

# Bathymetric and Sediment Survey of Osage City Lake, Osage County, Kansas



**Kansas Biological Survey**  
*Applied Science and Technology for  
Reservoir Assessment (ASTRA) Program*  
Report 2009-05 (February 2010)



**KANSAS**  

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**WATER**  

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## SUMMARY

On August 26, 2009, the Kansas Biological Survey (KBS) performed a bathymetric survey of Osage City Lake in Osage 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:

<b>Bathymetric Survey:</b>		
Date of survey:		August 26, 2009
<b>Reservoir Statistics:</b>		
Elevation on survey date		1064.2 ft
Area on survey date (acres):		48
Volume on survey date (acre-feet):		267
Maximum depth (feet):		10
<b>Elevation Benchmark (if applicable)</b>		
UTM location of elevation benchmark:		253594.5 , 4278087.5
UTM Zone:		15N
UTM datum:		NAD83
Elevation of benchmark, from GPS:		1065.38 ft
Vertical datum, all data:		NAVD88
<b>Sediment Survey:</b>		
Date of sediment survey:		August 26, 2009

# TABLE OF CONTENTS

<b>SUMMARY</b> .....	i
<b>TABLE OF CONTENTS</b> .....	ii
<b>LIST OF FIGURES</b> .....	iii
<b>LIST OF TABLES</b> .....	iv
<b><u>LAKE HISTORY AND PERTINENT INFORMATION</u></b> .....	1
<b><u>BATHYMETRIC SURVEYING PROCEDURE</u></b>	
Pre-survey preparation:.....	3
Survey procedures: .....	3
Establishment of lake level on survey date: .....	4
Location of lake elevation benchmark .....	5
NGS OPUS solution report .....	6
Post-processing .....	8
<b><u>BATHYMETRIC SURVEY RESULTS</u></b>	
Area-Volume-Elevation Tables.....	11
<b><u>SEDIMENT SAMPLING</u></b> .....	13
Procedures.....	13
Results .....	13

## **LIST OF FIGURES**

Figure 1.	Osage City Lake .....	1
Figure 2.	Location of Osage City Lake in Osage County, Kansas. ....	2
Figure 3.	a. View of dam and benchmark site .....	5
	b. Close-up view of lake elevation benchmark site .....	5
Figure 4.	Bathymetric survey transects.....	7
Figure 5.	Reservoir depth map .....	10
Figure 6.	Cumulative area-elevation curve. ....	12
Figure 7.	Cumulative volume-elevation curve. ....	12
Figure 8.	Location of sediment sampling sites in Osage City Lake .....	14
Figure 9.	Sediment particle size analysis .....	15
Figure 10.	Particle size distribution of sediment samples in Osage City Lake.....	16

**LIST OF TABLES**

Table 1. Cumulative area in acres by tenth foot elevation increments..... 11

Table 2. Cumulative volume in acre-feet by tenth foot elevation increments ..... 11

Table 3. Sediment sampling site data..... 13

## LAKE HISTORY AND PERTINENT INFORMATION



**Figure 1. Osage City Lake near Osage City, Kansas in Osage County**

**Location:** Osage City Lake is located about 1 and ½ miles south of Osage City at the intersection of S. Burlingame Rd. (Highway 170) and W. 253<sup>rd</sup> St. The lake is within the Marais des Cygnes River Basin.

**Purpose:** Osage City Lake is a municipal lake of Osage City. It is used for recreation, flood control, food procurement, industrial water source and secondary drinking water source for Osage City.

