Bathymetric and Sediment Survey of Rock Creek Lake, Bourbon County, Kansas

KANSAS BIOLOGICAL SURVEY

Kansas Biological Survey

Applied Science and Technology for Reservoir Assessment (ASTRA) Program

Report 2009-04 (February 2010)

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

SUMMARY

On September 17, 2009, the Kansas Biological Survey (KBS) performed a bathymetric survey of Rock Creek Lake in Bourbon 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:		
	Date of survey:	September 17, 2009
Reservoir Statistics:		
	Elevation on survey date	807.2 ft
	Area on survey date:	62 acres
	Volume on survey date:	388 acre-feet
	Maximum depth:	14.9 ft.
Elevation Benchmark (if applicable)		
	UTM location of elevation benchmark:	345796.7, 4186450.0
	UTM Zone:	15N
	UTM datum:	NAD83
	Elevation of benchmark, from GPS:	808.83 ft.
	Vertical datum, all data:	NAVD88
Sediment Survey:		
	Date of sediment survey:	September 17, 2009

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LAKE HISTORY AND PERTINENT INFORMATION

Figure 1. Rock Creek Lake, west of Fort Scott, Kansas.

Rock Creek Lake: Constructed in 1920, Rock Creek Lake is an integral part of the Fort Scott City and rural water reserve system. Located on the Marmaton River,and surrounded by deep woods, Rock Creek serves as a habitat for wildlife,as well as a quiet haven for fishermen, canoers, and campers. Rock Creek Lake is located one mile south and 2.5 miles west of Fort Scott (text from http://www.fortscott.com/outdoor.php)

