Bathymetric and Sediment Survey of Sedan Old City Lake, Chautauqua County, Kansas

Kansas Biological Survey

Applied Science and Technology for Reservoir Assessment (ASTRA) Program

Report 2013-06 (May 2013)

KANSAS WATER OFFICE

This work was funded by the Kansas Water Office through the State Water Plan Fund in support of the Reservoir Sustainability Initiative.

SUMMARY

On June 21, 2012, the Kansas Biological Survey (KBS) performed a bathymetric survey of Sedan Old City Lake in Chautauqua County, Kansas. The survey was carried out using acoustic echosounding apparatus linked to a global positioning system. The bathymetric survey was georeferenced to both horizontal and vertical reference datums.

Sediment samples were collected from three sites within the reservoir: One sample was taken near the dam; a second at mid-lake; and a third in the upper end. Sampling was performed on the same day as the bathymetric survey, following completion of the survey. Sediment samples were analyzed for particle size distributions.

Summary Data:

Bathymetric Survey:		
	Dates of survey:	June 21, 2012
Reservoir Statistics:		
	Elevation on survey date	919.6 ft
	Area on survey date:	49.2 acres
	Volume on survey date:	317 acre-feet
	Maximum depth:	19.1 ft
Elevation Benchmark (if applicable)		
	UTM location of elevation benchmark:	746915.4, 4117436.8
	UTM Zone:	14N
	UTM datum:	NAD83
	Elevation of benchmark, from GPS:	924.64 ft.
	Vertical datum, all data:	NAVD88
Sediment Survey:		
	Date of sediment survey:	June 21, 2012

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LAKE HISTORY AND PERTINENT INFORMATION

Figure 1. Sedan Old City Lake in Chautauqua County, Kansas.

The following is from the Kansas Department of Wildlife, Parks, and Tourism:

> *"The lake is located three miles north of Sedan, Kansas on Highway 99, then one half mile east. Construction of the lake was completed in 1935 by the Works Progress Administration, Civilian Conservation Corps, and City of Sedan. Their craftsmanship is still evident in the native limestone inlaid dam, spillway, shelters, retaining walls, and entrances. The lake was constructed for the purposes of flood control, civic water supply, and recreation. Sedan no longer uses the lake as its water supply."*

http://kdwpt.state.ks.us/news/Fishing/Where-to-Fish-in-Kansas/Fishing-Locations-Public-Waters/Region-5/Sedan-Old-City-Lake-north

Chautauqua County, Kansas

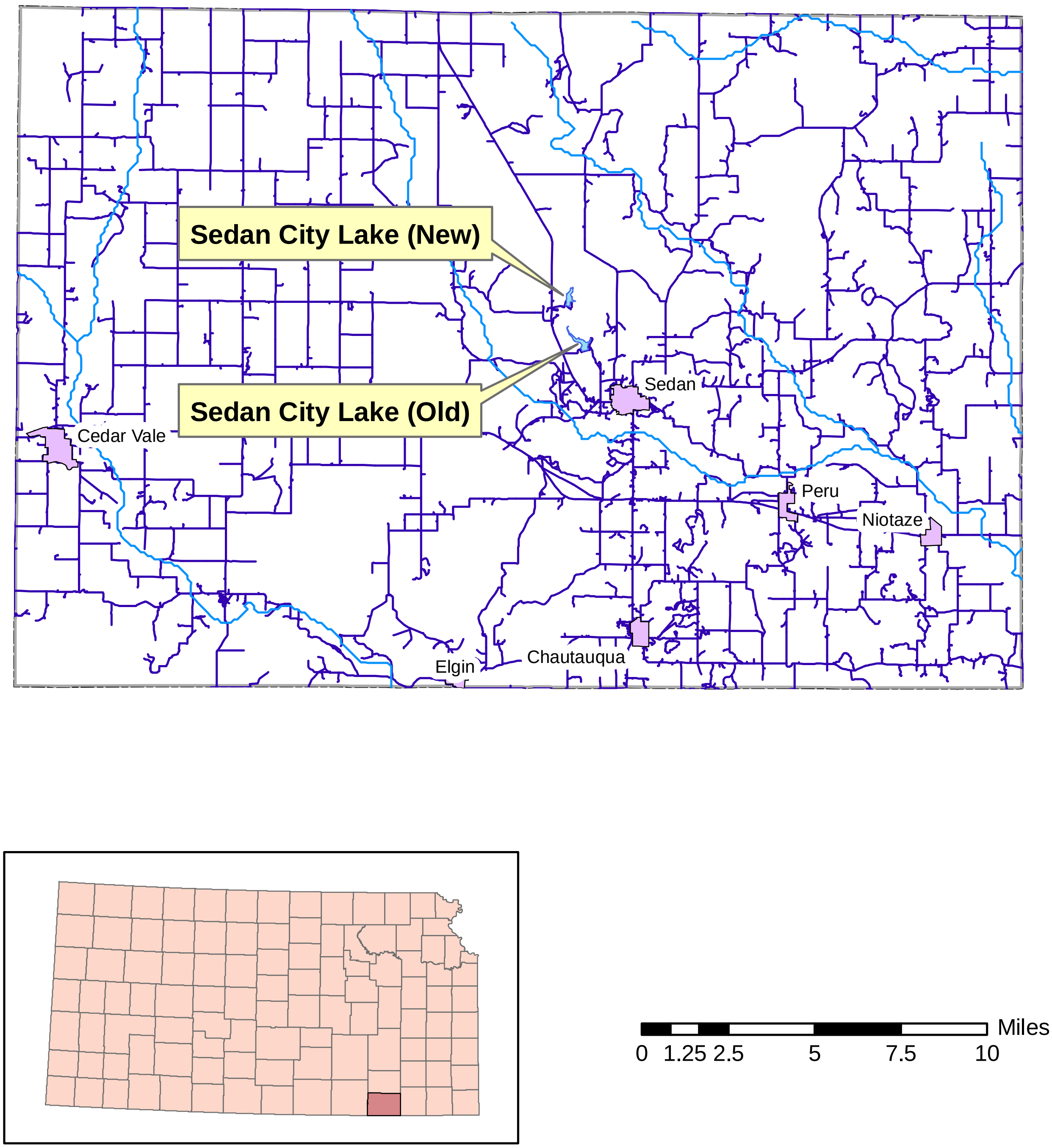

Figure 2. Location of Sedan New City Lake and Sedan Old City Lake in Chautauqua County, Kansas

