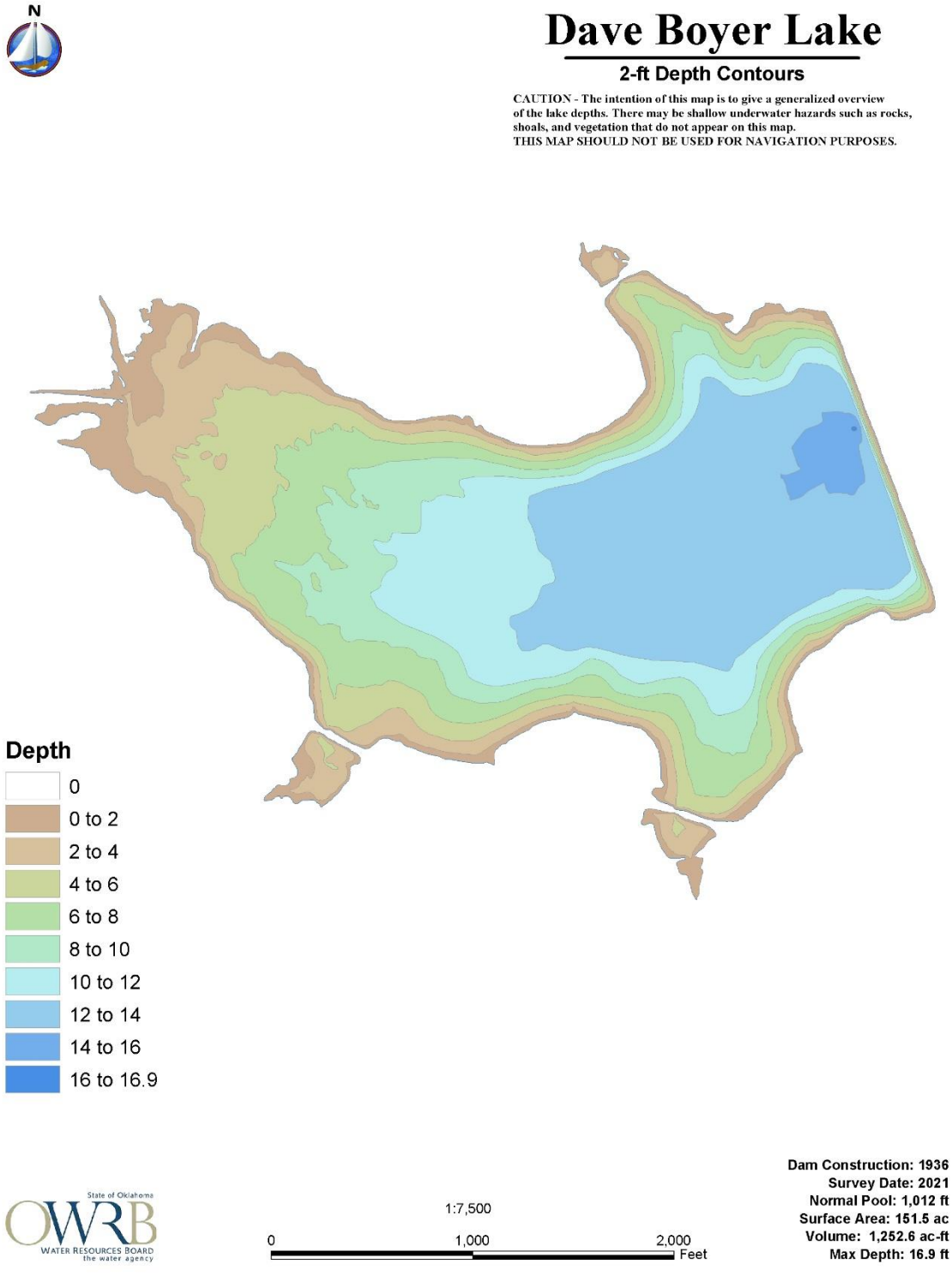


Figure C- 2: Dave Boyer (Walters) Lake Contour Map with 2 ft Intervals.

