

Bathymetric and Sediment Survey of Polk Daniels Lake, Elk County, Kansas



Kansas Biological Survey
*Applied Science and Technology for
Reservoir Assessment (ASTRA) Program*
Report 2011-09 (March 2011)



KANSAS

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

SUMMARY

On August 31, 2010, the Kansas Biological Survey (KBS) performed a bathymetric survey of Polk Daniels Lake in Elk 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:		August 31, 2010
Reservoir Statistics:		
Elevation on survey date		991.28 ft
Area on survey date:		60.6 acres
Volume on survey date:		506.5 acre-feet
Maximum depth:		21.2 ft
Elevation Benchmark (if applicable)		
UTM location of elevation benchmark:		745387.10, 4150059.00
UTM Zone:		14N
UTM datum:		NAD83
Elevation of benchmark, from GPS:		995.55 ft.
Vertical datum, all data:		NAVD88
Sediment Survey:		
Date of sediment survey:		August 31, 2010

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LAKE HISTORY AND PERTINENT INFORMATION



Figure 1. Polk Daniels Lake, Elk County, Kansas.

Polk Daniels Lake is a community lake that is located a little over a mile east of Howard, Kansas. Polk Daniels Lake was constructed as a WPA (Works Progress Administration) project, and was completed in 1935. Owned by the City of Howard, Polk Daniels serves as a water supply for the city, as well as providing various recreational activities to the surrounding community.

Elk County, Kansas

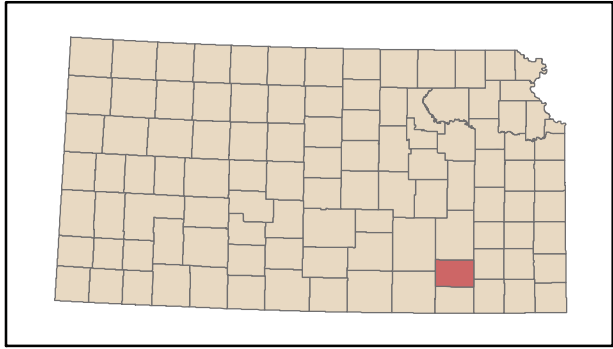
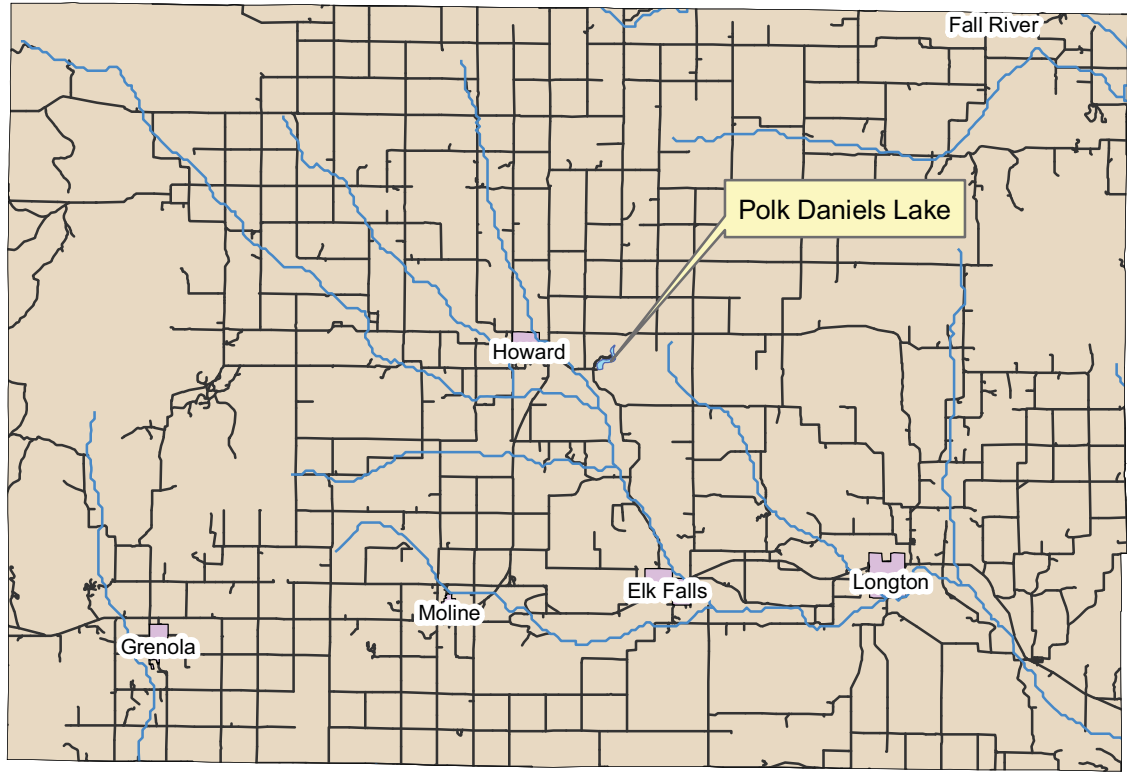