Bourbon County, Kansas

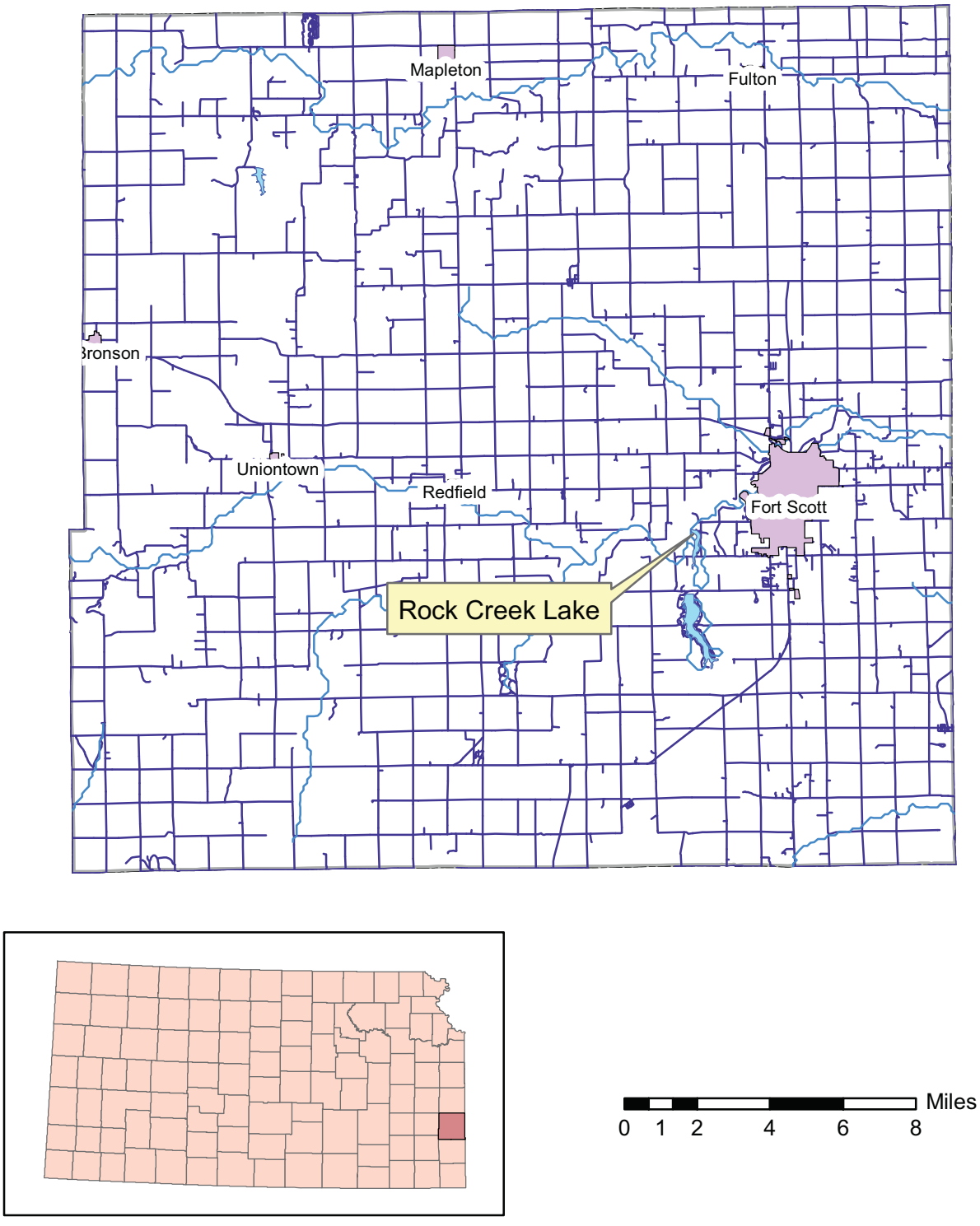

Figure 2. Location of Rock Creek Lake in Bourbon County, Kansas

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, geospatial data of the target lake is acquired, including georeferenced National Agricultural Imagery Project (NAIP) photography. The lake boundary is digitized as a polygon shapefile from the FSA NAIP georeferenced aerial photography obtained online from the Data Access and Service Center (DASC). 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 Rock Creek Lake is the boat ramp on the eastern side of the lake (Figure 3a, Figure 3b). A reference elevation from the water surface to the southwest corner of a nearby concrete pad just north of the boat ramp was shot as well, although the precise GPS reference elevation and coordinates for this pad have not yet been established.

The water surface elevation of Rock Creek Lake on September 17, 2009 was 807.21 feet AMSL.

Location of Lake Elevation Benchmark:

Rock Creek Lake: Boat ramp on east side of lake.

UTM (NAD83, Zone 15): Easting (X) [meters] 345796.703, Northing (Y) [meters] 4186450.012

Figure 3a. View west from boat ramp.

Figure 3b. Alternate reference level point, immediately north of boat ramp. Southwest corner of pad is reference point (Precision GPS reference coordinate not yet set).

LAKE: Rock Creek Lake

FILE: log0225q.08O 000416319

NGS OPUS SOLUTION REPORT
==========
All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: www.ngs.noaa.gov/OPUS/Using_OPUS.html#accuracy

USER: mjakub@ku.edu DATE: August 19, 2008