# Osage County, Kansas

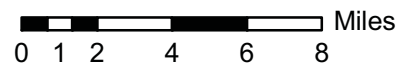
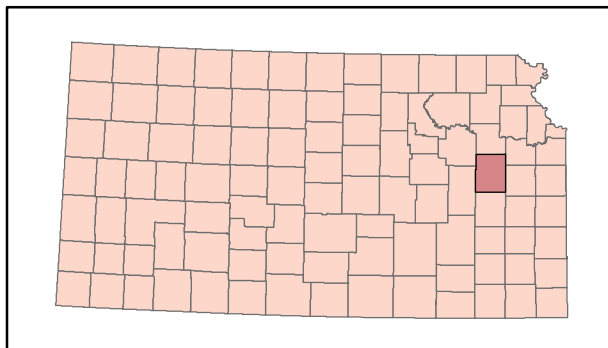
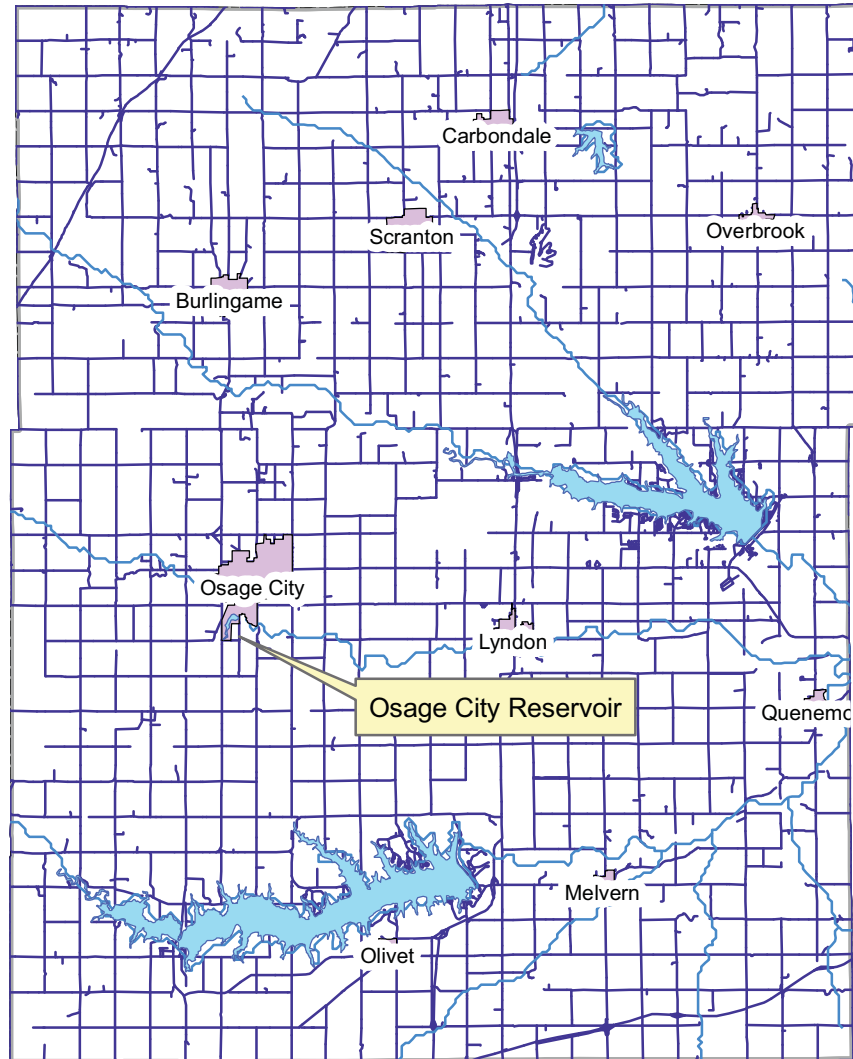


Figure 2. Location of Osage City Reservoir in Osage County, Kansas

## **Reservoir Bathymetric (Depth) Surveying Procedures**

KBS operates a Biosonics DT-X echosounding system ([www.biosonicsinc.com](http://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 an 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 Osage City Lake is the top of the concrete wall adjoining the south end of the dam/spillway (Figure 3a, Figure 3b).

The water surface elevation of Osage City Lake on August 26, 2009 was 1064.2 feet AMSL.

**Location of Lake Elevation Benchmark:**

Osage City Lake:

