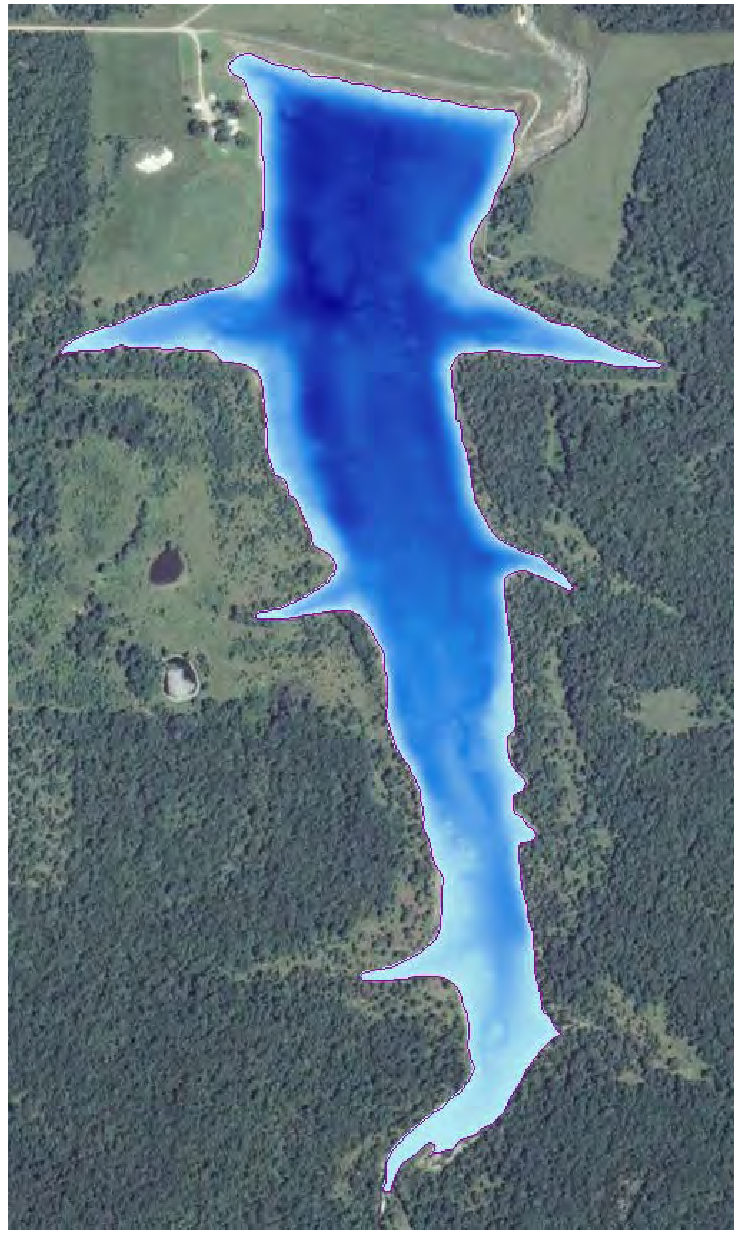
Bathymetric and Sediment Survey of Xenia Reservoir, Bourbon County, Kansas



Kansas Biological Survey

Applied Science and Technology for Reservoir Assessment (ASTRA) Program

Report 2012-06 (April 2013)

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

SUMMARY

On May 16, 2012, the Kansas Biological Survey (KBS) performed a bathymetric survey of Xenia City Reservoir 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:	May 16, 2012
Reservoir Statistics:		
	Elevation on survey date	921.6 ft
	Area on survey date:	61.1 acres
	Volume on survey date:	1452 acre-feet
	Maximum depth:	52 feet
Elevation Benchmark (if applicable)		
	UTM location of elevation benchmark:	325904, 4204464
	UTM Zone:	15N
	UTM datum:	NAD83
	Elevation of benchmark, from GPS:	923.632 ft.
	Vertical datum, all data:	NAVD88
Sediment Survey:		
	Date of sediment survey:	May 16, 2012

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LAKE HISTORY AND PERTINENT INFORMATION

Figure 1. Xenia Reservoir, Bourbon County, Kansas.

Xenia Reservoir is located approximately six miles northeast of the City of Bronson in northwest Bourbon County Kansas. This lake was completed in 1997 for a total cost of $2,016,000. The Multipurpose Small Lakes Program contributed $933,663. Bourbon County Rural Water District No. 4 acquired 12 percent of the available municipal water supply. The Kansas Water Office controls the remaining 88 percent of the storage or 0.46 million gallons per day. The dam is 1800 feet in length, and is of rolled earthen construction. The reservoir rests on a tributary of Limestone Creek.