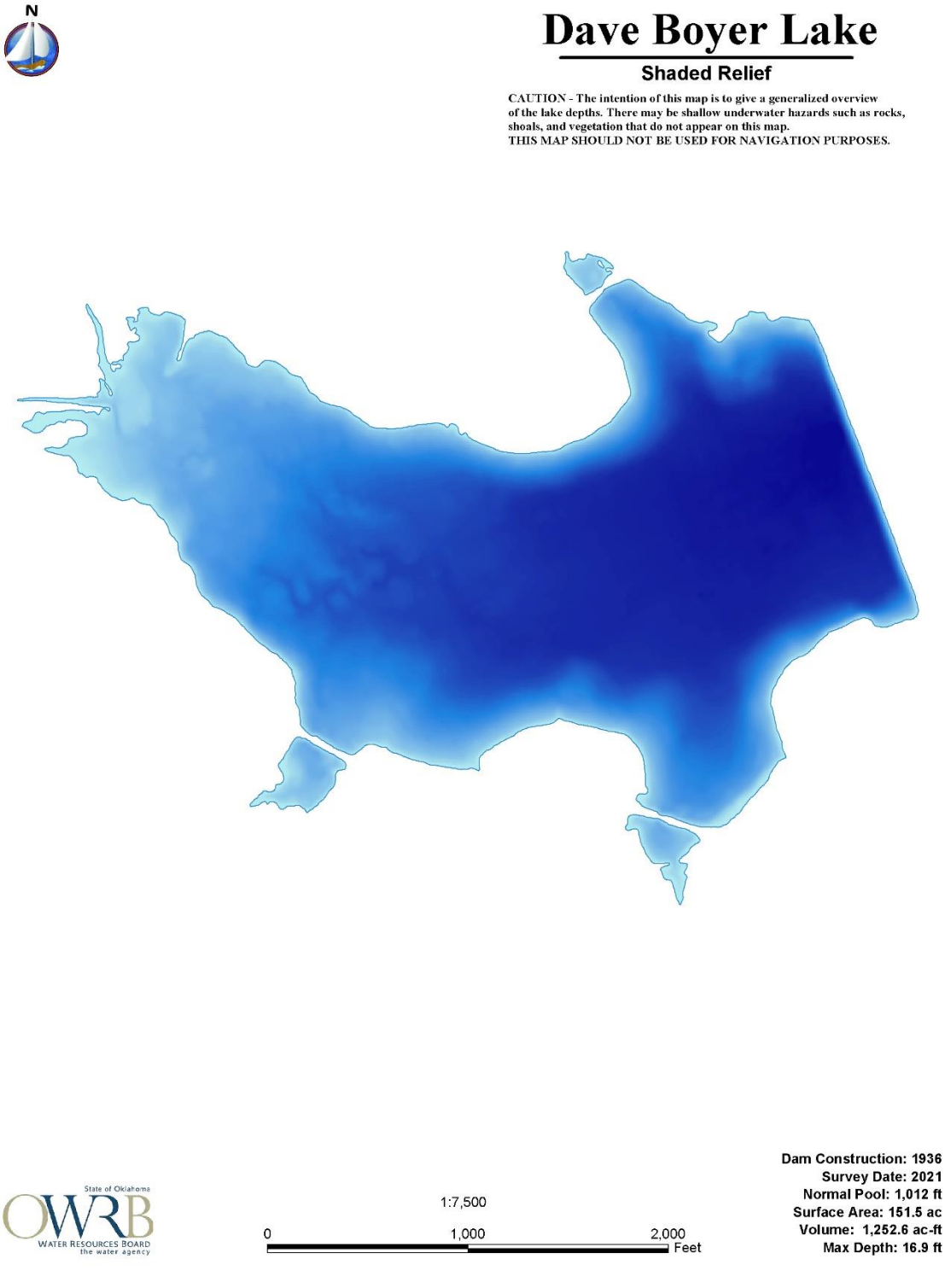


Figure C- 3: Dave Boyer (Walters) Lake Shaded Relief Map.