II. RESERVOIR BATHYMETRIC (DEPTH) SURVEYING PROCEDURES

KBS operates a Biosonics DT-X echosounding system (www.biosonicsinc.com) with a 200 kHz split-beam transducer and a 38-kHz single-beam transducer. Latitude-longitude information is provided by a global positioning system (GPS) that interfaces with the Biosonics system. ESRI's ArcGIS is used for on-lake navigation and positioning, with GPS data feeds provided by the Biosonics unit through a serial cable. Power is provided to the echosounding unit, command/navigation computer, and auxiliary monitor by means of a inverter and battery backup device that in turn draw power from the 12-volt boat battery.

Pre-survey preparation:

Geospatial reference data: Prior to conducting the survey, existing geospatial data of the target lake was acquired, including georeferenced National Agricultural Imagery Project (NAIP) photography. The lake boundary was digitized as a polygon shapefile from the Farm Service Agency (FAS) NAIP 2008 georeferenced aerial photography obtained online from the Data Access and Service Center (DASC) at the Kansas Geological Survey (http://www.kansasgis.org). Prior to the lake survey, a series of transect lines are created as a shapefile in ArcGIS for guiding the boat during the survey.

Survey procedures:

Calibration (Temperature and ball check): After boat launch and initialization of the Biosonics system and command computer, system parameters are set in the Biosonics Visual Acquisition software. The temperature of the lake at 1-2 meters is taken with a research-grade metric electronic thermometer. This temperature, in degrees Celsius, is input to the Biosonics Visual Acquisition software to calculate the speed of sound in water at the given temperature at the given depth. Start range, end range, ping duration, and ping interval are also set at this time. A ball check is performed using a tungsten-carbide sphere supplied by Biosonics for this purpose. The ball is lowered to a known distance (1.0 meter) below the transducer faces. The position of the ball in the water column (distance from the transducer face to the ball) is clearly visible on the echogram. The echogram distance is compared to the known distance to assure that parameters are properly set and the system is operating correctly.

On-lake survey procedures: Using the GPS Extension of ArcGIS, the GPS data feed from the GPS receiver via the Biosonics echosounder, and the pre-planned transect pattern, the location of the boat on the lake in real-time is shown on the command/navigation computer screen. The transect pattern is maintained except when modified by obstructions in the lake (e.g., partially submerged trees) or shallow water and mudflats. Data are automatically logged in new files every half-hour (approximately 9000-ping files) by the Biosonics system.

Establishment Of Lake Level On Survey Dates:

State and Local Reservoirs:

Most state and local lakes in Kansas do not have water surface elevation gauges. Therefore, a local benchmark at the edge of a lake is established, typically a concrete pad or wall adjacent to the water. The location of the benchmark is photographed and a description noted. On the day of the survey, the vertical distance between the water surface and the surface of the benchmark is measured. In cases where the benchmark must be established a distance away from the lake, a survey-grade laser level is used to establish the vertical distance between benchmark and water surface.

A TopCon HiPerLite+ survey-grade static global positioning system is used to establish the height of the benchmark. The unit is set at a fixed distance above the benchmark, and the vertical distance between the benchmark and the Antenna Reference Point recorded. The unit is allowed to record data points for a minimum of two hours at a rate of one point every 10 seconds.

Following GPS data acquisition, the data are downloaded at the office from the GPS unit, converted from TopCon proprietary format to RINEX format, and uploaded to the National Geodetic Survey (NGS) On-line Positioning User Service (OPUS). Raw data are processed by OPUS with respect to three NGS CORS (Continuously Operating Reference Stations) locations and results returned to the user.

The elevation of the benchmark is provided in meters as the orthometric height (NAVD88, computed using GEOID03). The vertical difference between the lake surface on the survey day is subtracted from the OPUS-computer orthometric height to produce the lake elevation value, in meters. This lake elevation value is entered as an attribute of the lake perimeter polygon shapefile in postprocessing.

The ASTRA elevation benchmark for Sedan Old City Lake is the concrete pad anchoring the dock on the western side of the lake (Figure 3a, Figure 3b).

The water surface elevation of Sedan Old City Lake on June 21, 2012 was 919.6 feet AMSL, NAVD88.

UTM Zone 14N
746915.4
4117436.8

Location of Lake Elevation Benchmark: Sedan Old City Lake:

Figure 3a. General view of benchmark, view east.