UTM (Zone 15) Easting (X) [meters] 253594.5 Northing (Y) [meters] 4278087.5

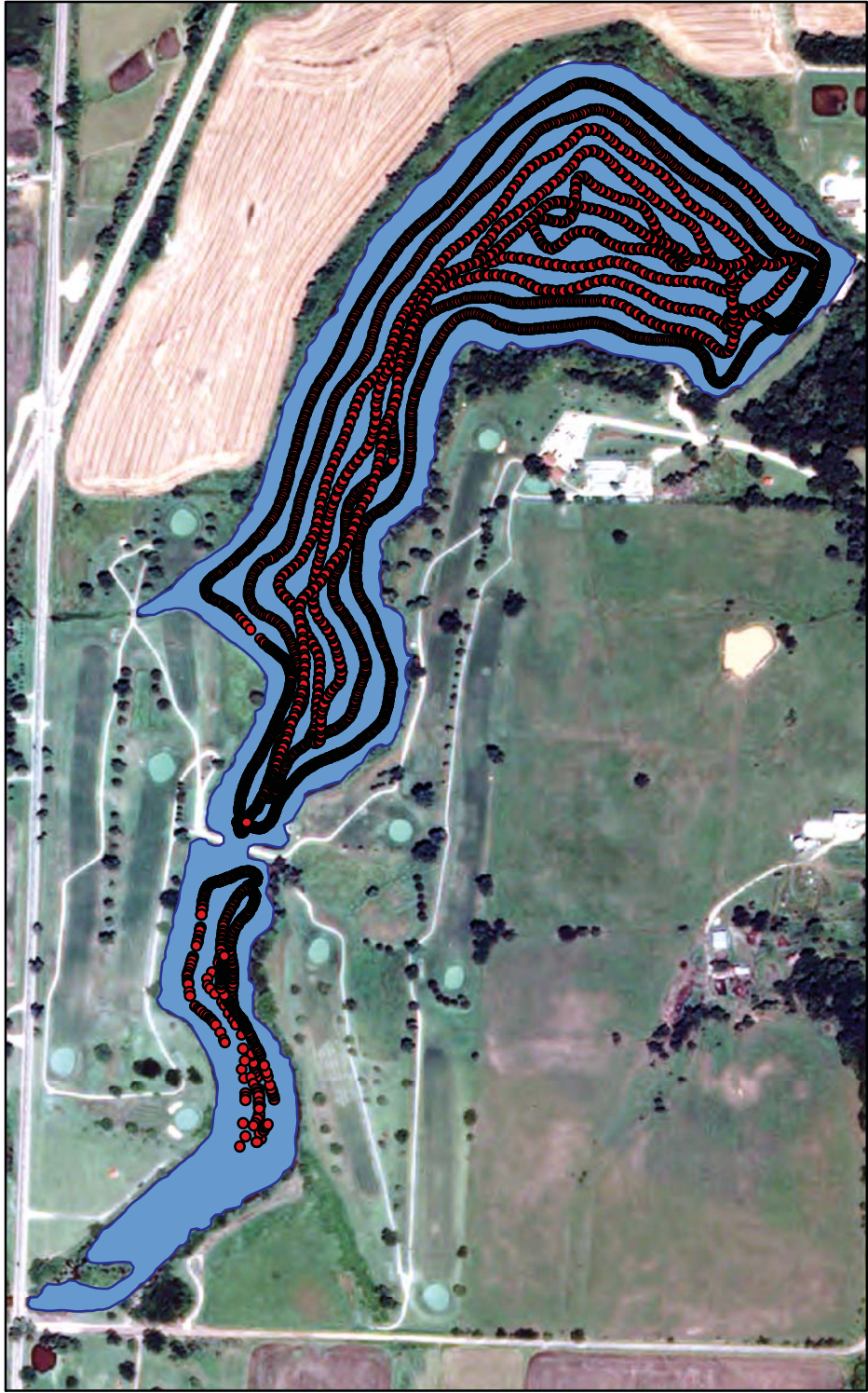


Figure 3a. View of dam and benchmark site.



Figure 3b. Close-up view of lake elevation benchmark site.





0 500 1,000 1,500 Feet



Figure 4. Bathymetric survey transects for Osage 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 ( $\text{ElevM} * 3.28084$ ).

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.