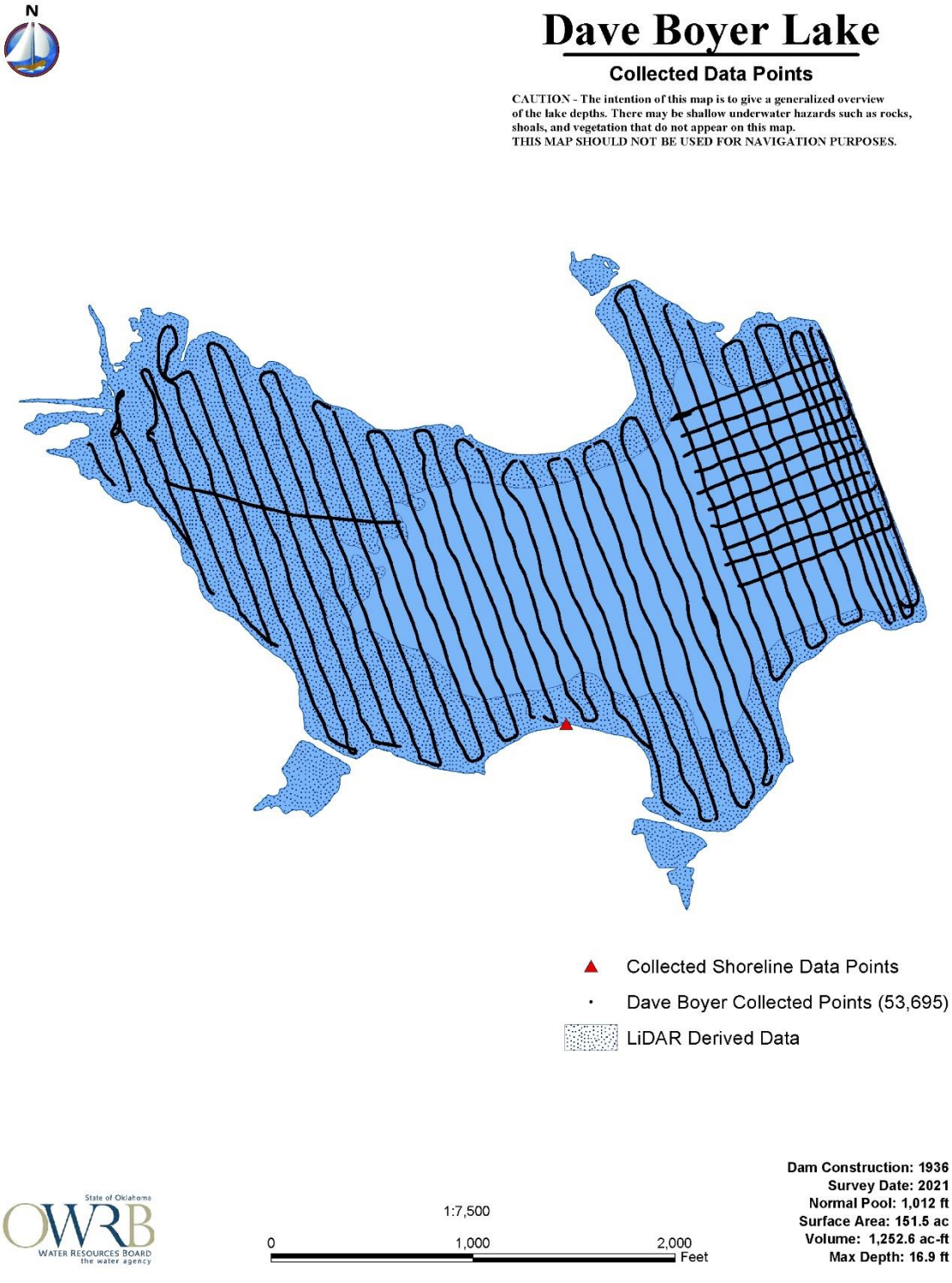


Figure C- 4: Dave Boyer (Walters) Lake Collected Data Points Map.

APPENDIX D: Additional Survey Data Tables.

Table D- 1: Survey offsets used during the calibration and editing process.

Survey Offsets			
Lake	Atoka Lake (04/19/21)	Atoka Lake (05/06/21)	Dave Boyer (Walters) Lake (01/26/21)
Static Draft (ft)	1.1	1.1	0.8
Average SOS (m/s)	1469.7	1469.7	1438.5
Echosounder SOS (m/s)	1469.7	1469.7	1438.4
Latency Offset (sec)	0.25	0.25	0.25

Table D- 2: Cross check statistic results showing accuracy of the survey data sets.

Cross Check Statistics		
Lake	Atoka Lake	Dave Boyer (Walters)
# of Intersections	332	101
Arithmetic Mean (ft)	0.121	0.058
Standard Deviation (ft)	0.387	0.053