Figure 3b. Detail view of benchmark.

```
FILE: log0178q.12O OP1342562593375    Sedan Old City Lake


                                 NGS OPUS SOLUTION REPORT
                                 ========================

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

      USER: mjakub@ku.edu                                DATE: July 17, 2012
RINEX FILE: log0178q.12o                                 TIME: 22:06:45 UTC

  SOFTWARE: page5  1108.09 master14.pl 071212      START: 2012/06/26  16:25:00
 EPHEMERIS: igs16942.eph [precise]                  STOP: 2012/06/26  18:42:00
  NAV FILE: brdc1780.12n                        OBS USED:  4036 /  6885   :
59%
  ANT NAME: TPSHIPER_PLUS   NONE               # FIXED AMB:    63 /    82   :
77%
ARP HEIGHT: .815                               OVERALL RMS: 0.041(m)

 REF FRAME: NAD_83(2011)(EPOCH:2010.0000)              IGS08 (EPOCH:2012.4856)

         X:      -551260.132(m)   0.256(m)          -551260.911(m)   0.256(m)
         Y:     -5058820.380(m)   0.260(m)         -5058818.995(m)   0.260(m)
         Z:      3832662.566(m)   0.177(m)          3832662.444(m)   0.177(m)

       LAT:   37 10 14.70651      0.054(m)        37 10 14.72869      0.054(m)
     E LON:  263 46 51.64252      0.251(m)       263 46 51.60505      0.251(m)
     W LON:   96 13  8.35748      0.251(m)        96 13  8.39495      0.251(m)
    EL HGT:          252.161(m)   0.308(m)               251.057(m)   0.308(m)
 ORTHO HGT:          281.831(m)   0.521(m) [NAVD88 (Computed using GEOID12)]

                        UTM COORDINATES    STATE PLANE COORDINATES
                         UTM (Zone 14)         SPC (1502 KS S)
Northing (Y) [meters]     4117436.868           458424.451
Easting (X)  [meters]      746915.485           602565.649
Convergence  [degrees]     1.68111525           1.40174588
Point Scale                1.00035110           1.00002024
Combined Factor            1.00031151           0.99998067

US NATIONAL GRID DESIGNATOR: 14SQG4691517436(NAD 83)

                              BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DK6489 ICT2 WICHITA ICT2 CORS ARP          N374506.458 W0972205.231  120395.6
DK6491 ICT3 WICHITA ICT3 CORS ARP          N374509.312 W0971258.381  109336.4
DK6487 ICT1 WICHITA ICT1 CORS ARP          N373515.773 W0971831.958  107051.3

                 NEAREST NGS PUBLISHED CONTROL POINT
HF0075      L 244                          N371034.    W0961337.        924.1

This position and the above vector components were computed without any
knowledge by the National Geodetic Survey regarding the equipment or
field operating procedures used.
```

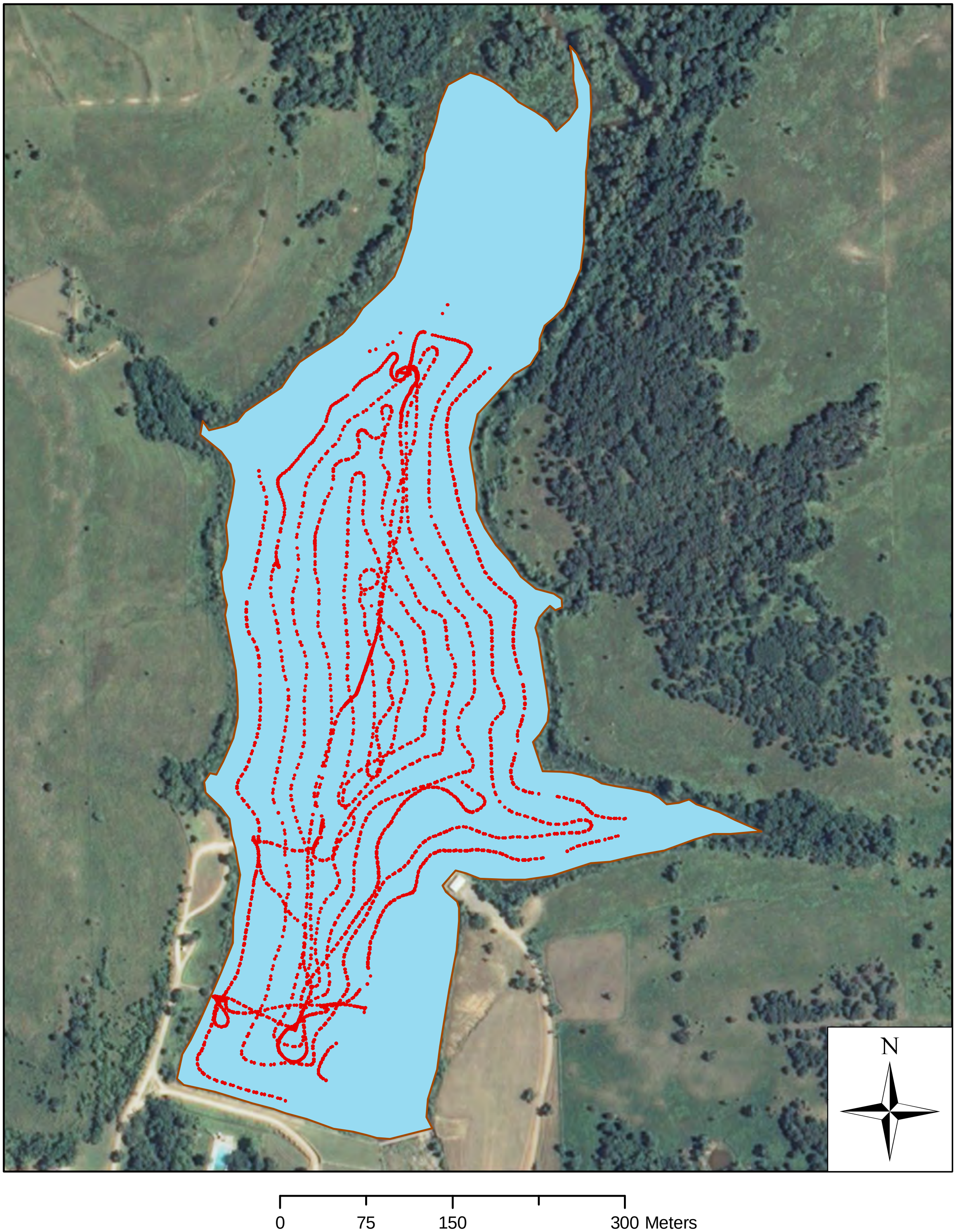

Figure 4. Bathymetric survey transects of Sedan Old City Lake.