Bourbon County, Kansas

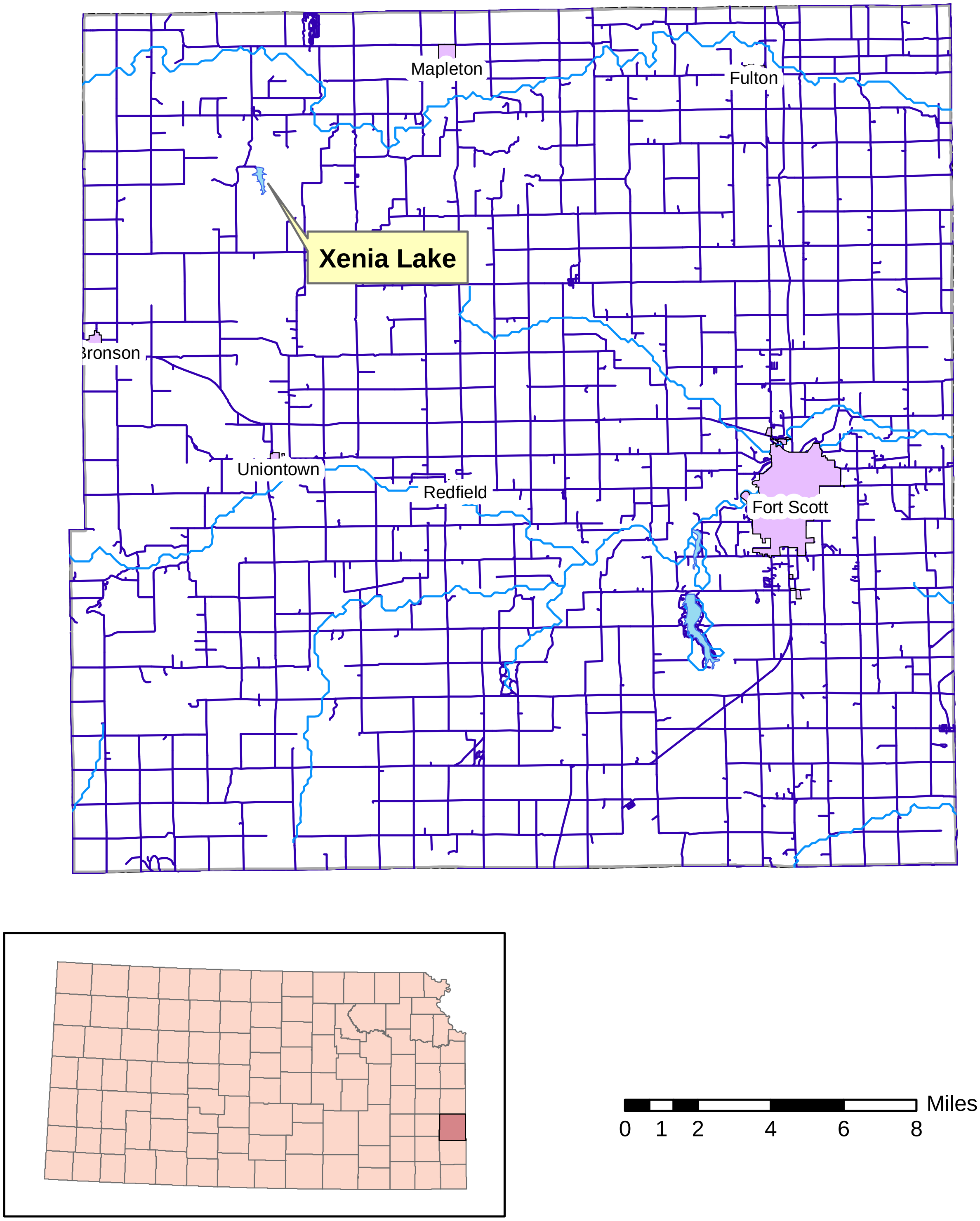

Figure 2. Location of Xenia Lake in Bourbon County, Kansas

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 Xenia Reservoir is a flat stone on the eastern shore of the reservoir near the east end of the dam (Figure 3a, Figure 3b).

The water surface elevation of Xenia Reservoir on May 16, 2012 was 921.61 feet AMSL, NAVD88.

Coordinates:
UTM zone 15N
325904.977
4204464.954

Location of Lake Elevation Benchmark:

Xenia Reservoir:

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

Figure 3b. Detail view of benchmark.

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FILE: log0136q00.12O OP1357660776278

                              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: January 08, 2013
RINEX FILE: log0136q.12o                          TIME: 16:00:34 UTC


  SOFTWARE: page5  1209.04 master63.pl 082112      START: 2012/05/15  16:06:00
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  ANT NAME: TPSHIPER_PLUS   NONE            # FIXED AMB:    34 /    37   :  92%
ARP HEIGHT: 0.93                            OVERALL RMS: 0.015(m)


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         Y:     -5015577.742(m)   0.013(m)         -5015576.359(m)   0.013(m)
         Z:      3903072.130(m)   0.017(m)          3903072.016(m)   0.017(m)

       LAT:   37 58 16.06728      0.019(m)       37 58 16.09051      0.019(m)
     E LON:  265  1  4.63597      0.006(m)      265  1  4.59921      0.006(m)
     W LON:   94 58 55.36403      0.006(m)       94 58 55.40079      0.006(m)
    EL HGT:          250.015(m)   0.012(m)              248.912(m)   0.012(m)
 ORTHO HGT:          281.523(m)   0.021(m) [NAVD88 (Computed using GEOID12A)]

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                         UTM (Zone 15)         SPC (1502 KS S)
Northing (Y) [meters]     4204464.954           550606.362
Easting (X)  [meters]      325904.977           709018.680
Convergence  [degrees]    -1.21978812           2.16188190
Point Scale                0.99997331           0.99993635
Combined Factor            0.99993408           0.99989712

US NATIONAL GRID DESIGNATOR: 15SUC2590404464(NAD 83)


                              BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
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DF9221 ZKC1 KANSAS CTY WAAS 1 CORS ARP     N385248.550 W0944726.963  102281.3
DL2740 MOSB SEILER BELTON CORS ARP         N384948.686 W0943204.447  103062.5