RINEX FILE: log0225q.08o TIME: 20:31:44 UTC

SOFTWARE: page5 0612.06 master11.pl START: 2008/08/12 16:40:00
EPHEMERIS: igr14922.eph [rapid] STOP: 2008/08/12 19:23:00
NAV FILE: brdc2250.08n OBS USED: 6876 / 7240 : 95%
ANT NAME: TPSHIPER_PLUS NONE # FIXED AMB: 34 / 38 : 89%
ARP HEIGHT: .96 OVERALL RMS: 0.020(m)

REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000) ITRF00 (EPOCH:2008.6141)

X:	-417960.646(m)	0.039(m)	-417961.358(m)	0.039(m)
Y:	-5028048.100(m)	0.069(m)	-5028046.720(m)	0.069(m)
Z:	3889149.483(m)	0.016(m)	3889149.351(m)	0.016(m)
LAT:	37 48 44.76138	0.040(m)	37 48 44.78417	0.040(m)
E LON:	265 14 53.39714	0.034(m)	265 14 53.36346	0.034(m)
W LON:	94 45 6.60286	0.034(m)	94 45 6.63654	0.034(m)
EL HGT:	215.231(m)	0.066(m)	214.110(m)	0.066(m)
ORTHO HGT:	246.532(m)	0.091(m)	[NAVD88 (Computed using GEOID03)]	

	UTM COORDINATES UTM (Zone 15)	STATE PLANE COORDINATES SPC (1502 KS S)
Northing (Y) [meters]	4186450.012	533795.296
Easting (X) [meters]	345796.703	729937.876
Convergence [degrees]	-1.07422342	2.30335330
Point Scale	0.99989288	0.99993760
Combined Factor	0.99985911	0.99990383

US NATIONAL GRID DESIGNATOR: 15SUB4579786450(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DJ3671	KST5 TOPEKA 5 CORS ARP	N390240.554	W0960220.776	177034.0
AJ1832	NDS1 NEODESHA (2) CORS ARP	N371805.504	W0953605.332	94083.5
DF9221	ZKC1 KANSAS CTY WAAS 1 CORS ARP	N385248.550	W0944726.964	118572.2

NEAREST NGS PUBLISHED CONTROL POINT

HE1192	SCOTTPORT	N374815.272	W0944607.175	1738.2

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.