Figure 2. Location of Polk Daniels Lake in Elk County, Kansas

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 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 to create lake bottom elevation and water depth models.

The ASTRA elevation benchmark for Polk Daniels Lake is a concrete pad just west of the boat ramp, on the north side of the lake (Figure 3a, Figure 3b, Figure 3c). The water surface elevation of Polk Daniels Lake of August 31, 2010 was **991.28** feet AMSL.

Coordinates:
UTM Zone 14
East: 745387.10
North: 4150059.00



Figure 3a. Location of ASTRA benchmark on Polk Daniels Lake.

Location of Lake Elevation Benchmark:

Polk Daniels Lake:

UTM (Zone 14) Easting (X) [meters] 745387.10, Northing (Y) [meters] 4150059.00



Figure 3b. View of concrete slab benchmark site, facing south.



Figure 3c. View of benchmark site, facing south.

FILE: log0180o.100 000047099

NGS OPUS SOLUTION REPORT

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

USER: mjakub@ku.edu DATE: July 22, 2010
RINEX FILE: log0180o.10o TIME: 20:47:58 UTC

SOFTWARE: page5 0909.08 master50.pl 081023 START: 2010/06/29 14:58:00
EPHEMERIS: igs15902.eph [precise] STOP: 2010/06/29 17:32:30
NAV FILE: brdc1800.10n OBS USED: 4528 / 5453 : 83%
ANT NAME: TPSHIPER_PLUS NONE # FIXED AMB: 33 / 43 : 77%
ARP HEIGHT: .7874 OVERALL RMS: 0.018 (m)

REF FRAME: NAD_83 (CORS96) (EPOCH:2002.0000) ITRF00 (EPOCH:2010.4923)

X: -549682.140 (m) 0.220 (m) -549682.879 (m) 0.220 (m)
Y: -5039102.716 (m) 0.120 (m) -5039101.340 (m) 0.120 (m)
Z: 3858635.839 (m) 0.093 (m) 3858635.698 (m) 0.093 (m)

LAT: 37 27 53.51132 0.022 (m) 37 27 53.53310 0.022 (m)
E LON: 263 46 28.55885 0.224 (m) 263 46 28.52288 0.224 (m)
W LON: 96 13 31.44115 0.224 (m) 96 13 31.47712 0.224 (m)
EL HGT: 273.279 (m) 0.134 (m) 272.172 (m) 0.134 (m)
ORTHO HGT: 303.446 (m) 0.134 (m) [NAVD88 (Computed using GEOID09)]

	UTM COORDINATES	STATE PLANE COORDINATES
	UTM (Zone 14)	SPC (1502 KS S)
Northing (Y) [meters]	4150059.004	491042.207
Easting (X) [meters]	745387.105	601200.081
Convergence [degrees]	1.68856118	1.39780545
Point Scale	1.00034178	0.99996695
Combined Factor	1.00029888	0.99992407

US NATIONAL GRID DESIGNATOR: 14SQG4538750059 (NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE (m)
DK6489	ICT2 WICHITA ICT2 CORS ARP	N374506.458	W0972205.232	105809.2
DK6487	ICT1 WICHITA ICT1 CORS ARP	N373515.773	W0971831.959	96742.5
DK6491	ICT3 WICHITA ICT3 CORS ARP	N374509.312	W0971258.381	93135.8

NEAREST NGS PUBLISHED CONTROL POINT

HF0093	73	N372918.	W0961413.	2804.6
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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.