Post-processing *(Visual Bottom Typer)*

The Biosonics DT-X system produces data files in a proprietary DT4 file format containing acoustic and GPS data. To extract the bottom position from the acoustic data, each DT4 file is processed through the Biosonics Visual Bottom Typer (VBT) software. The processing algorithm is described as follows:

> *"The BioSonics, Inc. bottom tracker is an "end_up" algorithm, in that it begins searching for the bottom echo portion of a ping from the last sample toward the first sample. The bottom tracker tracks the bottom echo by isolating the region(s) where the data exceeds a peak threshold for N consecutive samples, then drops below a surface threshold for M samples. Once a bottom echo has been identified , a bottom sampling window is used to find the next echo. The bottom echo is first isolated by user_defined threshold values that indicate (1) the lowest energy to include in the bottom echo (bottom detection threshold) and (2) the lowest energy to start looking for a bottom peak (peak threshold). The bottom detection threshold allows the user to filter out noise caused by a low data acquisition threshold. The peak threshold prevents the algorithm from identifying the small energy echoes (due to fish, sediment or plant life) as a bottom echo."* (Biosonics Visual Bottom Typer User's Manual, Version 1.10, p. 70).

Data is output as a comma-delimited (*.csv) text file. A set number of qualifying pings are averaged to produce a single report (for example, the output for ping 31 {when pings per report is 20} is the average of all values for pings 12-31). Standard analysis procedure for all 2008 and later data is to use the average of 5 pings to produce one output value. All raw *.csv files are merged into one master *.csv file using the shareware program File Append and Split Tool (FAST) by Boxer Software (Ver. 1.0, 2006).

Post-processing (*Excel*)

The master *.csv file created by the FAST utility is imported into Microsoft Excel. Excess header lines are deleted (each input CSV file has its own header), and the header file is edited to change the column headers "#Ping" to "Ping" and "E1' " to "E11", characters that are not ingestable by ArcGIS. Entries with depth values of zero (0) are deleted, as are any entries with depth values less than the start range of the data acquisition parameter (0.49 meters or less) (indicating areas where the water was too shallow to record a depth reading).

In Excel, depth adjustments are made. A new field – Adj_Depth – is created. The value for AdjDepth is calculated as AdjDepth = Depth + (Transducer Face Depth), where the Transducer Face Depth represents the depth of the transducer face below water level in meters (Typically, this value is 0.2 meters; however, if changes were made in the field, the correct level is taken from field notes and applied to the data). Depth in feet is also calculated as DepthFt = Adj_Depth * 3.28084.

These water depths are RELATIVE water depths that can vary from day-to-day based on the elevation of the water surface. In order to normalize all depth measurements to an absolute reference, water depths must be subtracted from an established value for the elevation of the water surface at the time of the bathymetric survey. Determination of water surface elevation has been described in an earlier section on establishment of lake levels.

To set depths relative to lake elevation, two additional fields are added to the attribute table of the point shapefile: LakeElevM, the reference surface elevation (the elevation of the water surface on the day that the aerial photography from which the lake perimeter polygon was digitized)and Elev_Ft, the elevation of the water surface in feet above sea level (Elev_ft), computed by converting ElevM to elevation in feet (ElevM * 3.28084).

Particularly for multi-day surveys, Adj_Depth and Depth_Ft should **NOT** be used for further analysis or interpolation. If water depth is desired, it should be produced by subtracting Elev_M or Elev_Ft from the reference elevation used for interpolation purposes (for federal reservoirs, the elevation of the water surface on the day that the aerial photography from which the lake perimeter polygon was digitized).

Post-processing *(ArcGIS):*

Ingest to ArcGIS is accomplished by using the Tools – Add XY Data option. The projection information is specified at this time (WGS84). Point files are displayed as Event files, and are then exported as a shapefile (filename convention: ALLPOINTS_WGS84.shp). The pointfile is then reprojected to the UTM coordinate system of the appropriate zone (14 or 15) (filename convention ALLPOINTS_UTM.shp).

Raster interpolation of the point data is performed using the same input data and the Topo to Raster option within the 3D Extension of ArcGIS. The elevation of the reservoir on the date of aerial photography used to create the perimeter/shoreline shapefile was used as the water surface elevation in all interpolations from point data to raster data.

Contour line files are derived from the raster interpolation files using the ArcGIS command under 3D Analyst – Raster Surface – Contour.

Area-elevation-volume tables are derived using an ArcGIS extension custom written for and available from the ASTRA Program. Summarized, the extension calculates the area and volume of the reservoir at 1/10-foot elevation increments from the raster data for a series of water surfaces beginning at the lowest elevation recorded and progressing upward in 1/10-foot elevation increments to the reference water surface. Cumulative volume is also computed in acre-feet.