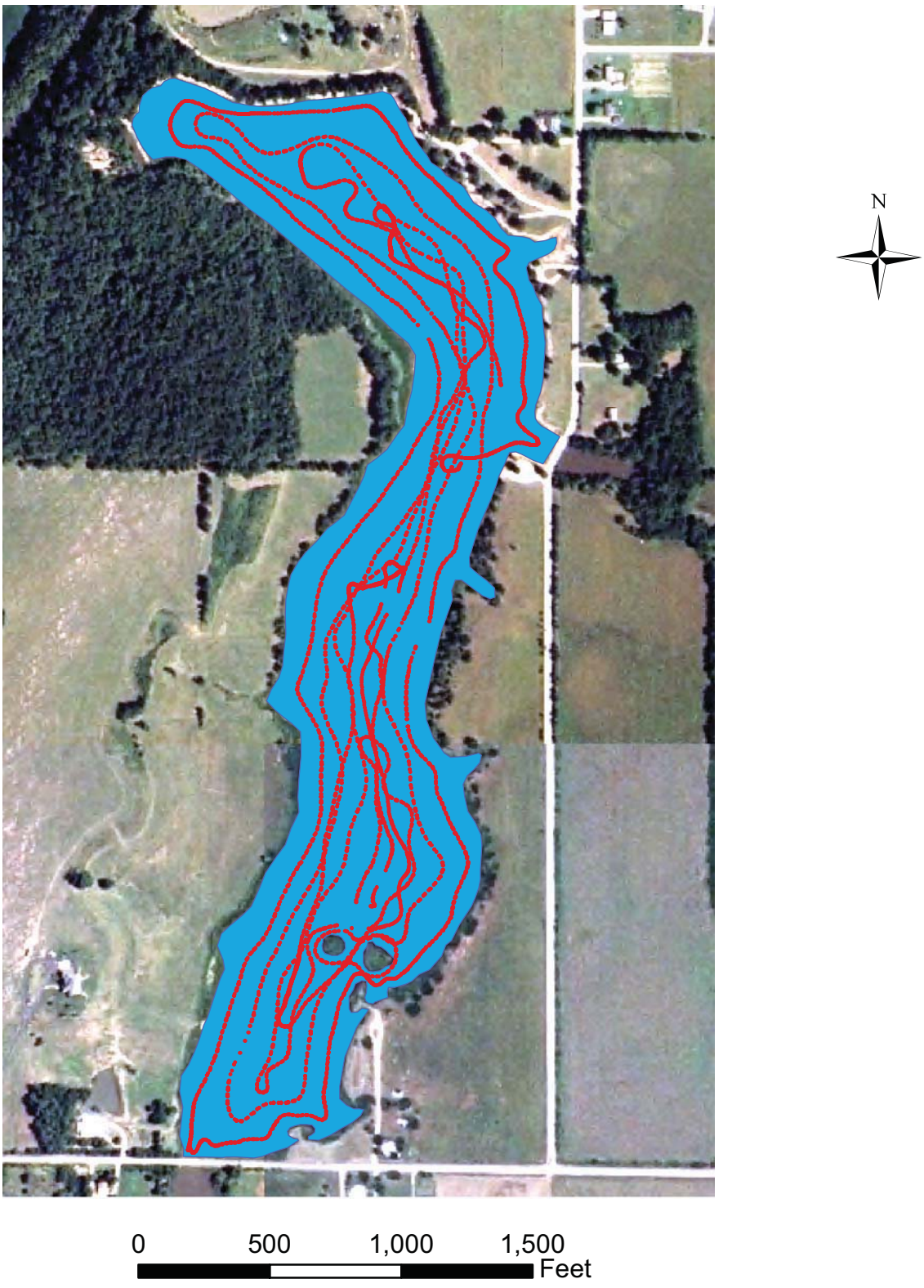

Figure 4. Bathymetric survey transects for Rock Creek Lake, September 17, 2009.

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.