                 NEAREST NGS PUBLISHED CONTROL POINT
HE1161      POPULAR                        N375532.964 W0945600.390    6606.1

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.
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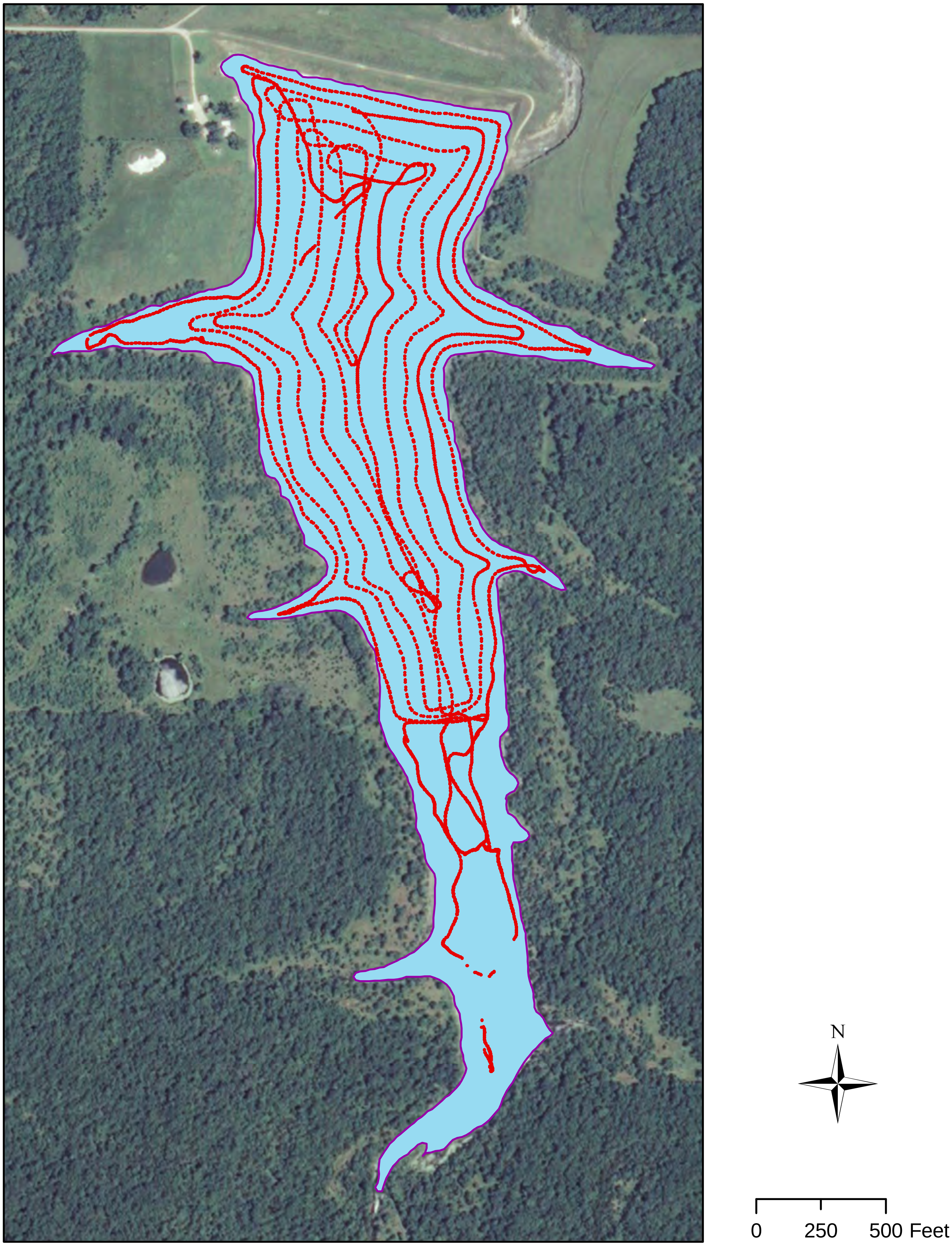

Figure 4. Bathymetric survey transects for Xenia Reservoir.

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.