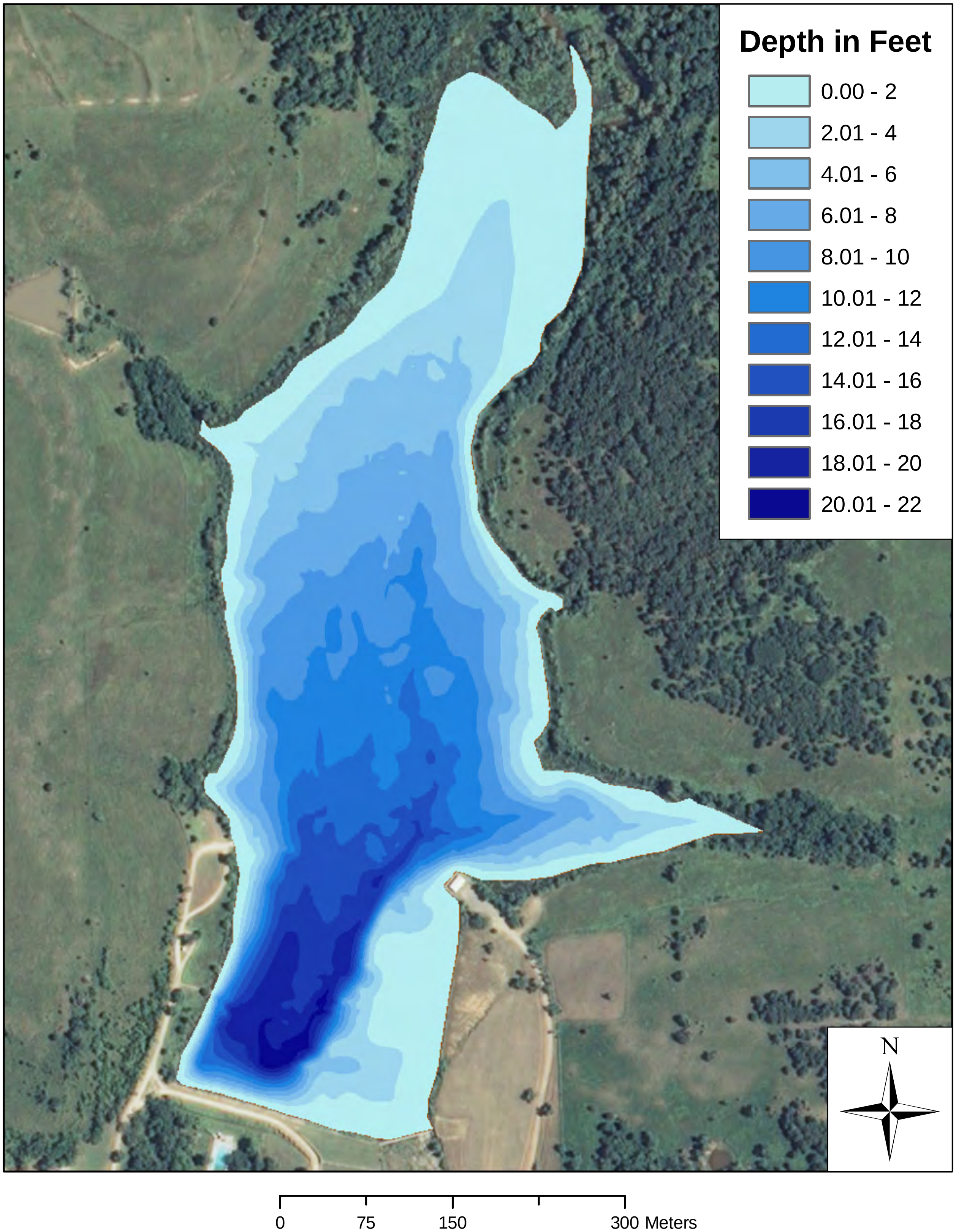

Figure 5. Lake depth map of Sedan Old City Lake.

Table 1
Cumulative area in acres by tenth foot elevation increments

Elevation (ft NGVD)	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
898	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
899	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4
900	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.9	0.9
901	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.6	1.7	1.8
902	1.9	2.0	2.1	2.2	2.2	2.3	2.4	2.5	2.6	2.6
903	2.7	2.8	2.8	2.9	3.0	3.0	3.1	3.2	3.3	3.3
904	3.4	3.5	3.6	3.7	3.8	3.8	3.9	4.0	4.1	4.2
905	4.3	4.4	4.5	4.6	4.8	4.9	5.0	5.2	5.3	5.5
906	5.6	5.8	5.9	6.1	6.2	6.4	6.5	6.6	6.7	6.9
907	7.0	7.1	7.3	7.5	7.6	7.8	8.0	8.2	8.4	8.6
908	8.8	9.0	9.2	9.4	9.6	9.8	10.1	10.3	10.7	11.0
909	11.2	11.5	11.8	12.1	12.4	12.7	13.0	13.3	13.5	13.8
910	14.0	14.3	14.5	14.7	15.0	15.2	15.4	15.6	15.8	16.1
911	16.4	16.6	16.9	17.1	17.4	17.6	17.9	18.2	18.4	18.7
912	19.0	19.3	19.5	19.8	20.0	20.3	20.5	20.8	21.0	21.3
913	21.5	21.8	22.0	22.3	22.5	22.8	23.0	23.3	23.5	23.8
914	24.1	24.3	24.6	24.9	25.2	25.5	25.7	26.0	26.3	26.6
915	26.8	27.1	27.4	27.7	28.0	28.2	28.5	28.8	29.1	29.4
916	29.7	30.0	30.3	30.7	31.0	31.3	31.7	32.0	32.3	32.7
917	33.1	33.4	33.8	34.2	34.6	35.0	35.4	35.9	36.4	36.8
918	37.3	37.8	38.4	38.9	39.5	40.1	40.7	41.3	42.0	42.6
919	43.3	44.1	44.8	45.7	46.6	47.6	49.2			

Table 2
Cumulative volume in acre-feet by tenth foot elevation increments

Elevation (ft NGVD)	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
898	0	0	0	0	0	0	0	0	0	0
899	0	0	0	0	0	0	0	0	0	0
900	0	0	0	0	0	1	1	1	1	1
901	1	1	1	1	1	2	2	2	2	2
902	2	3	3	3	3	3	4	4	4	4
903	5	5	5	6	6	6	6	7	7	7
904	8	8	8	9	9	10	10	10	11	11
905	12	12	13	13	13	14	14	15	15	16
906	17	17	18	18	19	20	20	21	22	22
907	23	24	24	25	26	27	27	28	29	30
908	31	32	33	33	34	35	36	37	38	40
909	41	42	43	44	45	47	48	49	51	52
910	53	55	56	58	59	61	62	64	65	67
911	69	70	72	74	75	77	79	81	82	84
912	86	88	90	92	94	96	98	100	102	104
913	106	109	111	113	115	118	120	122	125	127
914	129	132	134	137	139	142	144	147	149	152
915	155	157	160	163	166	169	171	174	177	180
916	183	186	189	192	195	198	201	205	208	211
917	214	218	221	224	228	231	235	239	242	246
918	249	253	257	261	265	269	273	277	281	285
919	290	294	299	303	308	312	317			