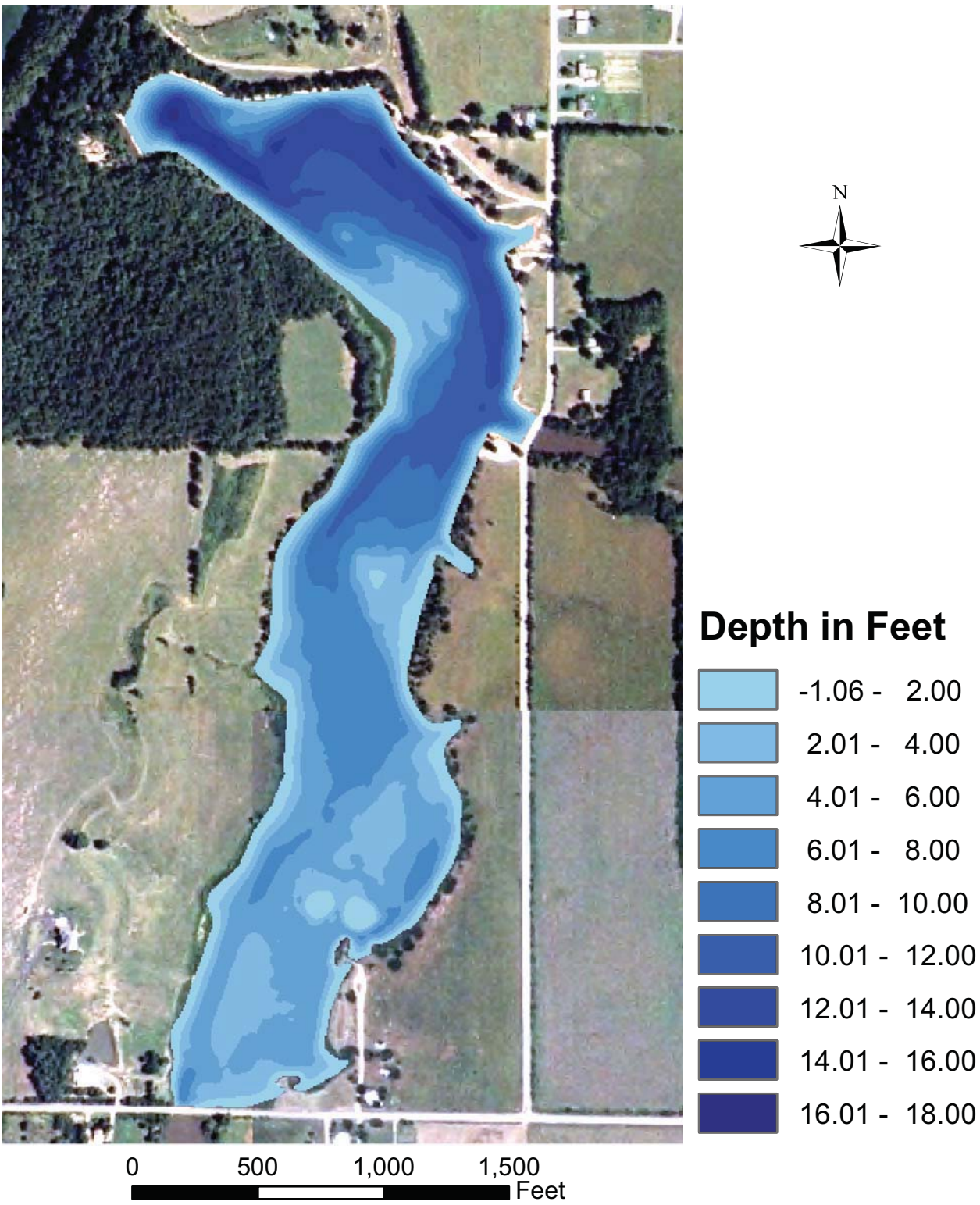

Figure 5. Water depth based on September 17, 2009 bathymetric survey.for Rock Creek Lake. Depths are based on a pool elevation of 807.2 feet.

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
792				1	1	1	1	1	1	1
793	1	1	1	1	2	2	2	2	3	3
794	3	3	4	4	4	4	5	5	5	5
795	6	6	6	6	7	7	7	7	8	8
796	8	9	9	9	10	10	11	11	12	12
797	12	13	13	13	14	14	14	14	15	15
798	15	15	16	16	16	16	17	17	17	17
799	18	18	18	19	19	19	19	20	20	21
800	21	22	22	23	23	23	24	25	25	26
801	27	27	28	29	29	30	31	31	32	33
802	33	34	35	36	36	37	38	39	40	40
803	41	42	43	44	44	45	46	46	47	47
804	48	49	49	50	50	51	52	52	53	54
805	54	55	55	55	56	56	56	57	57	57
806	58	58	58	59	59	59	60	60	60	61
807	61	62	62							