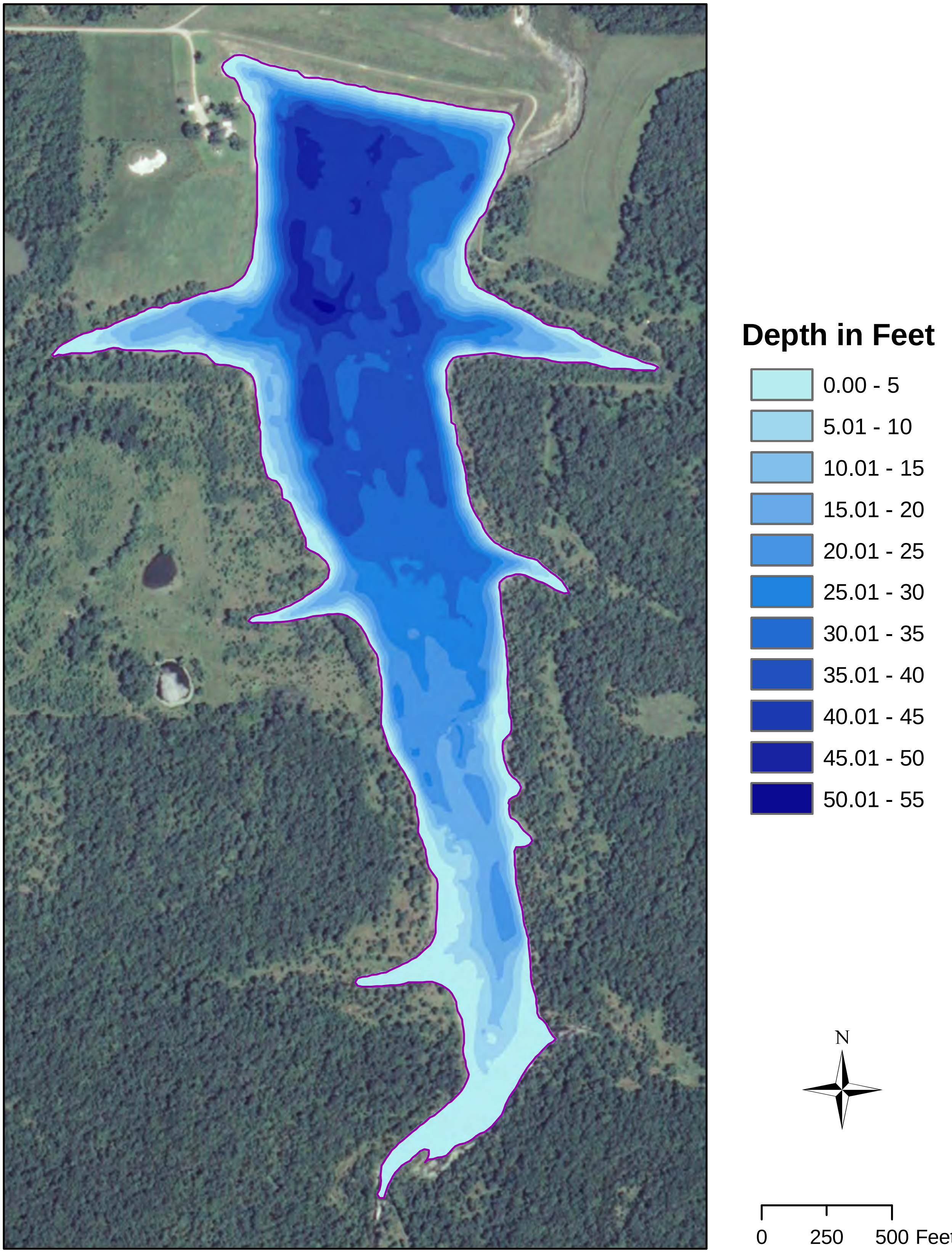

Figure 5. Lake depth map for Xenia Reservoir.

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
870	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
871	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
872	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
873	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3
874	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5
875	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.9
876	0.9	1.0	1.1	1.2	1.3	1.3	1.4	1.5	1.5	1.6
877	1.7	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5
878	2.7	2.8	2.9	3.1	3.2	3.4	3.5	3.6	3.8	4.0
879	4.2	4.3	4.5	4.6	4.8	5.0	5.1	5.3	5.5	5.6
880	5.8	6.0	6.1	6.3	6.4	6.6	6.7	6.8	7.0	7.1
881	7.2	7.4	7.5	7.6	7.7	7.9	8.0	8.1	8.3	8.4
882	8.6	8.7	8.9	9.1	9.3	9.4	9.6	9.8	10.0	10.2
883	10.3	10.5	10.7	10.9	11.0	11.2	11.4	11.6	11.8	12.0
884	12.2	12.4	12.6	12.8	13.0	13.2	13.4	13.6	13.8	14.0
885	14.1	14.3	14.5	14.7	14.9	15.0	15.2	15.4	15.6	15.8
886	16.0	16.2	16.4	16.6	16.8	17.0	17.2	17.4	17.6	17.8
887	18.1	18.3	18.5	18.8	19.0	19.3	19.6	19.9	20.1	20.3
888	20.5	20.6	20.8	20.9	21.1	21.2	21.4	21.5	21.7	21.8
889	21.9	22.1	22.2	22.3	22.4	22.6	22.7	22.8	22.9	23.0
890	23.2	23.3	23.4	23.5	23.6	23.7	23.8	23.9	24.0	24.1
891	24.2	24.3	24.4	24.5	24.6	24.7	24.8	24.9	25.1	25.2
892	25.3	25.4	25.5	25.6	25.8	25.9	26.0	26.1	26.2	26.3
893	26.4	26.5	26.6	26.7	26.8	27.0	27.1	27.2	27.3	27.4
894	27.5	27.6	27.7	27.9	28.0	28.1	28.2	28.2	28.3	28.4
895	28.5	28.6	28.7	28.8	28.9	29.0	29.1	29.3	29.4	29.5
896	29.7	29.8	30.0	30.1	30.3	30.4	30.6	30.7	30.8	31.0
897	31.1	31.2	31.4	31.5	31.7	31.8	31.9	32.1	32.2	32.3
898	32.5	32.6	32.7	32.9	33.0	33.2	33.3	33.5	33.6	33.8
899	34.0	34.1	34.2	34.3	34.5	34.6	34.7	34.8	34.9	35.1