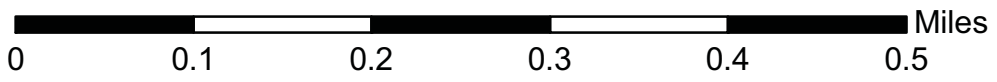
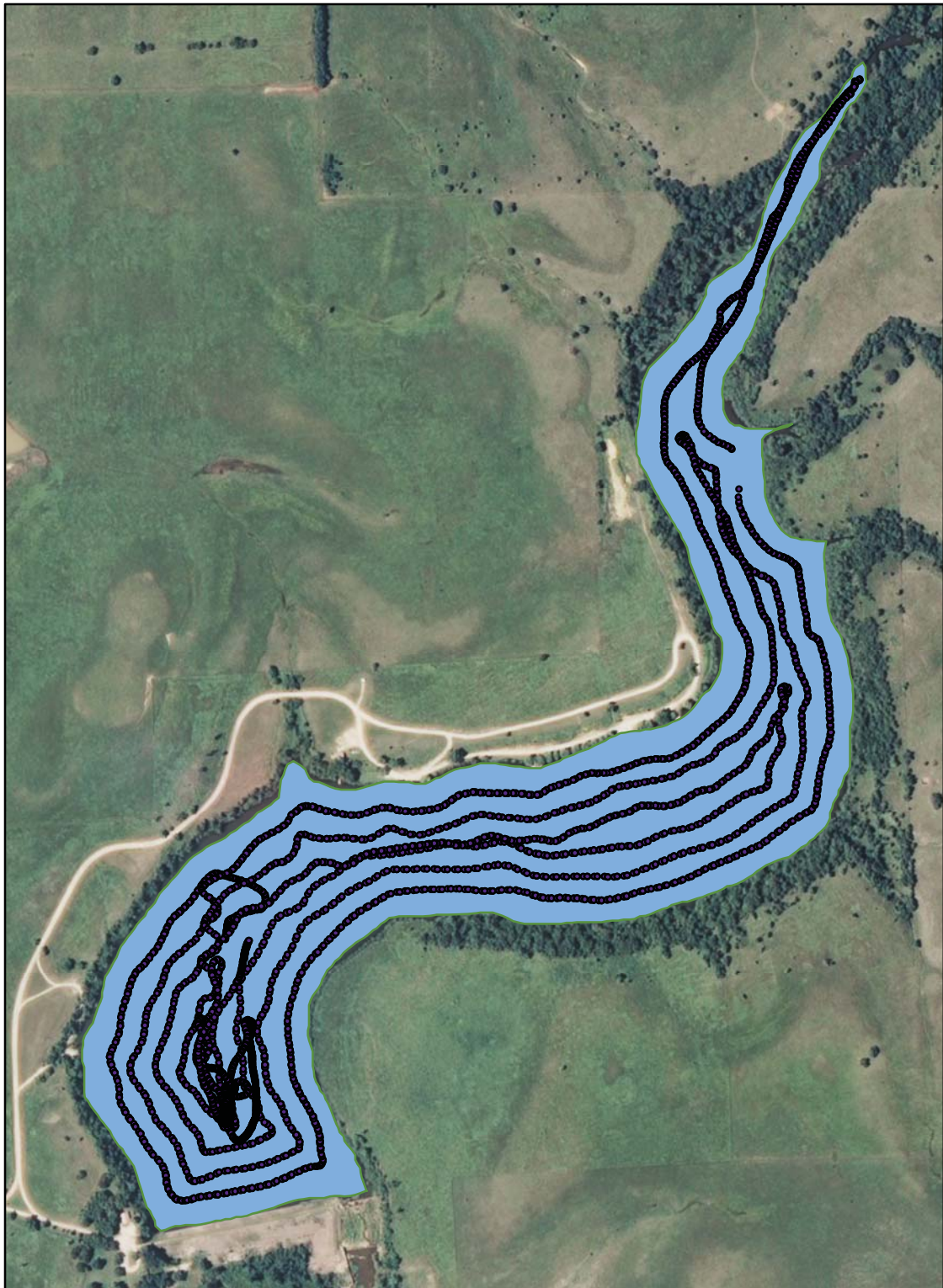


