Abstract

The increasing use and importance of lakes for water supply to communities enhance the need for an accurate methodology to determine lake bathymetry and storage capacity. A global positioning receiver and a fathometer were used to collect position data and water depth in February 2008 at Lake William C. Bowen and Municipal Reservoir #1, Spartanburg County, South Carolina. All collected data were imported into a geographic information system database. A bathymetric surface model, contour map, and stage-area and -volume relations were created from the geographic information database.

Introduction

Bathymetric surveys can be used to create maps of the lakebed and to compute water-level (stage) area and volume tables so that water-supply managers can regulate the use of these valuable resources more reliably. Knowledge of reservoir volume is particularly important for the management of water-supply reservoirs during periods of drought or high-water use in the area supplied by the lake. These data also can be used to document areas of sediment deposition and changes in storage volume, and when compared to historical surveys, to estimate sediment-deposition rates. As part of an investigation to assess water-quality conditions affecting taste and odor compounds in Lake William C. Bowen and Municipal Reservoir #1 (fig. 1), the U.S. Geological Survey (USGS), in cooperation with the Spartanburg Water System (SWS), collected bathymetric and shoreline data from these two reservoirs.

Purpose and Scope

The purpose of this report is to provide the SWS personnel with bathymetric, stage-area, and stage-volume data that can be used to more effectively plan and manage the water resources available for Spartanburg County. The USGS conducted a bathymetric survey of Lake William C. Bowen and Municipal Reservoir #1 during February 2008. The survey was conducted using a global positioning system (GPS) receiver and data logger interfaced to a fathometer. The field data were differentially corrected and then transferred to groundwater modeling system (GMS) software and a geographic information system (GIS), which were used to map contour lines and determine stage-area and stage-volume curves. Since no previous bathymetric surveys exist for the study area, the results of this investigation will be a valuable tool by which to compare future surveys to predict sedimentation rates, sediment distribution, and the longevity of the two reservoirs.

Description of Study Area

Lake William C. Bowen is a manmade lake created in 1960 by the impoundment of the South Pacolet River (fig. 1). At full pool elevation of 815 feet (ft) relative to National Geodetic Vertical Datum of 1929 (NGVD 29), Lake William C. Bowen is an impoundment of 1,530 acres with 33.0 miles (mi) of shoreline (J. Cann, Spartanburg Water System, oral commun., June 2007).

Water flows from Lake William C. Bowen downstream into a second impoundment, Municipal Reservoir #1, which was created in 1926 (fig. 1). At full pool elevation of 777 ft (NGVD 29), the lake surface of Municipal Reservoir #1 covers 272 acres with 13.1 mi of shoreline (J. Cann, Spartanburg Water System, oral commun., June 2007). Recreational activities are allowed on Lake William C. Bowen but are restricted on Municipal Reservoir #1. Outflow from Municipal Reservoir #1 is about 2,600 ft upstream from the confluence of the South and North Pacolet Rivers.

The South Pacolet River watershed, which encompasses these lakes, drains 91.4 square miles (mi^2) and is located in Spartanburg and eastern Greenville Counties, South Carolina (SC; fig. 1). The entire watershed for Lake William C. Bowen and Municipal Reservoir #1 lies within the Piedmont Physiographic Province. Flow in the South Pacolet River is measured at USGS gaging station 02154790 (South Pacolet River near Campobello, SC). This gaging station is located 1.1 mi upstream from Lake William C. Bowen and monitors a drainage area of 55.4 mi^2. The average annual flow measured at station 02154790 was 96.6 cubic feet per second (ft^3/s) for the period 1989–2007 (U.S. Geological Survey, 2008).

Data-Collection Methodology

Bathymetric data were collected by interfacing a 12-channel GPS receiver and data logger (Trimble™ Pro XL with TDC1 data logger running Asset Surveyor™ firmware) to a dual-frequency fathometer. The fathometer was set to the 200-kilohertz (kHz) frequency because this signal produces greater detail and resolution relative to the lower frequency of 50 kHz, which produces a wider signal and generally is used to transverse depths greater than 400 ft. The horizontal coordinates and times in which the signals were received were recorded by the data logger. The depth soundings from the fathometer also were time-tagged and recorded to the data logger. These data were processed by using GPS mapping software (Trimble™ Pathfinder Office 3.00). The horizontal coordinate information was differentially corrected from a dataset from another GPS receiver known as a base station. In this investigation, the closest base station used was a continuously operating reference station (CORS) operated and maintained by the National Geodetic Survey (NGS). Data processed this way, by using a GPS, can be expected to achieve accuracies in the horizontal of 1 meter (m) (multiply by 3.281 to convert to feet) or less. Any horizontal coordinates that were found to be out of this tolerance were deleted from the dataset. The depth soundings were assigned a horizontal coordinate by interpolating the time reading from both sets of measurements.