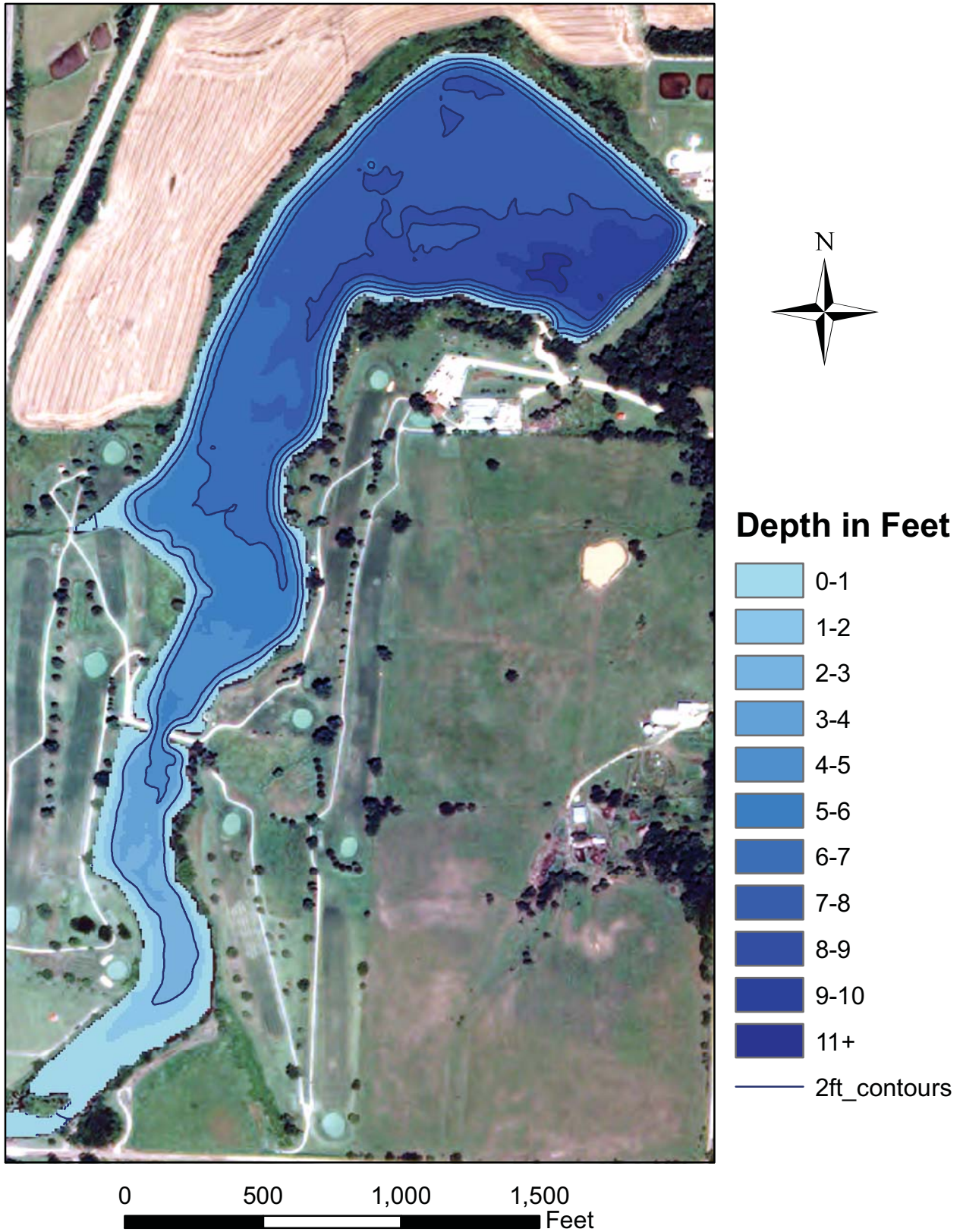


Figure 5. Water depth based on August 2009 bathymetric survey for Osage City Lake. Depths are based on a pool elevation of 1064.2 ft.

**Table 1**

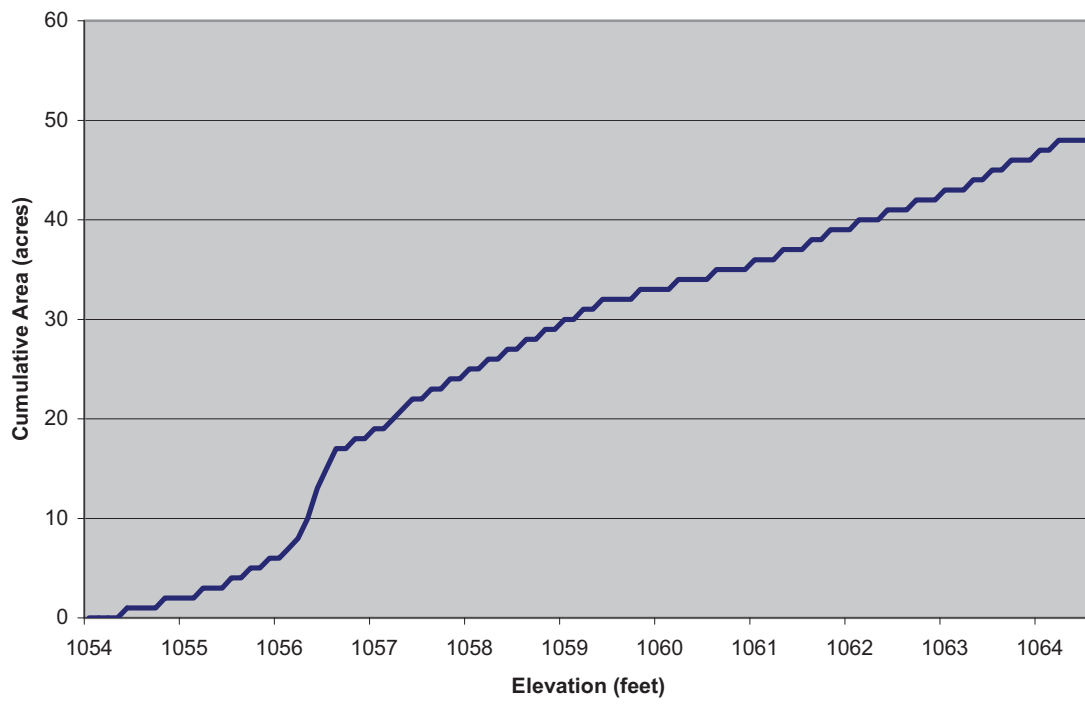
**Cumulative area in acres by tenth foot elevation increments**