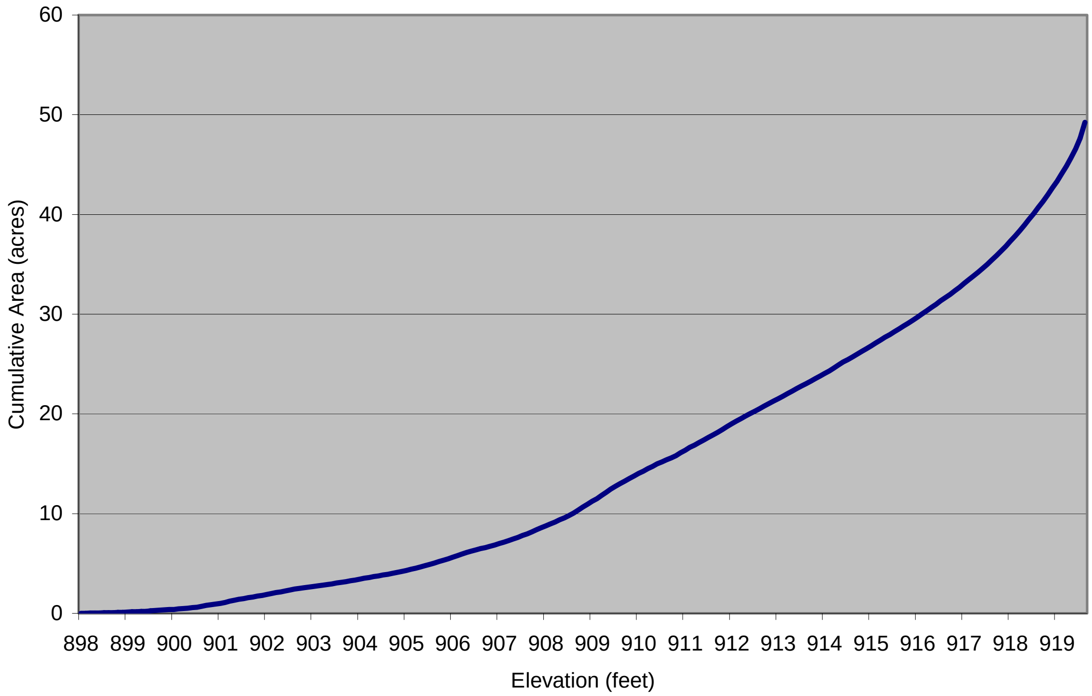

Figure 6. Cumulative area-elevation curve

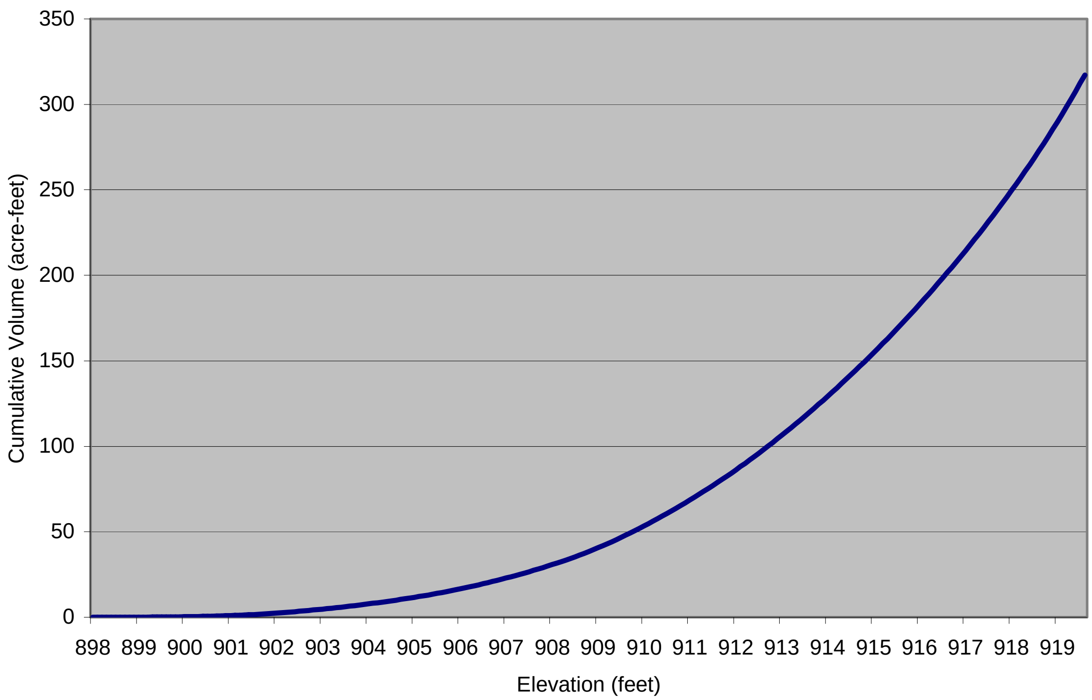

Figure 7. Cumulative volume-elevation curve

SEDIMENT SAMPLING PROCEDURES

Sediment samples were collected from three sites within the reservoir using a Wildco drop-corer (Wildlife Supply Company, Buffalo, NY). One sample is taken near the dam; a second at mid-lake; and a third in the upper end/transitional area. Sampling is typically performed on the same day as the bathymetric survey, following completion of the survey. As the drop-corer samples only the upper sediment, the entire sample in each case is collected and sealed in a sampling container. The samples are then shipped to the Kansas State University Soil Testing Laboratory (Manhattan, KS), for texture and other analyses.