The travel time of the sound pulse from a fathometer is measured either electronically in a depth digitizing device or mechanically (graphically) on an analog recording-type instrument. The accuracy of the absolute time measurement generally varies with depth because of signal attenuation, noise, and the ability of the measurement circuitry to correlate the outgoing and incoming pulses. In addition, the acoustic reflectivity characteristics of the target (size, shape, orientation, material, and so on) can significantly affect the returning pulse. Variations in return-signal strength and sharpness will affect the depth measurement accuracy. The irregularity of the reflected pulse causes uncertainty in the overall time-measurement process. There is no practical calibration process for minimizing this error. The accuracy of echo-sounding time measurement usually is rated by manufacturers at plus or minus (+/–) 0.1 ft plus 0.1 to 0.5 percent of the depth (U.S. Army Corps of Engineers, 2002). Depth readings were verified periodically by using a steel tape measured to tenths of a foot.

Data were collected during February 2008. Transects were selected by plotting them on a 1:24,000-scale USGS topographic map and using visual recognition and line-of-sight landmarks (fig. 2). In this figure, while the transects are shown as lines they are actually comprised as data points.

Shoreline data were digitized from March 4, 2006, aerial photography, and water-surface elevation data were monitored from USGS streamgaging station 02154950 in Lake William C. Bowen and from a staff gage in Municipal Reservoir #1 that was manually read in the morning and in the afternoon. Table 1 summarizes the data-collection dates, range of surface-water elevations, and number of data points collected in Lake William C. Bowen and Municipal Reservoir #1.

Data Analysis

The differentially corrected data were exported to a spreadsheet. The lake and reservoir levels that coincide with the date and time that the bathymetry data were collected also were exported into the spreadsheet. The depths were then subtracted from the recorded water level so that all depths for the data-collection period were based on a common datum. For the purposes of this report, all vertical data were referenced to NGVD 29.

A 2-ft contour interval map was produced for Lake William C. Bowen and Municipal Reservoir #1 using three-dimensional surface-mapping software (Environmental Modeling Systems, Inc.; fig. 3). The point data collected in the bathymetric surveys were interpolated using a geostatistical technique called natural neighbor interpolation (Sibson, 1981). Natural neighbor interpolation is based on the Thiessen polygon network of the scatter point set. Stage-volume and stage-area curves also were generated from this software (figs. 4–7; tables 2, 3). The upper-most water-surface elevations of 815.12 ft and 776.09 ft, for Lake Bowen and Municipal Reservoir #1, respectively, were the stages when the aerial photography was taken on March 6, 2006.

Two historical maps of the lake and reservoir area that were constructed prior to impoundment were obtained from the National Archives and Records Administration. However, both maps, dated 1907 and 1934, respectively, were at a scale of 1:125,000 and a contour interval of 100 ft and were not detailed enough to be useable. Therefore, no comparisons were made to document areas of sediment deposition or estimate rates of sediment deposition.

Summary

A bathymetric survey was conducted on Lake William C. Bowen and Municipal Reservoir #1, Spartanburg County, South Carolina, in February 2008. The survey was performed by using a dual-frequency fathometer to collect water depths and a mapping-grade GPS receiver mounted above the fathometer to collect horizontal-position data. The accuracy of the vertical measurement obtained by echo sounding usually is rated by manufacturers at +/- 0.1 ft plus 0.1 to 0.5 percent of the depth. The horizontal coordinates had an accuracy of 1 m (multiply by 3.281 to convert to feet) or less. The results of the survey included area and volume curves and a bathymetric-contour map.

References Cited

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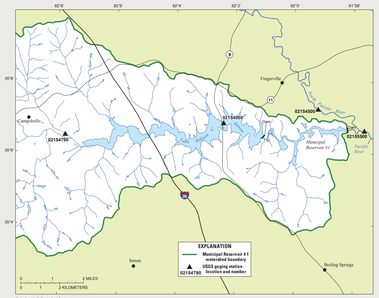

Figure 1. Lake William C. Bowen and Municipal Reservoir #1 in Spartanburg County, Spartanburg, South Carolina.

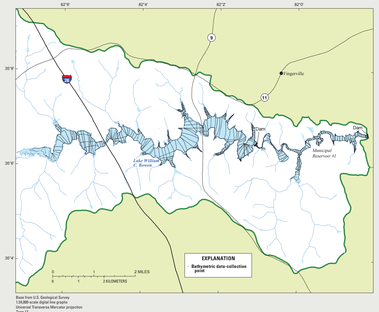

Figure 2. Bathymetric data-collection points used to generate contours for Lake William C. Bowen and Municipal Reservoir #1 in Spartanburg County, Spartanburg, South Carolina.

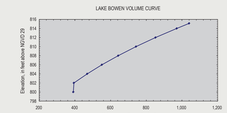

Figure 4. Stage-volume curve for Lake William C. Bowen, Spartanburg County, South Carolina, February 2008.

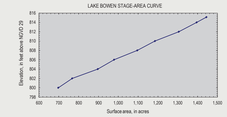

Figure 5. Stage-area curve for Lake William C. Bowen, Spartanburg County, South Carolina, February 2008.