Table 1, continued

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
900	35.2	35.3	35.4	35.5	35.6	35.7	35.8	35.9	36.0	36.1
901	36.2	36.3	36.4	36.5	36.6	36.7	36.8	36.9	37.0	37.1
902	37.2	37.3	37.4	37.6	37.7	37.8	37.9	38.0	38.1	38.2
903	38.3	38.4	38.6	38.7	38.8	38.9	39.0	39.2	39.3	39.4
904	39.5	39.6	39.8	39.9	40.0	40.1	40.3	40.4	40.5	40.6
905	40.7	40.8	41.0	41.1	41.2	41.3	41.4	41.5	41.6	41.7
906	41.8	41.9	42.0	42.1	42.2	42.4	42.5	42.6	42.7	42.8
907	42.9	43.0	43.2	43.3	43.4	43.5	43.6	43.7	43.7	43.8
908	43.9	44.0	44.1	44.2	44.3	44.3	44.4	44.5	44.6	44.7
909	44.8	44.9	44.9	45.0	45.1	45.2	45.3	45.4	45.4	45.5
910	45.6	45.7	45.8	45.9	46.0	46.0	46.1	46.2	46.3	46.4
911	46.5	46.6	46.7	46.7	46.8	46.9	47.0	47.1	47.2	47.3
912	47.4	47.4	47.5	47.6	47.7	47.8	47.9	48.0	48.1	48.2
913	48.3	48.3	48.4	48.5	48.6	48.7	48.8	48.9	49.0	49.1
914	49.2	49.3	49.4	49.5	49.6	49.7	49.8	49.9	50.0	50.1
915	50.2	50.3	50.4	50.5	50.6	50.7	50.8	50.9	51.1	51.2
916	51.3	51.4	51.5	51.6	51.7	51.8	52.0	52.1	52.2	52.3
917	52.4	52.6	52.7	52.8	53.0	53.1	53.2	53.4	53.5	53.6
918	53.8	53.9	54.1	54.2	54.4	54.5	54.7	54.8	55.0	55.2
919	55.3	55.5	55.7	55.8	56.0	56.2	56.4	56.6	56.7	56.9
920	57.1	57.3	57.5	57.7	57.9	58.1	58.4	58.6	58.8	59.0
921	59.3	59.5	59.8	60.1	60.4	60.7	61.1			

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
870	0	0	0	0	0	0	0	0	0	0
871	0	0	0	0	0	0	0	0	0	0
872	0	0	0	0	0	0	0	0	0	0
873	0	0	0	0	0	0	0	0	0	0
874	0	1	1	1	1	1	1	1	1	1
875	1	1	1	1	1	1	1	1	1	1
876	2	2	2	2	2	2	2	2	3	3
877	3	3	3	3	4	4	4	4	4	5
878	5	5	6	6	6	6	7	7	8	8
879	8	9	9	10	10	11	11	12	12	13
880	13	14	15	15	16	16	17	18	18	19
881	20	21	21	22	23	24	24	25	26	27
882	28	29	30	30	31	32	33	34	35	36
883	37	38	39	40	42	43	44	45	46	47
884	48	50	51	52	54	55	56	58	59	60
885	62	63	65	66	68	69	71	72	74	75
886	77	78	80	82	83	85	87	88	90	92
887	94	96	97	99	101	103	105	107	109	111
888	113	115	117	119	121	124	126	128	130	132
889	134	137	139	141	143	145	148	150	152	155
890	157	159	162	164	166	169	171	173	176	178
891	181	183	185	188	190	193	195	198	200	203
892	205	208	210	213	216	218	221	223	226	229
893	231	234	236	239	242	245	247	250	253	255
894	258	261	264	266	269	272	275	278	281	283
895	286	289	292	295	298	301	304	306	309	312
896	315	318	321	324	327	330	333	336	340	343
897	346	349	352	355	358	361	365	368	371	374
898	378	381	384	387	391	394	397	401	404	407
899	411	414	418	421	424	428	431	435	438	442

Table 2, continued

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
900	445	449	452	456	460	463	467	470	474	477
901	481	485	488	492	496	499	503	507	510	514
902	518	522	525	529	533	537	540	544	548	552
903	556	559	563	567	571	575	579	583	587	591
904	595	599	603	607	611	615	619	623	627	631
905	635	639	643	647	651	655	659	664	668	672
906	676	680	684	689	693	697	701	706	710	714
907	718	723	727	731	736	740	744	749	753	758
908	762	766	771	775	780	784	788	793	797	802
909	806	811	815	820	824	829	833	838	842	847
910	852	856	861	865	870	874	879	884	888	893
911	898	902	907	912	916	921	926	930	935	940
912	945	949	954	959	964	968	973	978	983	988
913	992	997	1002	1007	1012	1017	1022	1026	1031	1036
914	1041	1046	1051	1056	1061	1066	1071	1076	1081	1086
915	1091	1096	1101	1106	1111	1116	1121	1126	1131	1137
916	1142	1147	1152	1157	1162	1167	1173	1178	1183	1188
917	1194	1199	1204	1209	1215	1220	1225	1231	1236	1241
918	1247	1252	1258	1263	1268	1274	1279	1285	1290	1296
919	1301	1307	1312	1318	1324	1329	1335	1340	1346	1352
920	1358	1363	1369	1375	1381	1386	1392	1398	1404	1410
921	1416	1422	1428	1434	1440	1446	1452			