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
792				<1	<1	<1	<1	1	1	1
793	1	1	1	1	1	1	2	2	2	2
794	3	3	3	4	4	4	5	5	6	6
795	7	7	8	9	9	10	11	11	12	13
796	14	15	15	16	17	18	19	20	22	23
797	24	25	27	28	29	31	32	33	35	36
798	38	39	41	43	44	46	47	49	51	53
799	54	56	58	60	62	64	65	67	69	72
800	74	76	78	80	82	85	87	90	92	95
801	97	100	103	106	109	112	115	118	121	124
802	127	131	134	138	141	145	149	153	156	160
803	165	169	173	177	182	186	191	195	200	205
804	209	214	219	224	229	234	239	245	250	255
805	261	266	271	277	283	288	294	299	305	311
806	317	322	328	334	340	346	352	358	364	370
807	376	382	388							

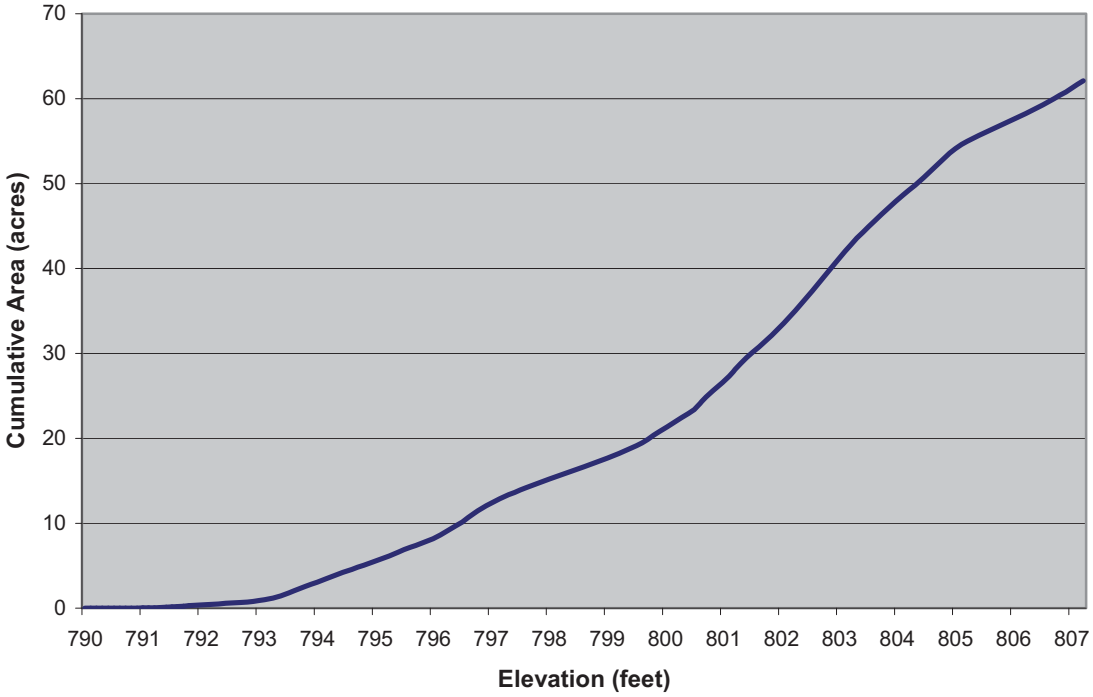

Figure 6. Cumulative area-elevation curve

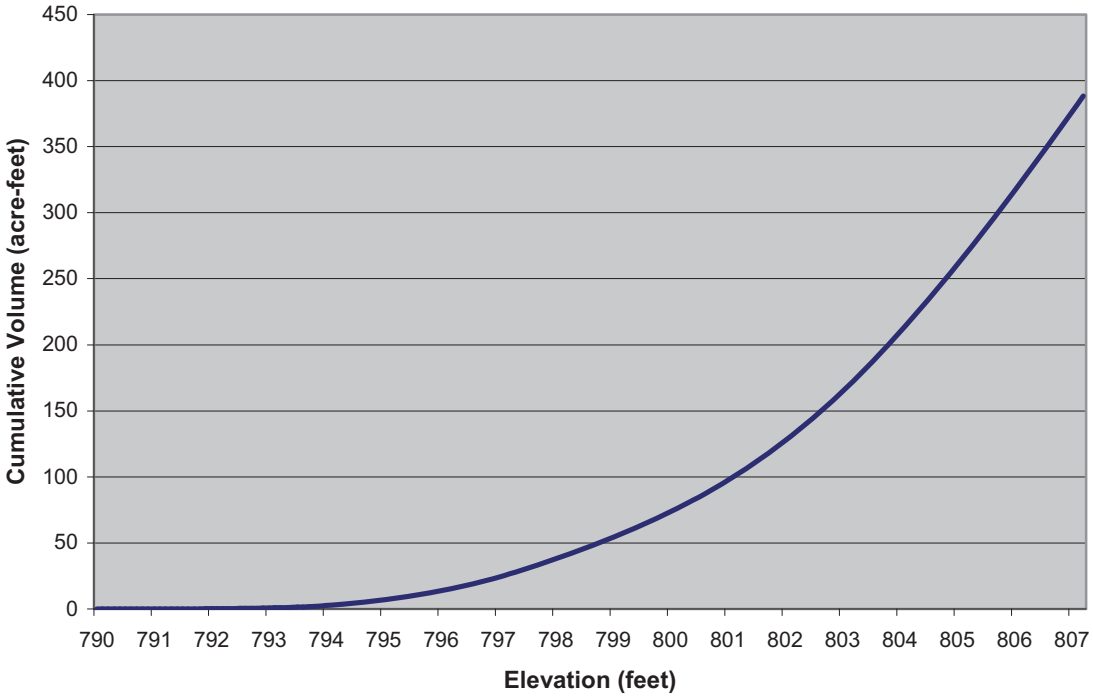

Figure 7. Cumulative volume-elevation curve

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 was 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 was collected and sealed in a sampling container. The samples were then shipped to the Kansas State University Soil Testing Laboratory (Manhattan, KS), for texture analysis. No bulk density sampling or analysis was performed for Rock Creek Lake.

SEDIMENT SAMPLING RESULTS:

Sampling sites were distributed across the length of the reservoir (Figure 8). Proportions of silt and clay were fairly equal across all samples, exhibiting little particle size differentiation from site to site across the reservoir. Silt decreased slightly from inflow end (RC-1) to dam end (RC-3), while clay increased slightly. Sand constituted a minor or non-existent fraction in all three samples (Table 3; Figure 9; Figure 10).

Table 3
Rock Creek Lake Sediment Sampling Site Data

CODE	UTMX	UTMY	%Sand	% Silt	% Clay
RC-1	345552.3	4185872.0	0	70	30
RC-2	345676.4	4186339.8	6	68	26
RC-3	345659.6	4186762.5	0	66	34