SEDIMENT SAMPLING RESULTS:

Sampling sites were distributed around the reservoir (Figure 8). Sand was a minor fraction in two of three samples, and constituted nearly one-third in sample SNCL-1 at the lower end of the lake (Table 3; Figure 9; Figure 10).

Table 3
Sediment sampling site data

CODE	UTMX	UTMY	%Sand	% Silt	% Clay
SOCL-1	746995	4117407	28	44	28
SOCL-2	747058	4117737	6	44	50
SOCL-3	747093	4117983	2	34	64

Coordinates are Universal Transverse Mercator (UTM), NAD83, Zone 14 North

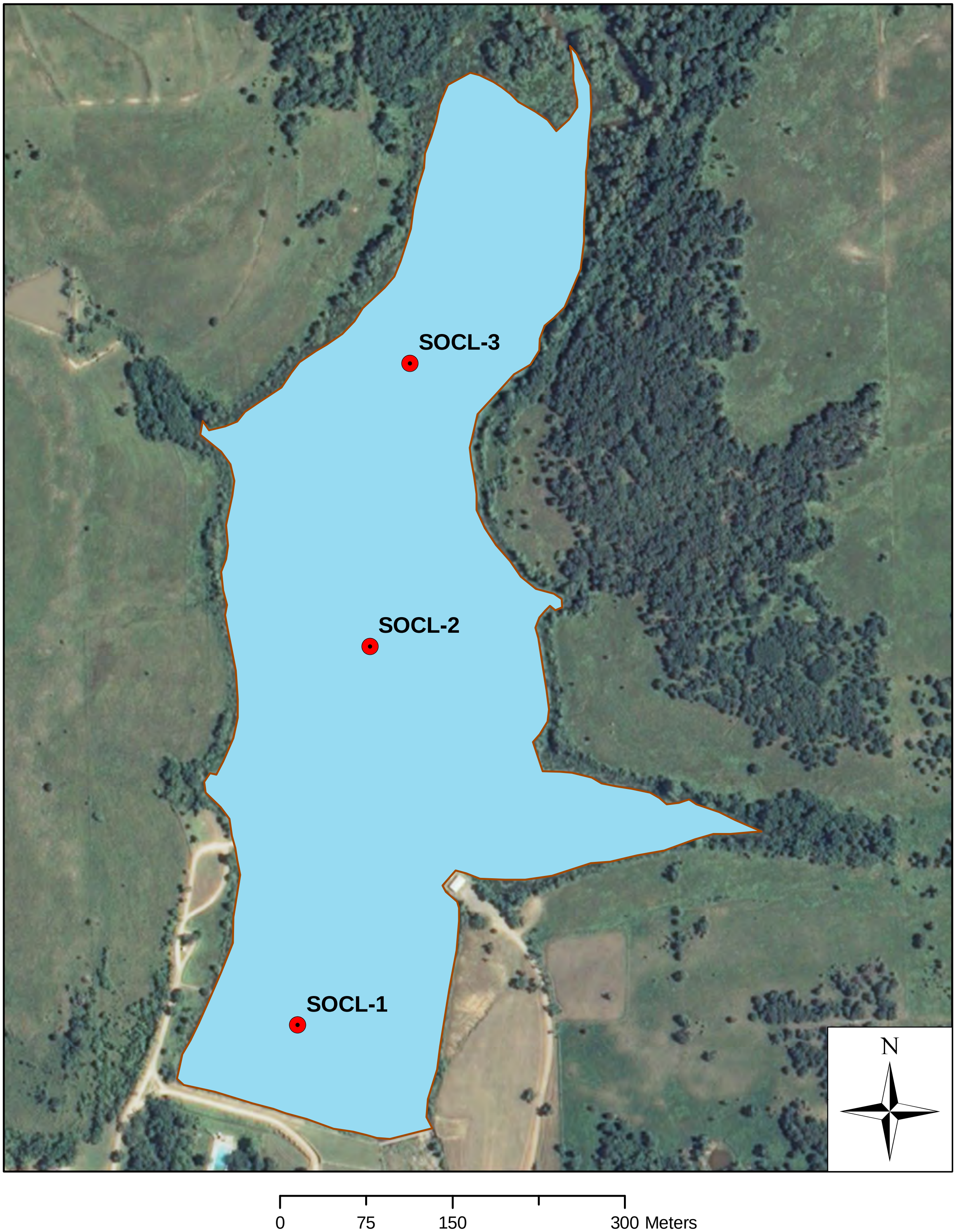

Figure 8. Sediment sampling sites in Sedan Old City Lake.