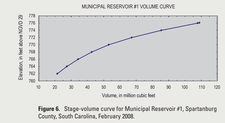

Figure 6. Stage-volume curve for Municipal Reservoir #1, Spartanburg County, South Carolina, February 2008.

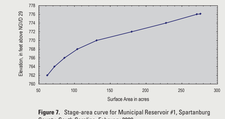

Figure 7. Stage-area curve for Municipal Reservoir #1, Spartanburg County, South Carolina, February 2008.

Table 1. Measurement dates, water-surface elevations, and number of data points collected in Lake William C. Bowen and Municipal Reservoir #1, Spartanburg County, South Carolina.

[SC, South Carolina; ft, feet; elevations are relative to National Geodetic Vertical Datum of 1929; –, data not collected]

Date	Range of water-surface elevations for Lake Bowen, SC (ft)	Number of bathymetric points collected in Lake Bowen, SC	Range of water-surface elevations for Municipal Reservoir #1 (ft)	Number of bathymetric points collected in Municipal Reservoir #1
02-06-2008	815.16 – 815.17	3,287	–	–
02-07-2008	815.15	3,060	–	–
02-08-2008	815.14 – 815.13	2,196	–	–
02-13-2008	815.17 – 815.18	2,754	–	–
02-14-2008	815.14	821	–	–
02-14-2008	–	–	777.88	2,282
02-15-2008	–	–	777.94	1,698
02-28-2008	–	–	777.56	792

Table 2. Stage-area and stage-volume relations for selected elevations of Lake William C. Bowen, Spartanburg County, South Carolina, February 2008.

Elevation (feet, NGVD 29)	Surface area (acres)	Volume (cubic feet x 10^6)
815.12	1,440	1,040
814	1,400	970
812	1,300	852
810	1,180	742
808	1,100	643
806	979	551
804	897	469
802	768	394
800	698	391

Table 3. Stage-area and stage-volume relations for selected elevations of Municipal Reservoir #1, Spartanburg County, South Carolina, February 2008.

Elevation (feet, NGVD 29)	Surface area (acres)	Volume (cubic feet x 10^6)
776.09	276	109
776	271	108
774	228	85.5
772	180	67.3
770	131	53.1
768	104	42.7
766	86	34.1
764	72	27.4
762	62	21.5

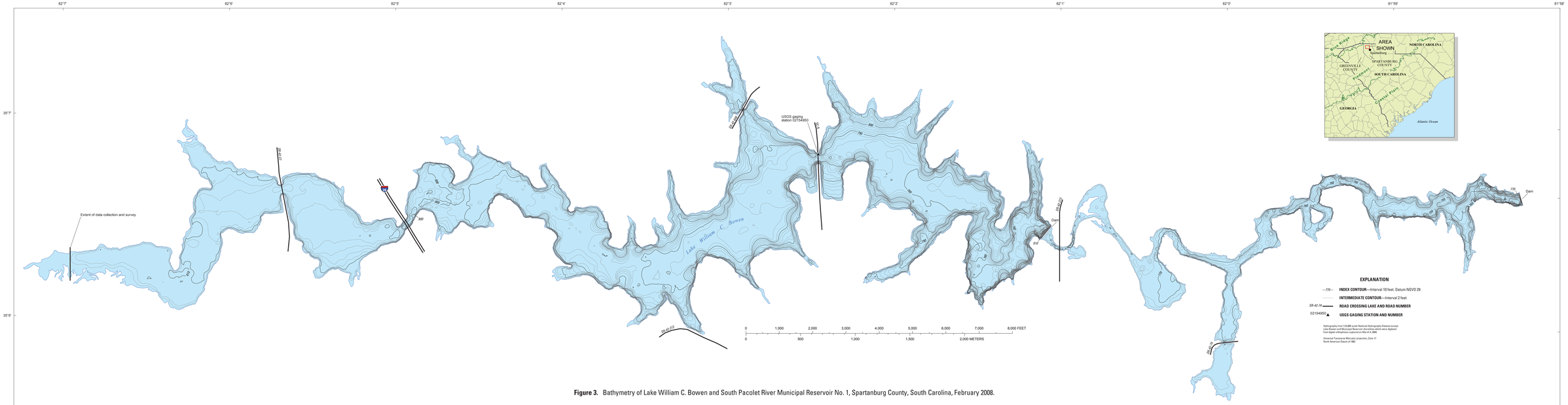

Figure 3. Bathymetry of Lake William C. Bowen and South Pacolet River Municipal Reservoir No. 1, Spartanburg County, South Carolina, February 2008.

Suggested citation: Nagle, D.D., Campbell, B.G., and Lowery, M.A., 2009, Bathymetry of Lake William C. Bowen and Municipal Reservoir #1, Spartanburg County, South Carolina, 2008 (ver. 1.1, March 2015): U.S. Geological Survey Scientific Investigations Map 3076, 1 sheet, http://dx.doi.org/10.3133/sim3076.

Bathymetry of Lake William C. Bowen and Municipal Reservoir #1, Spartanburg County, South Carolina, 2008

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2009