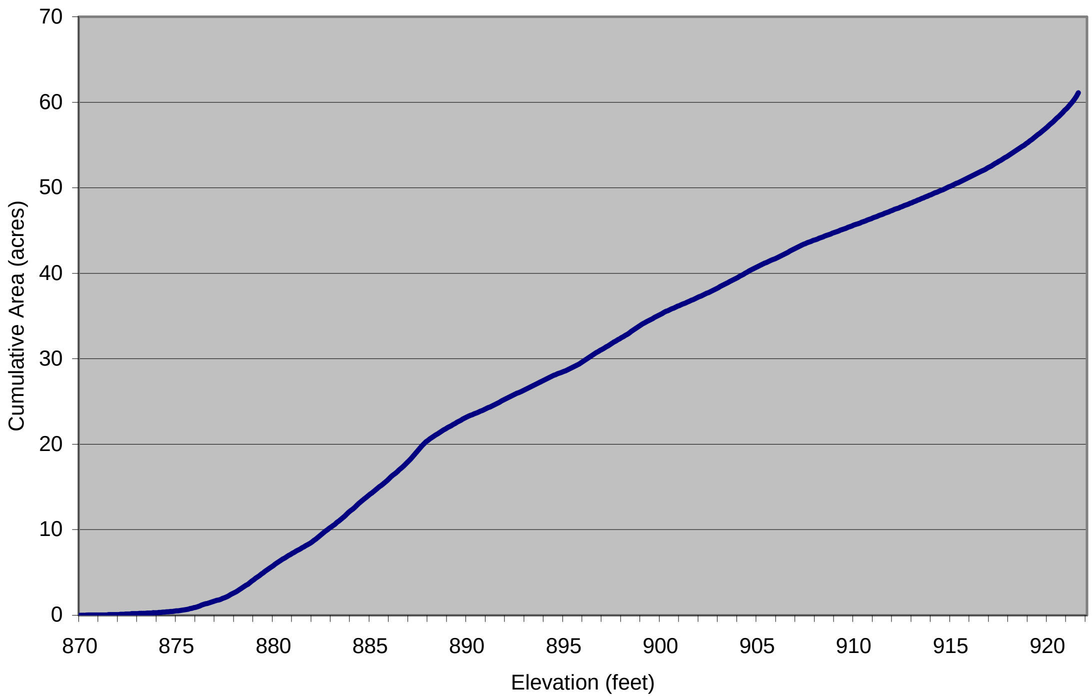

Figure 6. Cumulative area-elevation curve

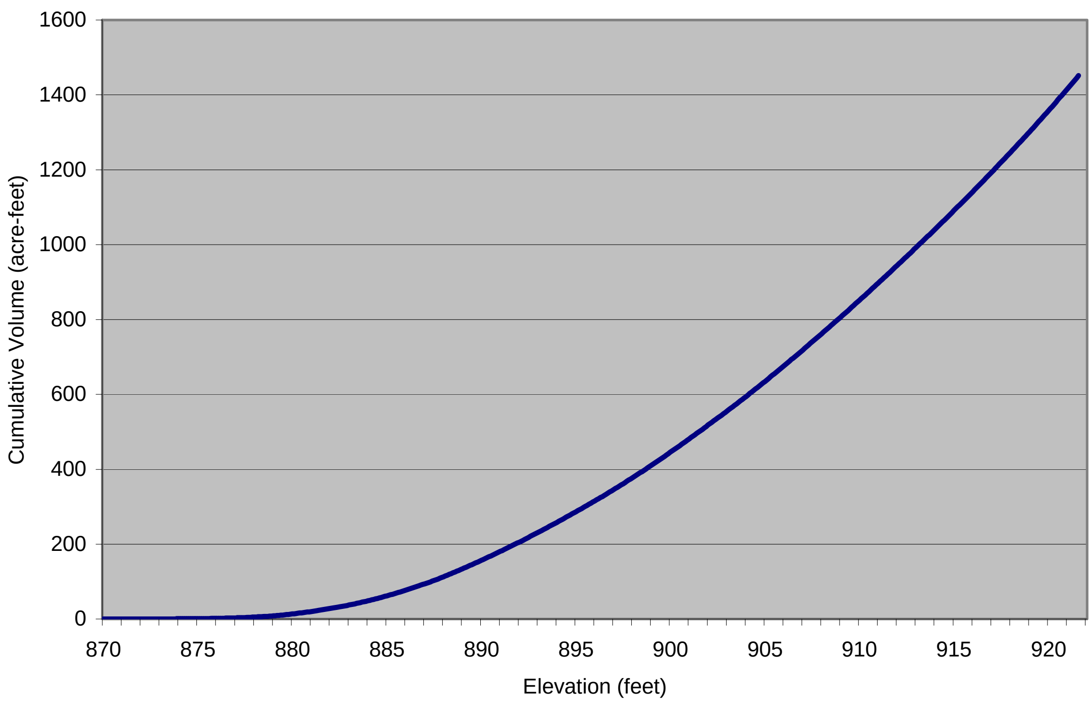

Figure 7. Cumulative volume-elevation curve

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 across the length of the reservoir (Figure 8). Sand was absent from two of three samples, and only a very minor fraction in XEN-2 (Table 3; Figure 9; Figure 10).

