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SCIENTIFIC INVESTIGATIONS MAP 3051
Bathymetric Contours for Silver Lake, Palo Alto County, Iowa—SHEET 2 of 2
Linhart, S.M., and Lund, K.D., 2008, Bathymetric Contour Maps of Lakes Surveyed in Iowa in 2006

Abstract

The U.S. Geological Survey, in cooperation with the Iowa Department of Natural Resources, conducted bathymetric surveys on two lakes in Iowa during 2006 (Little Storm Lake and Silver Lake). The surveys were conducted to provide the Iowa Department of Natural Resources with information for the development of total maximum daily load limits, particularly for estimating sediment load and deposition rates. The bathymetric surveys can provide a baseline for future work on sediment loads and deposition rates for these lakes. Both of the lakes surveyed in 2006 are natural lakes.

For Silver Lake, bathymetric data were collected using boat-mounted, differential global positioning system, echo depth-sounding equipment, and computer software. For Little Storm Lake, because of its shallow nature, bathymetric data were collected using manual depth measurements. Data were processed with commercial hydrographic software and exported into a geographic information system for mapping and calculating area and volume. Lake volumes were estimated to be 7,547,000 cubic feet (173 acre-feet) at Little Storm Lake and 126,724,000 cubic feet (2,910 acre-feet) at Silver Lake. Surface areas were estimated to be 4,110,000 square feet (94 acres) at Little Storm Lake and 27,957,000 square feet (640 acres) at Silver Lake.

Introduction

Bathymetric mapping can provide useful information for water-quality managers to address a variety of issues on Iowa's lakes and reservoirs. The Iowa Water Science Center of the U.S. Geological Survey (USGS) began a lake bathymetric mapping program in June 2001 on Lake Delhi in east central Iowa, which resulted in a published bathymetric map and report (Schnoebelen and others, 2003). The USGS, in cooperation with the Iowa Department of Natural Resources (IDNR), conducted a bathymetric survey of Silver Lake in 2006 to provide the IDNR with information for the development of total maximum daily load limits (TMDLs), particularly for estimating sediment load and deposition rates. The bathymetric contours also can provide a baseline for future work on sediment load and deposition rates for Silver Lake.

Silver Lake is located in northwestern Iowa approximately 2 miles (mi) to the west of the city of Ayrshire in Palo Alto County, in the Silver Lake State Game Management Area, and is used primarily for recreational activities. Silver Lake receives flow from two unnamed creeks at the west end of the lake and by Drainage Ditch 6 from the north. Discharge from Silver Lake is to Silver Creek at the outlet located at southeast end of the Lake.

Methods

Bathymetry data were collected on July 17 and 18, 2006. Bathymetric mapping was accomplished using boat-mounted global positioning system (GPS), echo depth-sounding equipment, and computer software. The GPS allowed for accuracies of about 3.28 feet (ft) (approximately 1 meter) in the horizontal direction. The echo sounder emits sound pulses that are reflected off the lake bottom and received by a transducer. The echo sounder transmitted at a frequency of 200 kilohertz; water depths were determined by the echo sounder based on the speed of sound in water compensated for temperature (Specialty Devices, Inc., 2003). In some areas of the lake, the depth limitations (less than 3.3 ft) of the echo-sounding equipment necessitated determining the depths manually at target points using a measuring device marked in 0.1-ft increments; these data were collected on July 17, 2006. Using the echo sounder, the bathymetry data were collected along planned transect lines spaced approximately 200 ft apart (fig. 1). Individual data-collection locations along a transect line generally were 1 to 4 ft apart; these data were collected on July 17 and 18, 2006. The depth data were later converted to elevations in the post-processing software (Coastal Oceanographics, Inc., 2002), by subtracting the depths at each location from the reference surface elevation of the lake. The reference surface elevation was determined at the beginning and end of each day of bathymetric data collection by measuring from a reference point of known elevation on the outlet structure. The elevation of the reference point was determined using a combination of GPS and standard surveying techniques. The bathymetry data then were filtered in the post-processing software to reduce the density of data points (fig. 1) and entered into geographic information system (GIS) software to produce a three-dimensional surface of the lake-bottom elevations (Environmental Systems Research Institute, Inc., 1999–2006). The three-dimensional surface was contoured, and the contours were adjusted manually to correct for interpretive errors. (See the Silver Lake metadata at *http://water.usgs.gov/lookup/getgislist* for a more detailed explanation of methods used to collect and process the bathymetric data.)