Figure 4. Bathymetric survey lines for Polk Daniels Lake

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.

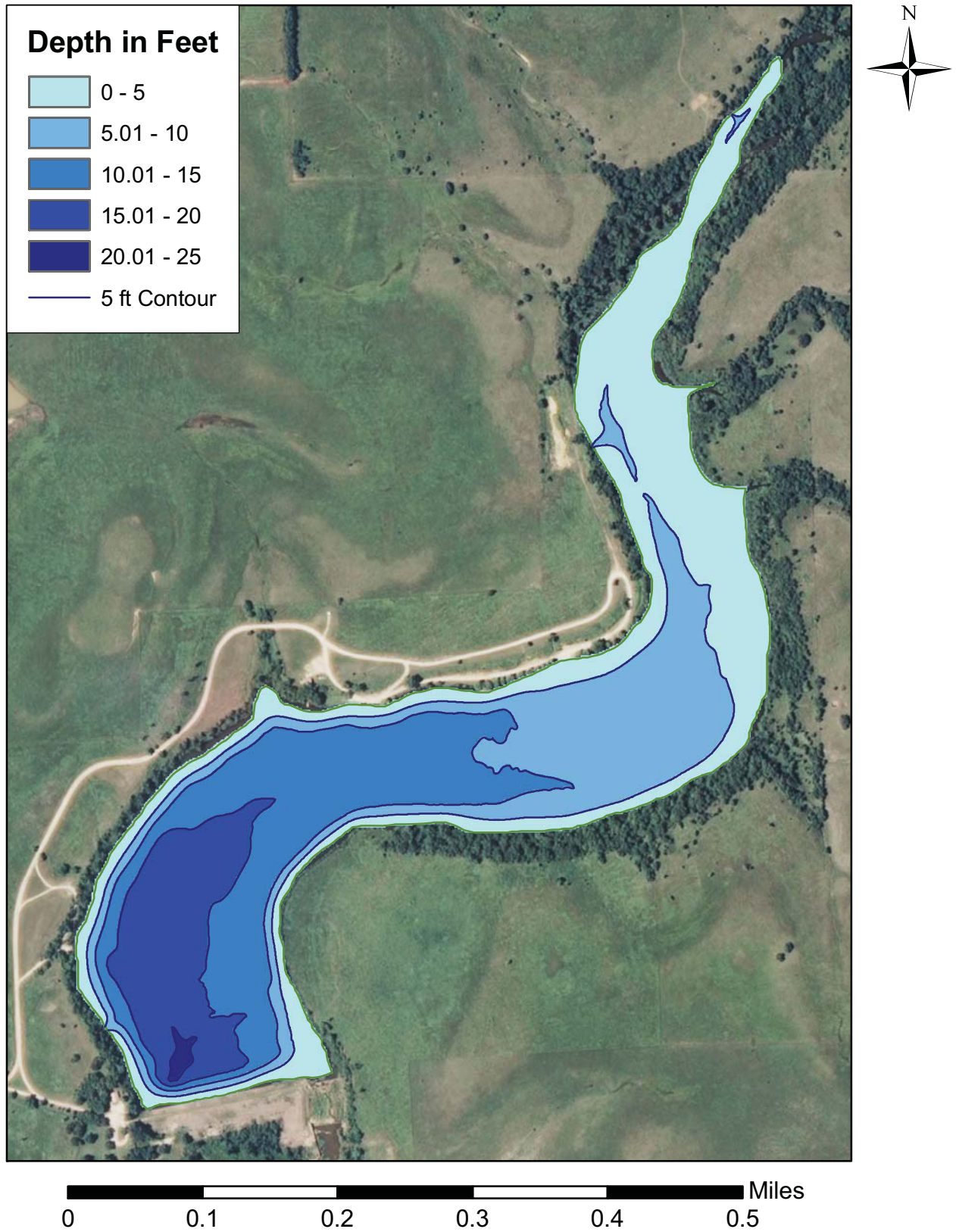


Figure 5. Water depth based on August 31, 2010 bathymetric surveys for Polk Daniels Lake. Depths are based on a pool elevation of 991.28 ft.

Table 1

Cumulative area in acres by tenth foot elevation increments

<u>Elevation (ft NGVD)</u>	<u>0.00</u>	<u>0.10</u>	<u>0.20</u>	<u>0.30</u>	<u>0.40</u>	<u>0.50</u>	<u>0.60</u>	<u>0.70</u>	<u>0.80</u>	<u>0.90</u>
970	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2
971	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5
972	0.5	0.6	0.7	0.7	0.8	0.9	1.0	1.1	1.2	1.3
973	1.4	1.5	1.6	1.7	1.8	1.9	2.1	2.3	2.5	2.7
974	2.9	3.1	3.3	3.6	3.8	4.0	4.2	4.5	4.7	5.0
975	5.2	5.4	5.7	6.0	6.2	6.5	6.7	7.0	7.3	7.5
976	7.8	8.1	8.3	8.6	8.9	9.1	9.4	9.7	10.0	10.3
977	10.6	11.0	11.3	11.7	12.0	12.4	12.8	13.1	13.6	14.0
978	14.5	15.0	15.5	15.9	16.2	16.6	16.9	17.2	17.4	17.7
979	18.0	18.2	18.4	18.7	18.9	19.1	19.4	19.6	19.8	20.0
980	20.2	20.5	20.7	20.9	21.2	21.4	21.7	22.0	22.3	22.6
981	22.9	23.2	23.6	24.0	24.5	24.9	25.2	25.5	25.8	26.1
982	26.3	26.6	26.9	27.1	27.4	27.6	27.9	28.1	28.4	28.6
983	28.9	29.2	29.5	29.8	30.1	30.4	30.8	31.2	31.5	31.9
984	32.3	32.8	33.2	33.7	34.1	34.5	34.9	35.2	35.6	35.9
985	36.2	36.5	36.7	37.0	37.2	37.4	37.7	37.9	38.2	38.5
986	38.8	39.1	39.4	39.7	40.0	40.4	40.7	41.0	41.4	41.8
987	42.2	42.8	43.5	44.1	44.6	45.3	45.9	46.5	47.1	47.6
988	48.1	48.5	49.0	49.4	49.8	50.2	50.6	51.0	51.3	51.7
989	52.0	52.4	52.7	53.1	53.4	53.8	54.1	54.5	54.8	55.1
990	55.5	55.9	56.2	56.6	57.0	57.4	57.7	58.2	58.6	59.0
991	59.5	60.0	60.6							