Table 3
Sediment sampling site data

CODE	UTMX	UTMY	%Sand	% Silt	% Clay
XEN-1	325726	4204422	0	42	58
XEN-2	325725	4204150	2	42	56
XEN-3	325814	4203850	0	48	52

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

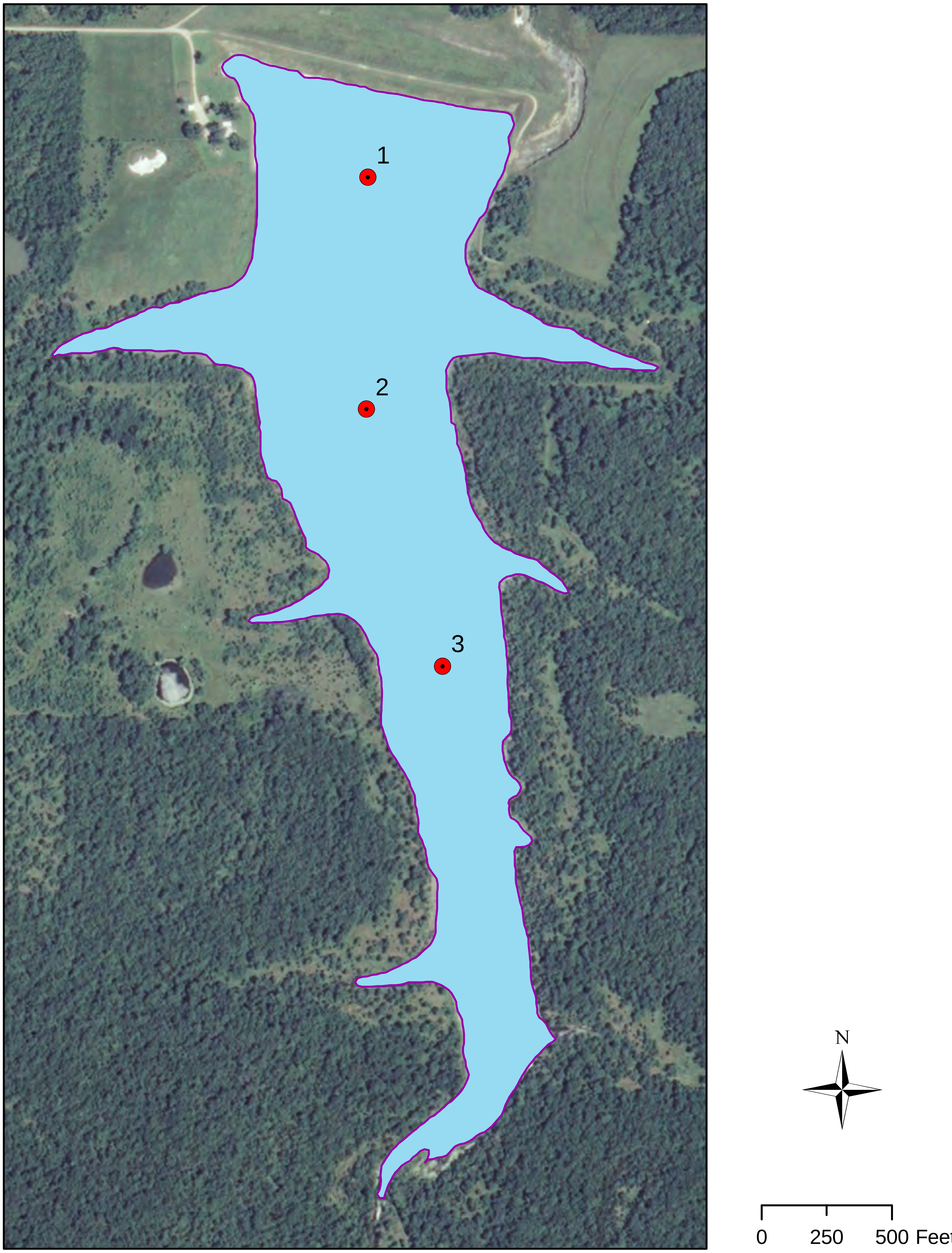

Figure 8. Sediment sampling locations in Xenia Reservoir.