Quality Assurance

A bar check on the echo sounder was performed at the beginning of each day of data collection following established protocols (U.S. Army Corps of Engineers, 2002). This was done to ensure that the echo sounder was calibrated correctly. The bar check involved suspending a 2-ft-diameter flat aluminum plate directly below the echo sounder. The suspension line was marked in 5-ft increments. In deeper lakes, the initial calibration is made at 5 ft; the aluminum plate is then lowered in 5-ft increments, depending on the range of depths expected to be encountered, and adjustments in the speed of sound are made until depth readings and the depth of the aluminum plate agreed to within approximately 0.1 ft. Because of the shallow nature of Silver Lake, the calibration was made at 4 ft by entering the speed of sound in water, and adjusting the offset of the transducer in the computer software. The offset is the draft of the transducer below the lake surface.

A second independent bathymetry data set (control data set) was collected for Silver Lake to estimate the precision and accuracy of the vertical aspects of the survey. The control data set was collected along transects spaced at 500-ft intervals and oriented at an oblique angle to the original planned transect lines. The control data set was used to estimate the precision (repeatability) of the sounding data collected with the echo sounder, to estimate the accuracy of the interpolation in the three-dimensional surface, and to estimate the accuracy of the contours (Wilson and Richards, 2006). The control data elevations were compared to the elevations of the original unfiltered sounding data, the three-dimensional surface, and the contours. For the original unfiltered data points and the contours, data were considered spatially coincident with the control data points if they were within 0.5 ft of each other. For the three-dimensional surface, the paired data set was obtained by extracting elevation values from the three-dimensional surface at the corresponding control data point locations. Within 0.5 ft of each other there were 114 paired original unfiltered data and control points with a calculated Root Mean Square Error (RMSE) of 0.15 ft. At corresponding locations there were 20,939 paired three-dimensional surface elevations and control points with a calculated RMSE of 0.15 ft, and within 0.5 ft of each other there were 72 paired contours and control points with a calculated RMSE of 0.18 ft.

Generally, for depths measured manually, and depending on the lake-bottom type, surface-water conditions, and boat movement, accuracy of these manual measurements can vary between 0.05 ft and 0.5 ft. Measurements collected in lakes with bottoms consisting of softer sediments, as is the case for much of Silver Lake, can be less accurate because of difficulty in determining the sediment/water interface. Under similar conditions, previous comparisons between manually measured depths and depths measured using echo depth-sounding equipment indicate that manually measured depths were over measured by an average of +0.3 ft (Wilson and Richards, 2006). In those comparisons, however, the range of measured depths were much greater (4 to 26 ft) than was present at Silver Lake (0.5 to 5.0 ft). An assumption could be made that, for a given lake-bottom type and surface-water condition, less error might be expected where the range of depths is less, as is the case for Silver Lake.

Bathymetric Contours

The water-surface elevation of Silver Lake was 1,321.3 ft above North American Vertical Datum of 1988 (NAVD88) on July 17 and 18, 2006. Generally, the water depth increases toward the middle of the lake (fig. 2). The deepest part of the lake is located approximately 3,630 ft northwest of the outlet to Silver Creek, and the lowest elevation measured was 1,314.1 ft (7.2 ft deep). The average elevation of the lake bottom, based on the three-dimensional surface, was 1,316.8 ft (4.5 ft deep). The slope of the lake bottom generally is greatest near the shoreline. Data from this survey indicate that the total surface area of Silver Lake, at a water-surface elevation of 1,321.3 ft, is approximately 27,957,000 square feet (ft^2) (640 acres) and the total water volume of Silver Lake is approximately 126,724,000 cubic feet (ft^3) (2,910 acre-ft).