Coordinates are Universal Transverse Mercator (UTM), NAD83, Zone 15 North

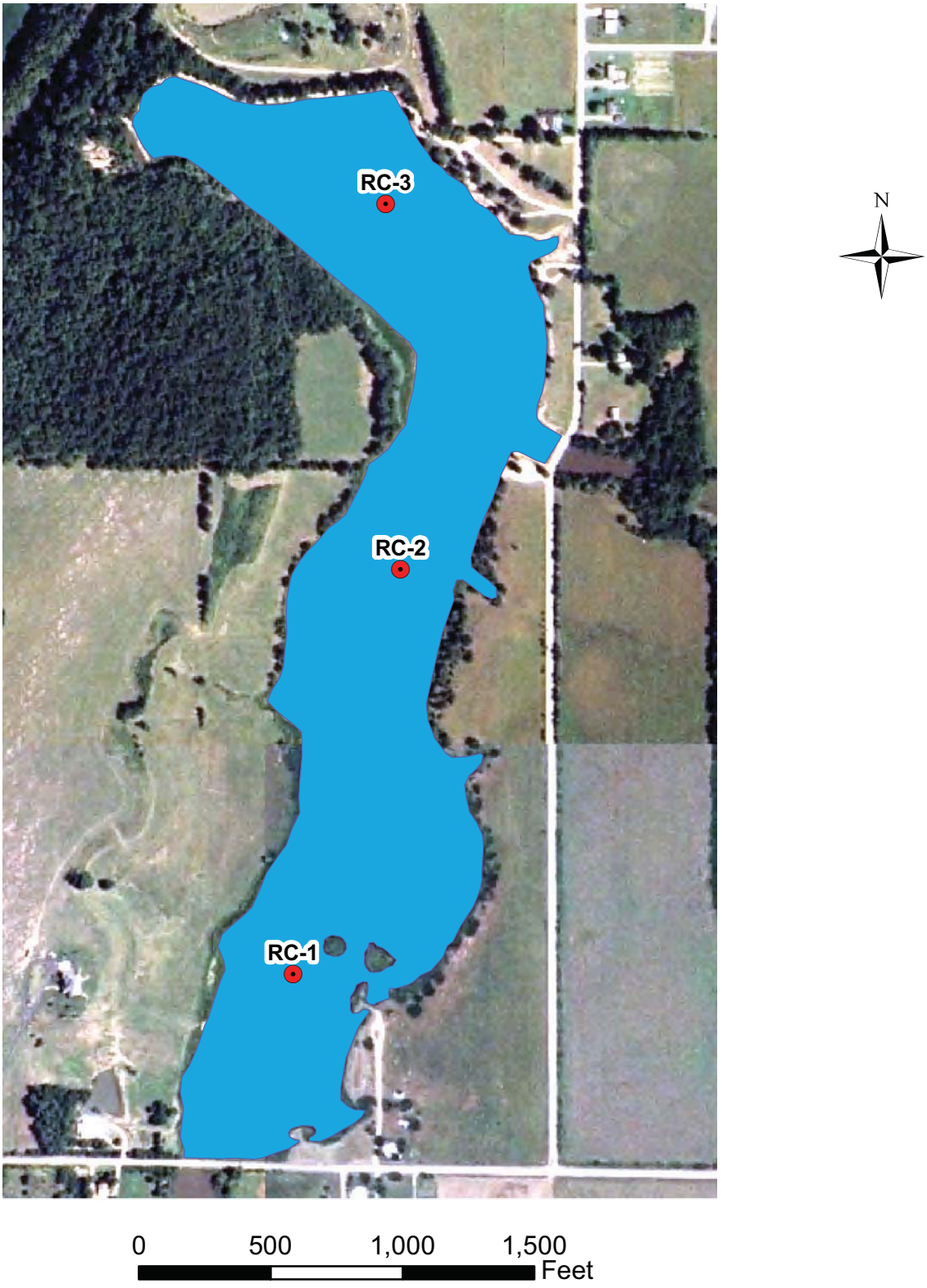

Figure 8. Location of sediment samples in Rock Creek Lake.

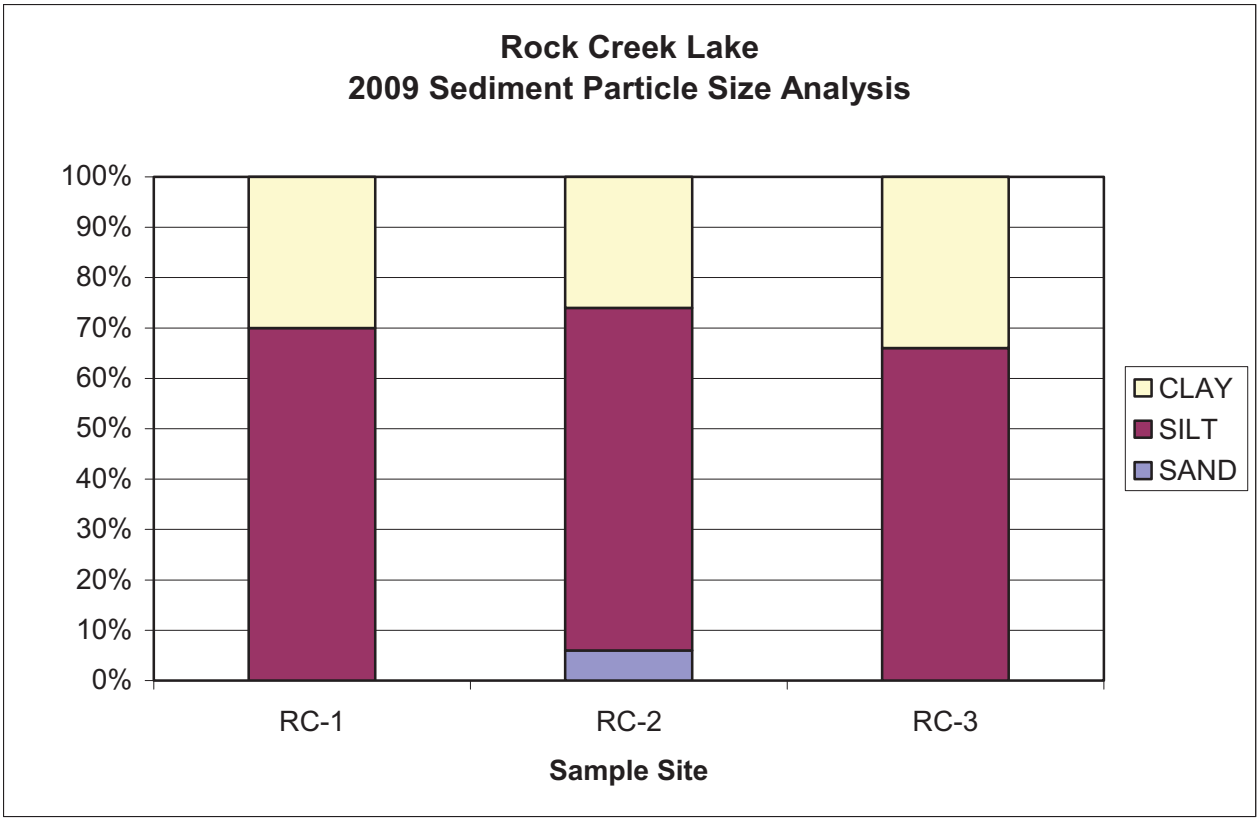

Figure 9. Sediment particle size analysis.