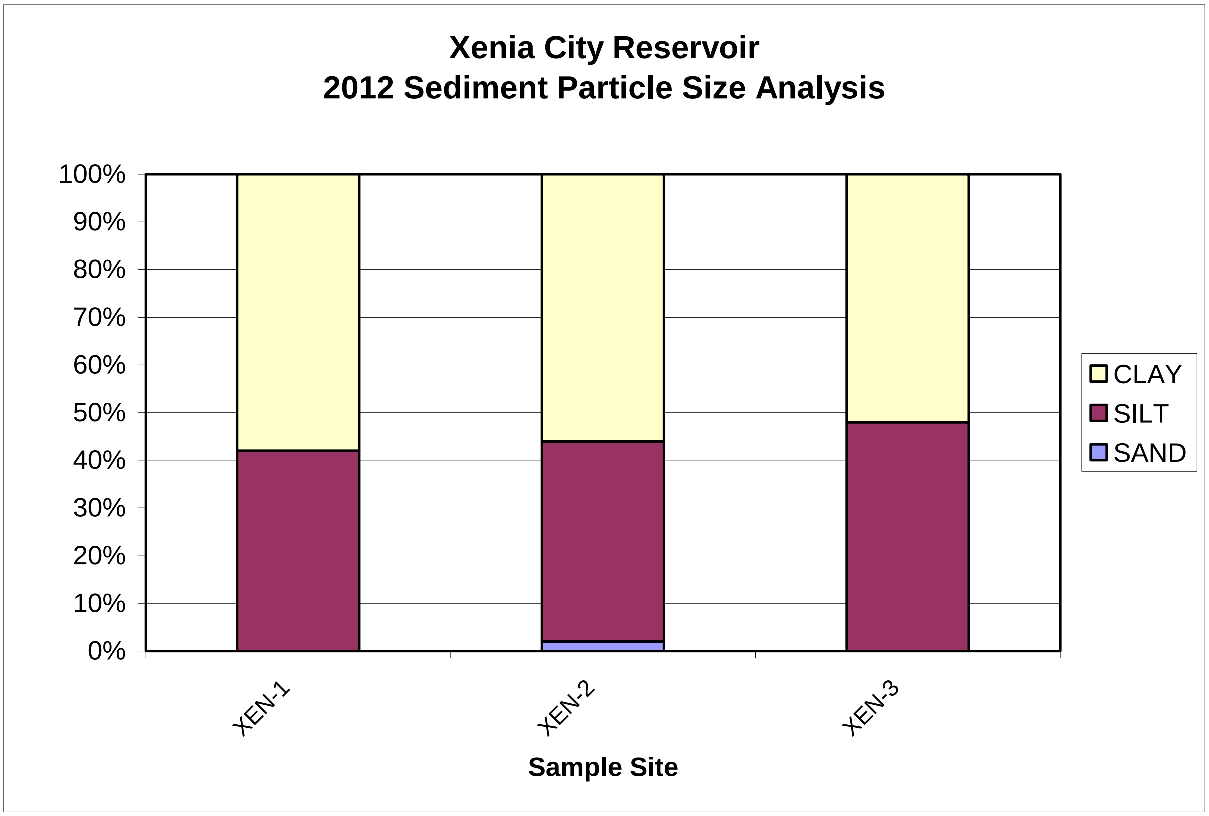

Figure 9. Sediment particle size analysis.

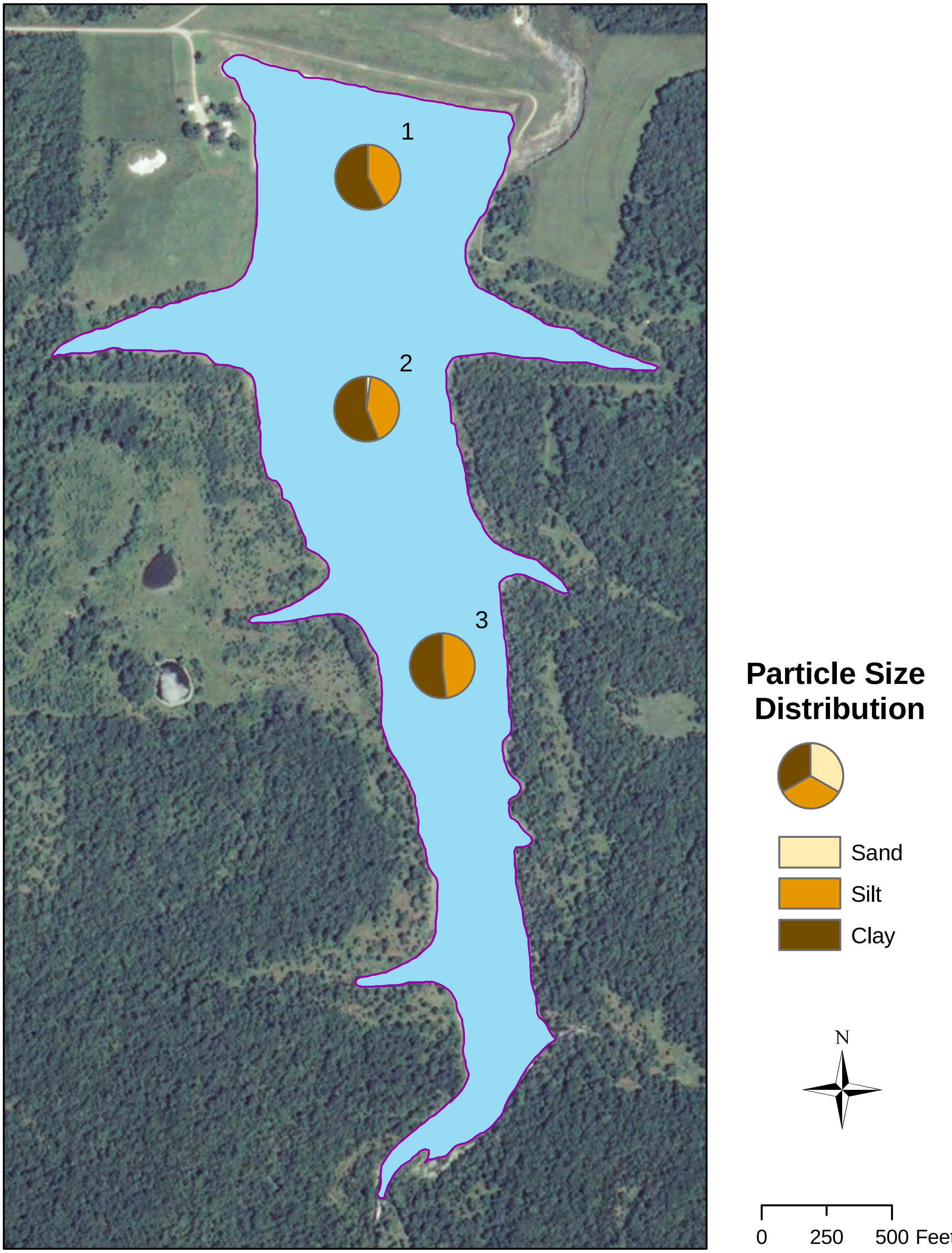

Figure 10. Particle size distribution of sediment samples in Xenia Reservoir.