Table 2

Cumulative volume in acre-feet by tenth foot elevation increments

<u>Elevation (ft NGVD)</u>	<u>0.00</u>	<u>0.10</u>	<u>0.20</u>	<u>0.30</u>	<u>0.40</u>	<u>0.50</u>	<u>0.60</u>	<u>0.70</u>	<u>0.80</u>	<u>0.90</u>
970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
971	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4
972	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
973	1.3	1.5	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.1
974	3.3	3.7	4.0	4.3	4.7	5.1	5.5	5.9	6.4	6.9
975	7.4	7.9	8.5	9.0	9.6	10.3	10.9	11.6	12.3	13.1
976	13.8	14.6	15.5	16.3	17.2	18.1	19.0	20.0	20.9	22.0
977	23.0	24.1	25.2	26.4	27.5	28.8	30.0	31.3	32.7	34.0
978	35.5	36.9	38.5	40.0	41.7	43.3	45.0	46.7	48.4	50.2
979	51.9	53.7	55.6	57.4	59.3	61.2	63.1	65.1	67.1	69.1
980	71.1	73.1	75.2	77.2	79.4	81.5	83.6	85.8	88.0	90.3
981	92.6	94.9	97.2	99.6	102.0	104.5	107.0	109.5	112.1	114.7
982	117.3	120.0	122.6	125.3	128.1	130.8	133.6	136.4	139.2	142.1
983	144.9	147.8	150.8	153.7	156.7	159.8	162.8	165.9	169.1	172.2
984	175.4	178.7	182.0	185.3	188.7	192.2	195.6	199.2	202.7	206.3
985	209.9	213.5	217.2	220.9	224.6	228.3	232.1	235.9	239.7	243.5
986	247.4	251.3	255.2	259.1	263.1	267.1	271.2	275.3	279.4	283.6
987	287.8	292.0	296.3	300.7	305.2	309.7	314.2	318.8	323.5	328.3
988	333.0	337.9	342.8	347.7	352.7	357.7	362.7	367.8	372.9	378.1
989	383.2	388.5	393.7	399.0	404.4	409.7	415.1	420.6	426.0	431.5
990	437.1	442.6	448.2	453.9	459.6	465.3	471.1	476.9	482.7	488.6
991	494.5	500.5	506.5							