<b><u>Elevation</u></b> <b><u>(ft NGVD)</u></b>	<b><u>0.00</u></b>	<b><u>0.10</u></b>	<b><u>0.20</u></b>	<b><u>0.30</u></b>	<b><u>0.40</u></b>	<b><u>0.50</u></b>	<b><u>0.60</u></b>	<b><u>0.70</u></b>	<b><u>0.80</u></b>	<b><u>0.90</u></b>
<b>1054</b>					1	1	1	1	2	2
<b>1055</b>	2	2	3	3	3	4	4	5	5	6
<b>1056</b>	6	7	8	10	13	15	17	17	18	18
<b>1057</b>	19	19	20	21	22	22	23	23	24	24
<b>1058</b>	25	25	26	26	27	27	28	28	29	29
<b>1059</b>	30	30	31	31	32	32	32	32	33	33
<b>1060</b>	33	33	34	34	34	34	35	35	35	35
<b>1061</b>	36	36	36	37	37	37	38	38	39	39
<b>1062</b>	39	40	40	40	41	41	41	42	42	42
<b>1063</b>	43	43	43	44	44	45	45	46	46	46
<b>1064</b>	47	47	48							

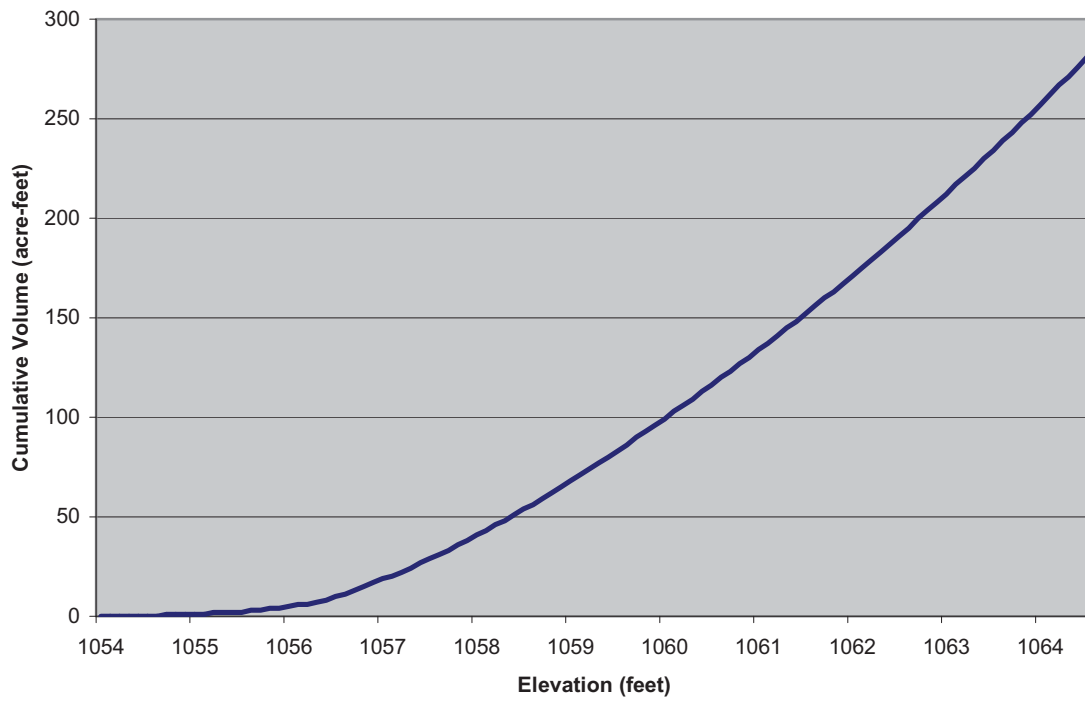
**Table 2**

**Cumulative volume in acre-feet by tenth foot elevation increments**

<b><u>Elevation</u></b> <b><u>(ft NGVD)</u></b>	<b><u>0.00</u></b>	<b><u>0.10</u></b>	<b><u>0.20</u></b>	<b><u>0.30</u></b>	<b><u>0.40</u></b>	<b><u>0.50</u></b>	<b><u>0.60</u></b>	<b><u>0.70</u></b>	<b><u>0.80</u></b>	<b><u>0.90</u></b>
<b>1054</b>					<1	<1	<1	1	1	1
<b>1055</b>	1	1	2	2	2	2	3	3	4	4
<b>1056</b>	5	6	6	7	8	10	11	13	15	17
<b>1057</b>	19	20	22	24	27	29	31	33	36	38
<b>1058</b>	41	43	46	48	51	54	56	59	62	65
<b>1059</b>	68	71	74	77	80	83	86	90	93	96
<b>1060</b>	99	103	106	109	113	116	120	123	127	130
<b>1061</b>	134	137	141	145	148	152	156	160	163	167
<b>1062</b>	171	175	179	183	187	191	195	200	204	208
<b>1063</b>	212	217	221	225	230	234	239	243	248	252
<b>1064</b>	257	262	267							



**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.

To assess bulk density, the syringe method described by Hilton et al (1986)<sup>1</sup> was used, employing a cutoff 35-ml syringe inserted into the exposed sample to extract a 15-cc sample of the sediment. Samples were ejected from the syringe using the plunger and sealed in sample canisters. In the lab, samples were weighed, dried at 100°C for 48 hours, and weighed again.

## **SEDIMENT SAMPLING RESULTS:**

Sampling sites were distributed across the length of the reservoir (Figure 8). Sand percentages decreased from 22% at the inflow end (OCL-1) to 0% near the dam (OCL-3). Silt percentages decreased from 50% to 32% from the inflow to the dam. Conversely, the clay fraction increased from the inflow end to the dam (Table 3; Figure 9; Figure 10).

**Table 3**  
**Osage City Lake Sediment Sampling Site Data**

<b>CODE</b>	<b>UTMX</b>	<b>UTMY</b>	<b>Bulk density (g/cm<sup>3</sup>)</b>	<b>%Sand</b>	<b>% Silt</b>	<b>% Clay</b>
OCL-1	253,013.6	4,277,507.1	0.76	22	50	28
OCL-2	253,144.5	4,277,929.4	0.61	2	42	56
OCL-3	253,424.2	4,278,174.1	0.52	0	32	68

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

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<sup>1</sup> J. Hilton, J., Lishman, P., and Millington, A. 1986. A comparison of some rapid techniques for the measurement of density in soft sediments. *Sedimentology* (33):777-781.