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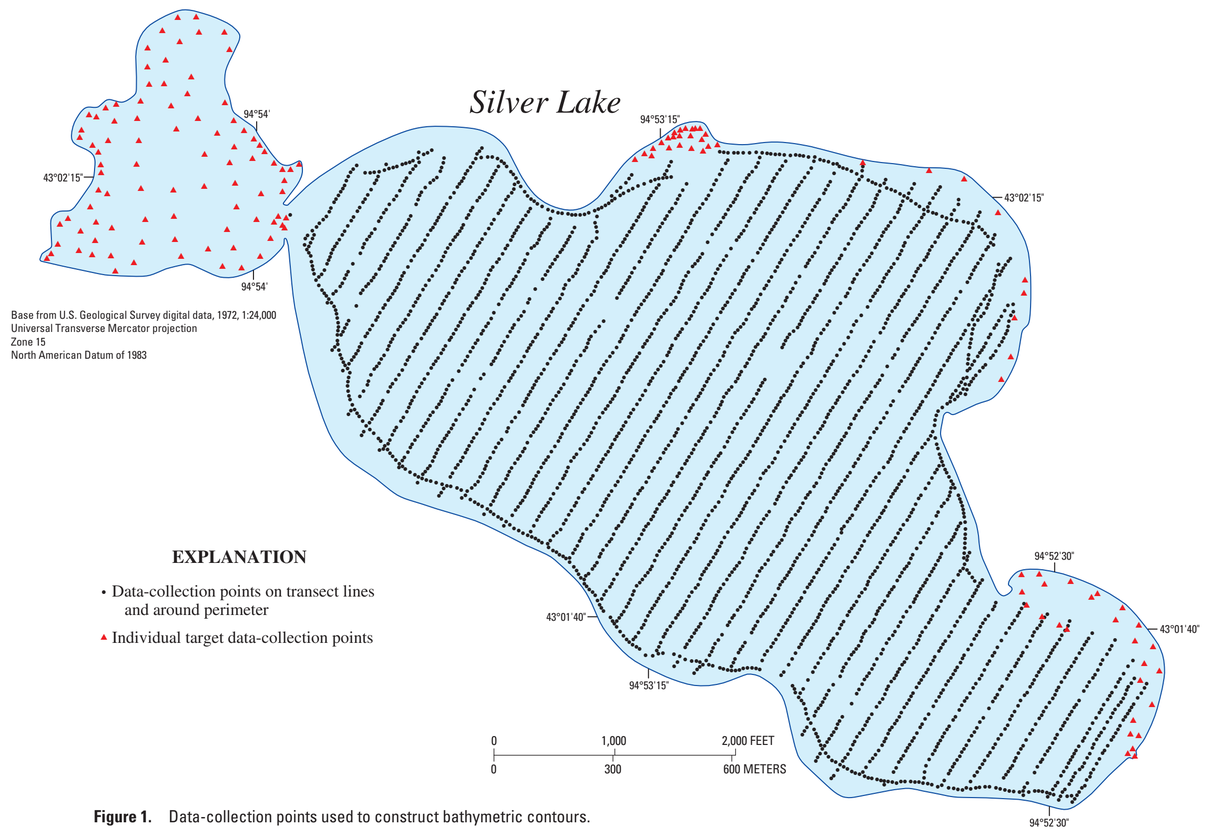


Figure 1. Data-collection points used to construct bathymetric contours.