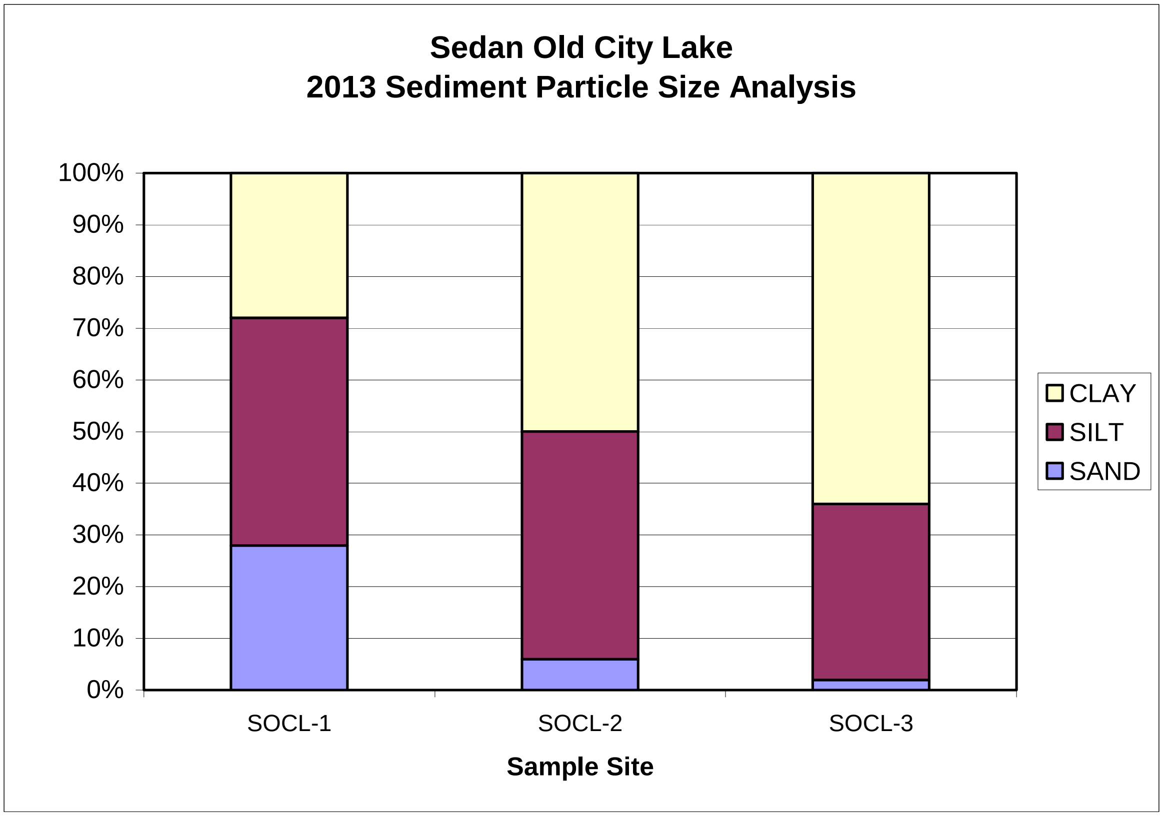

Figure 9. Sediment particle size analysis.

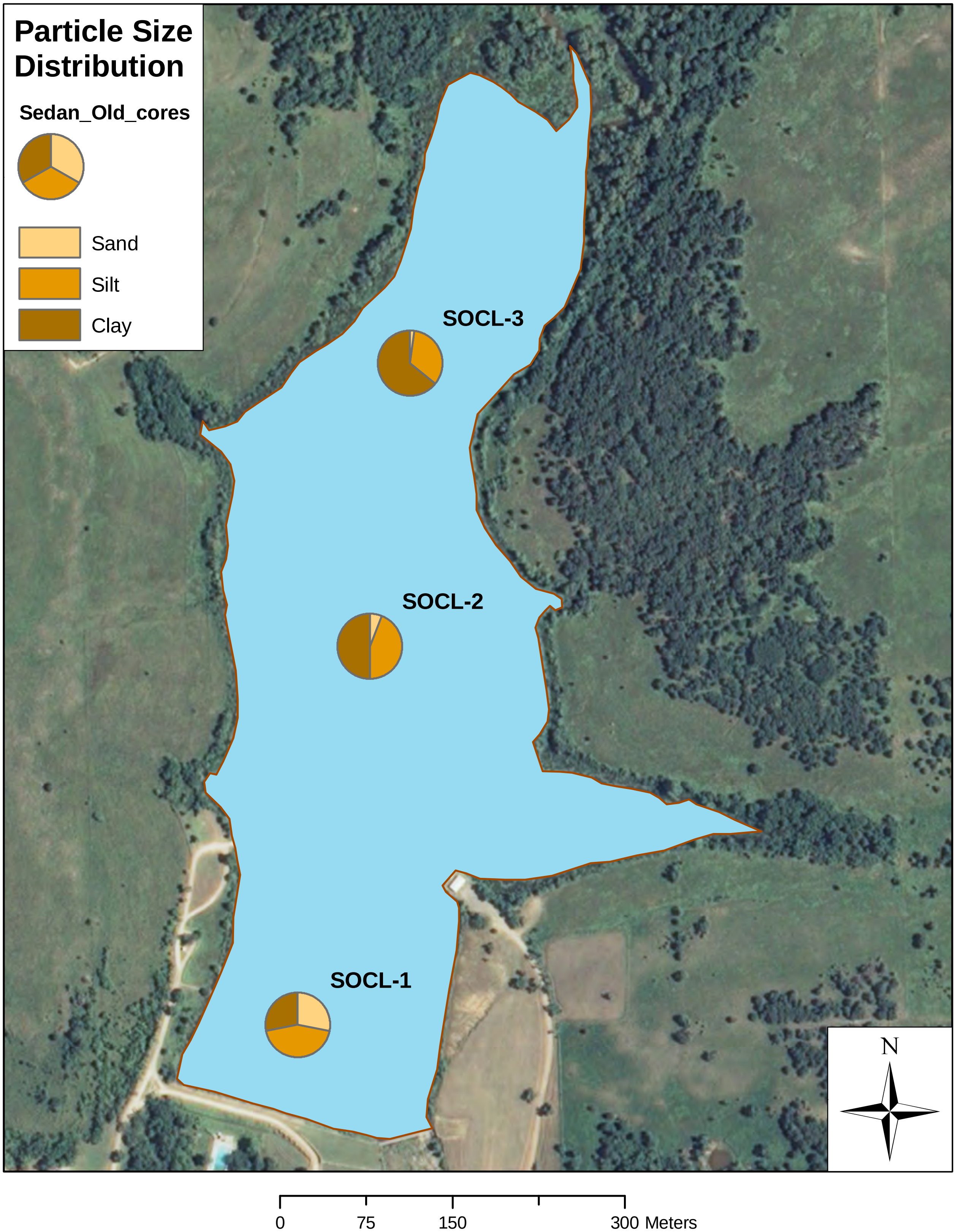

Figure 10. Particle size distributions of sediment in Sedan Old City Lake.