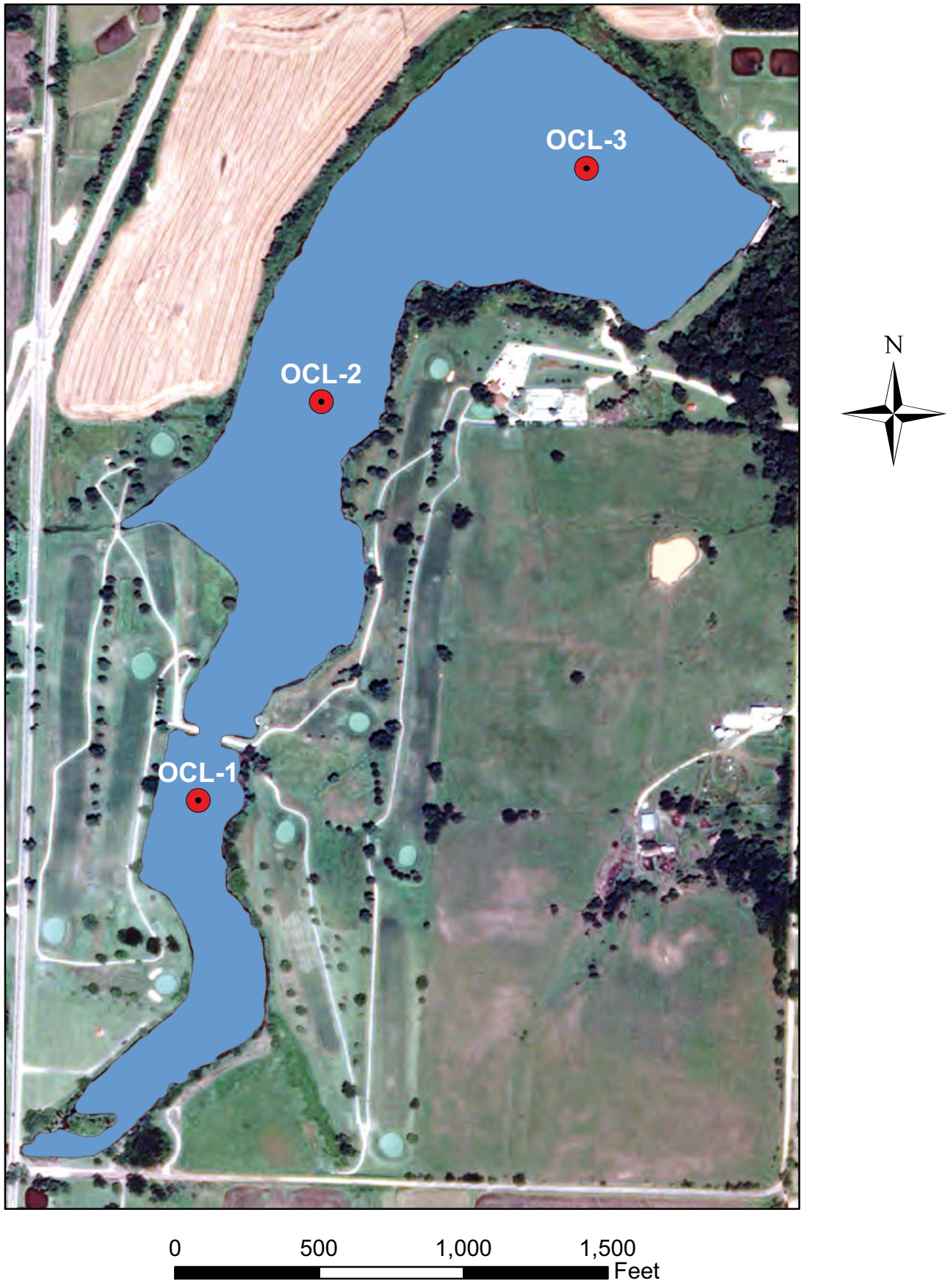