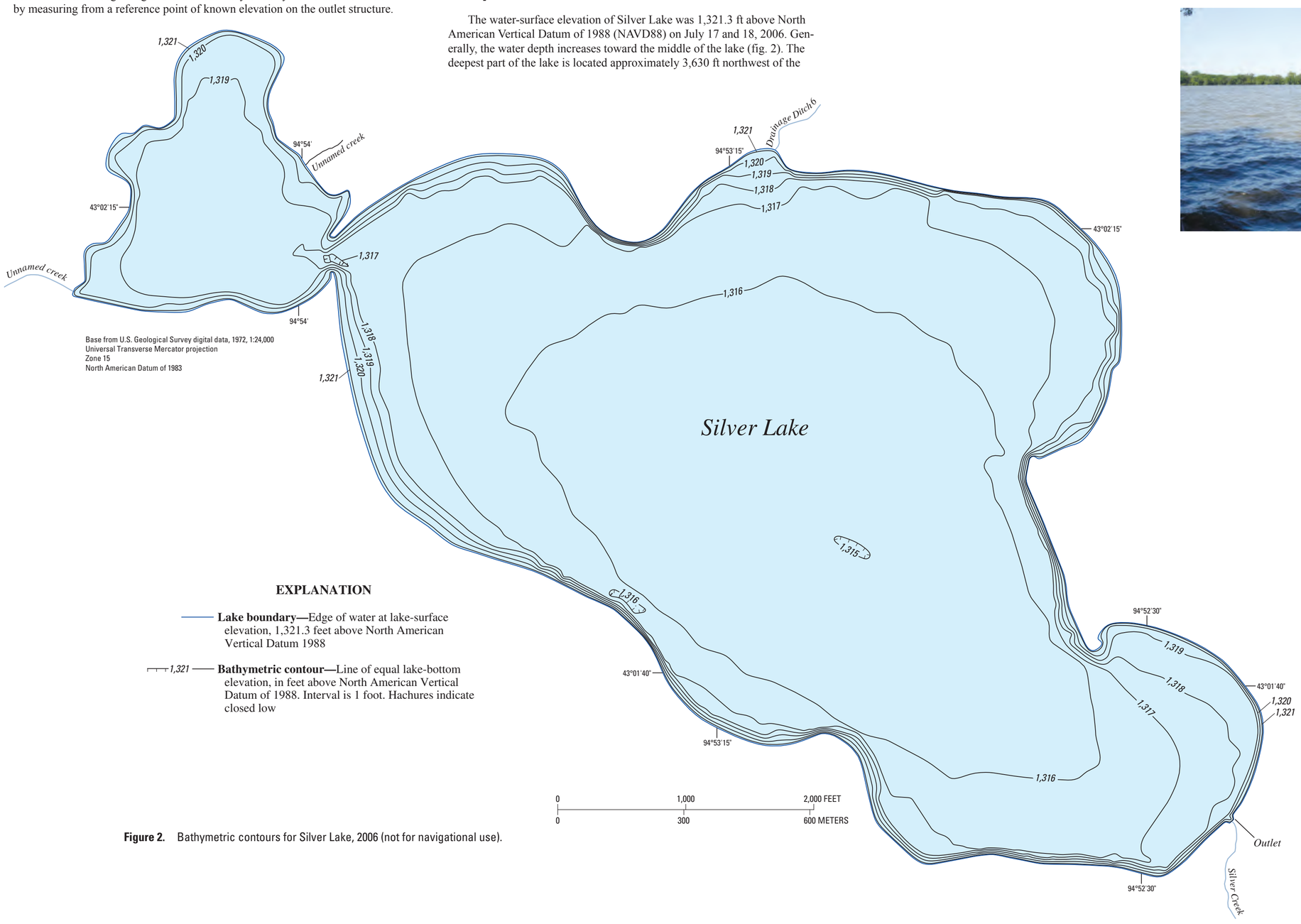
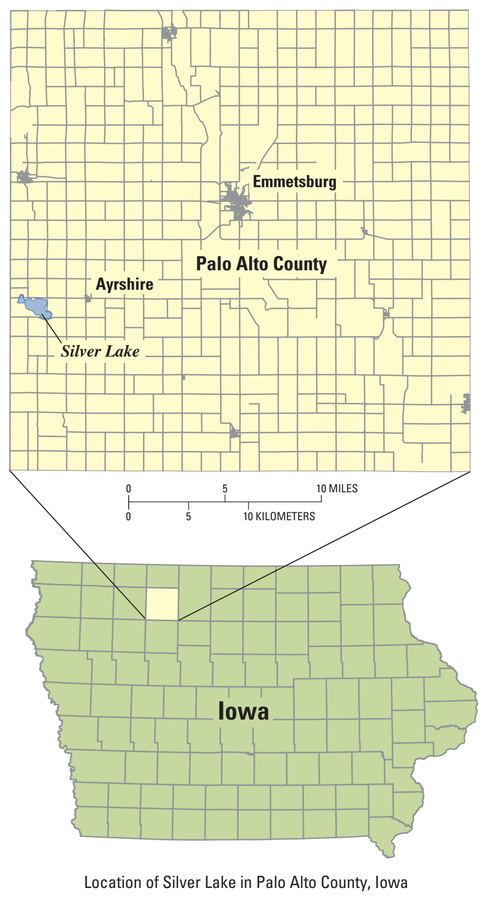


Figure 2. Bathymetric contours for Silver Lake, 2006 (not for navigational use).

Silver Lake in Palo Alto County, Iowa (photograph by Jon Nania, U.S. Geological Survey).



Location of Silver Lake in Palo Alto County, Iowa

Bathymetric Contours for Silver Lake, Palo Alto County, Iowa

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