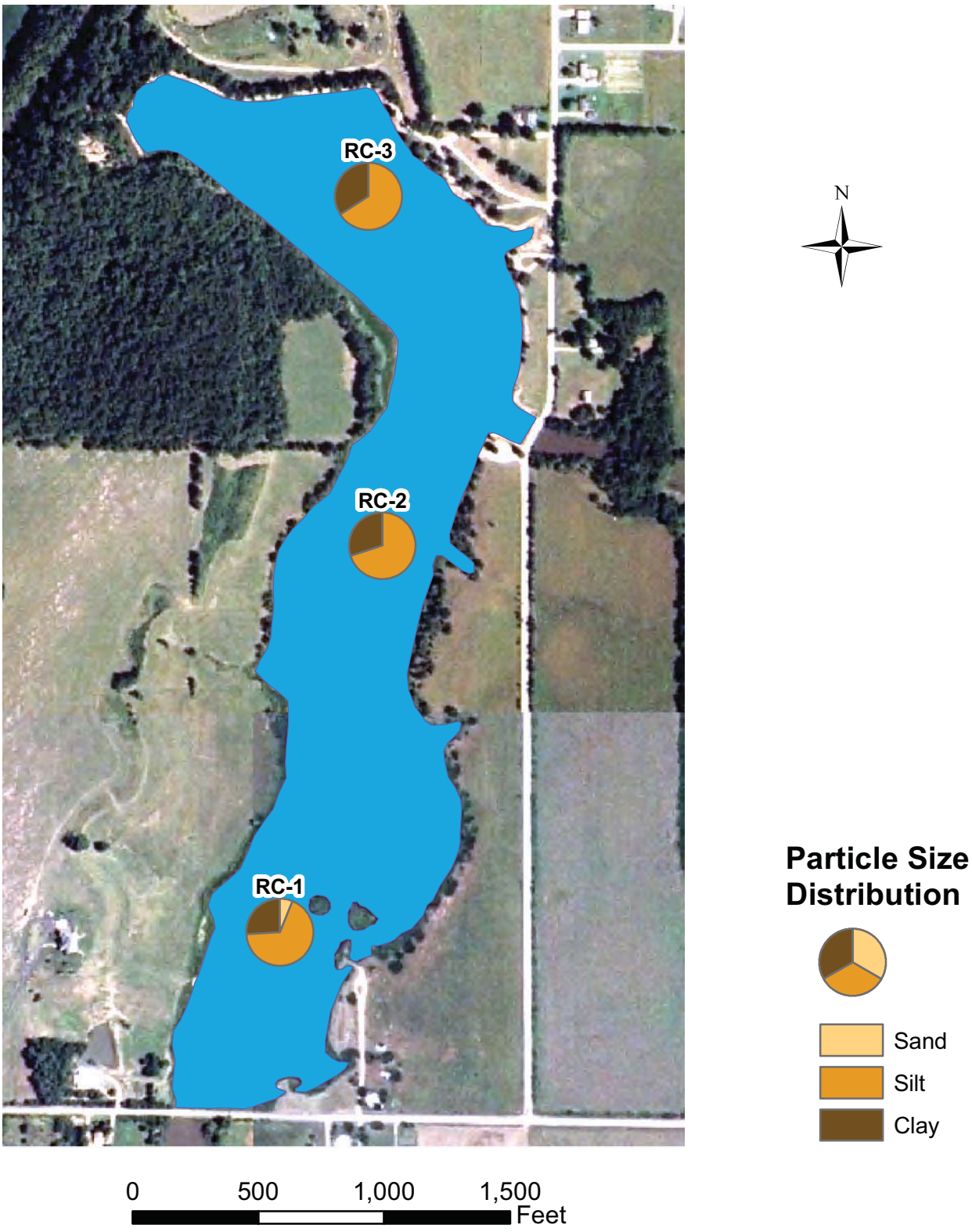

Figure 10. Particle size distribution of sediment samples in Rock Creek Lake.