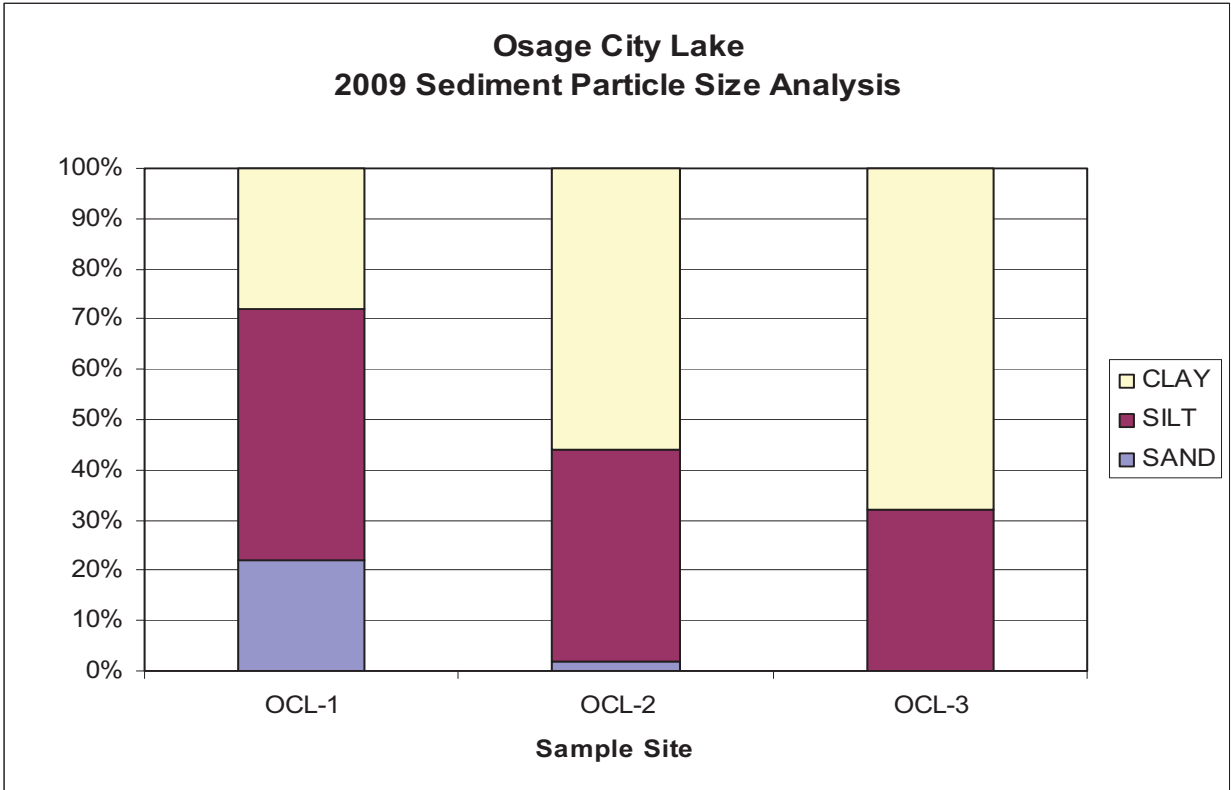


Figure 8. Location of sediment samples in Osage City Lake



**Figure 9. Sediment particle size analysis.**

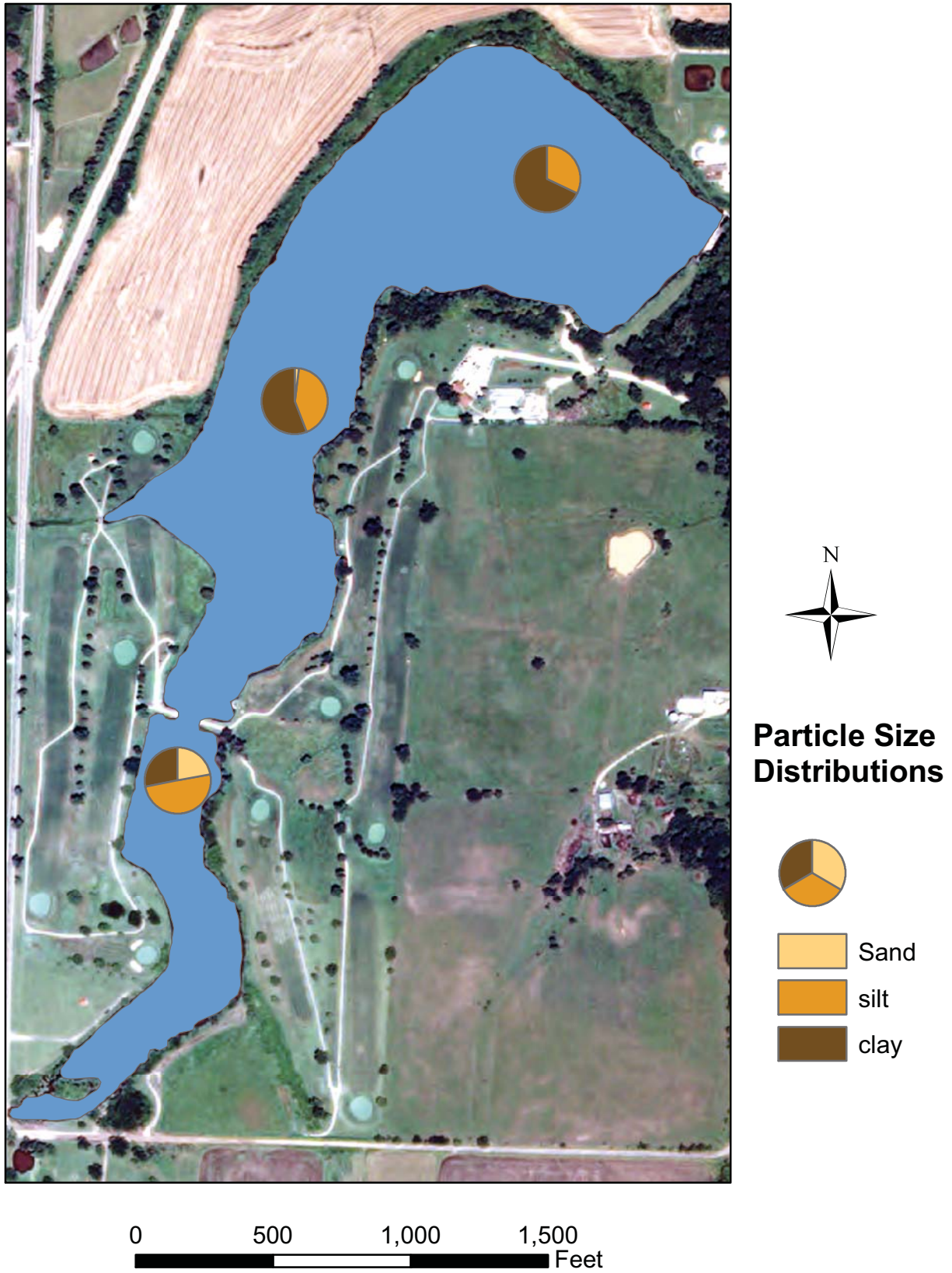


Figure 10. Particle size distribution of sediment samples in Osage City Lake