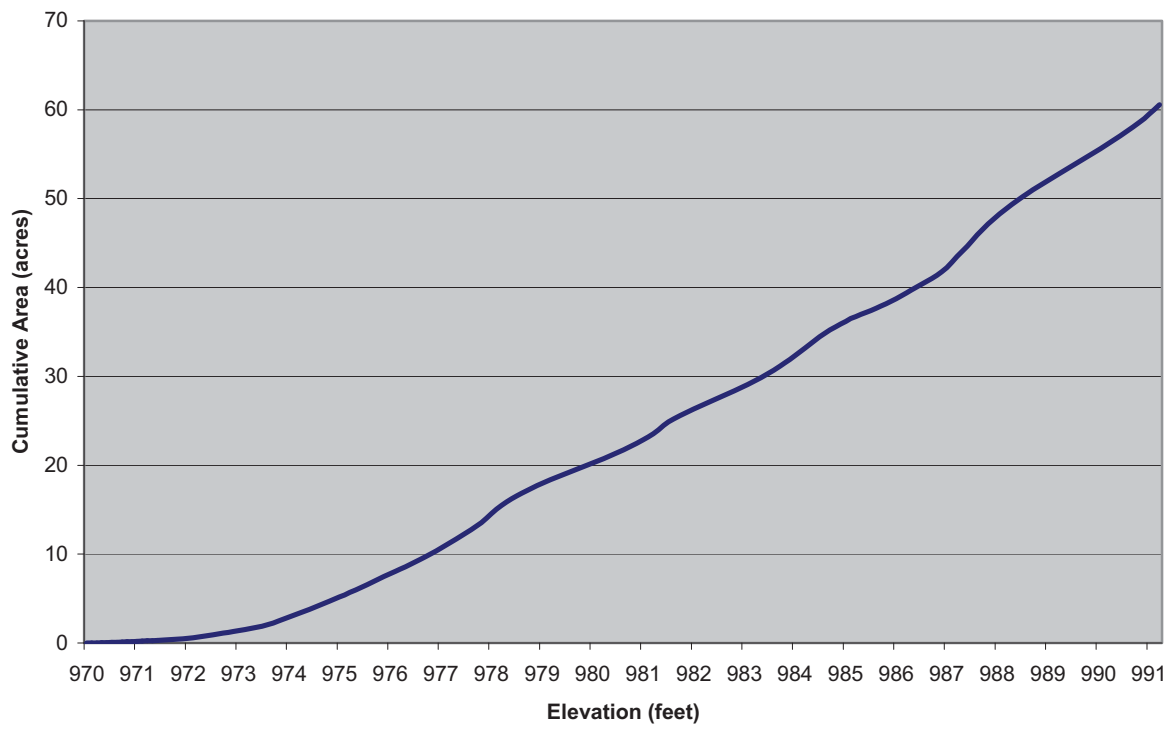


Figure 6. Cumulative area-elevation curve

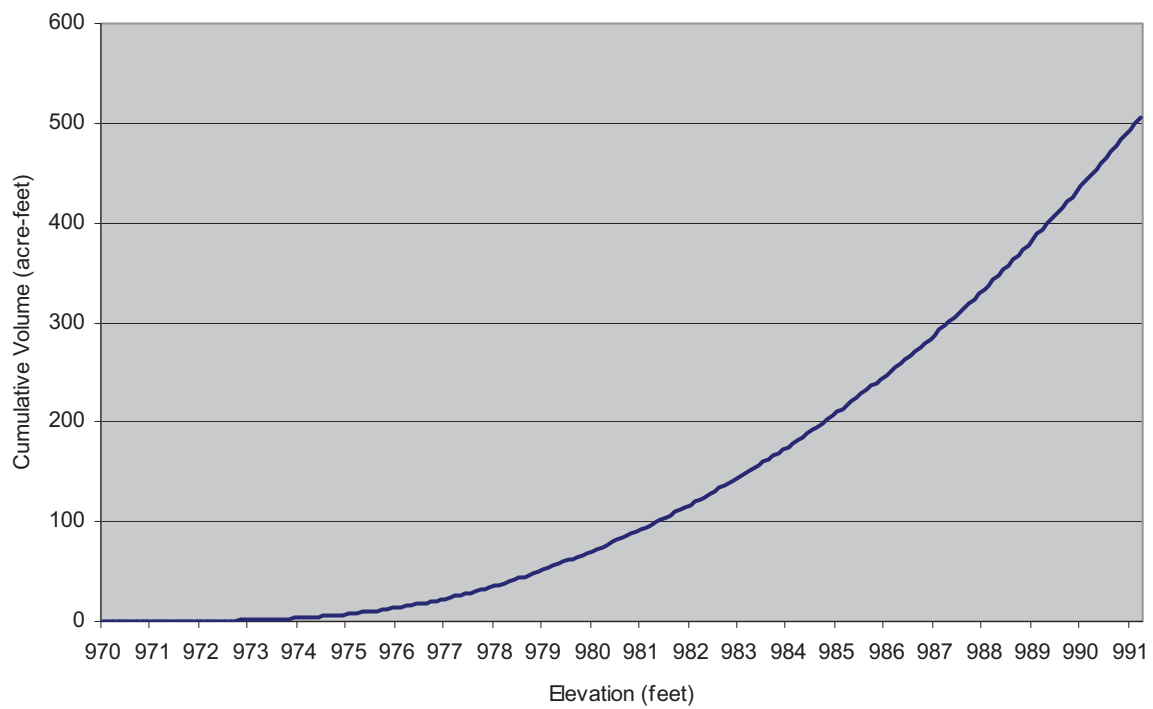


Figure 7. Cumulative volume-elevation curve

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.

SEDIMENT SAMPLING RESULTS:

Sampling sites were distributed across the length of the reservoir (Figure 8). Silt percentages were highest at the inflow end (POLK-3, 60%), decreasing to 24% at the dam end (Table 3; Figure 9; Figure 10).

Table 3
Polk Daniels Lake Sediment Sampling Site Data

CODE	UTMX	UTMY	%Sand	% Silt	% Clay
POLK-1	745205.9	4149701.8	0	24	76
POLK-2	745577.4	4150015.7	0	50	50
POLK-3	745761.8	4150298.9	6	60	34

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

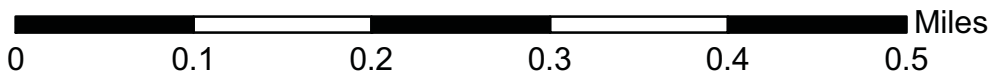
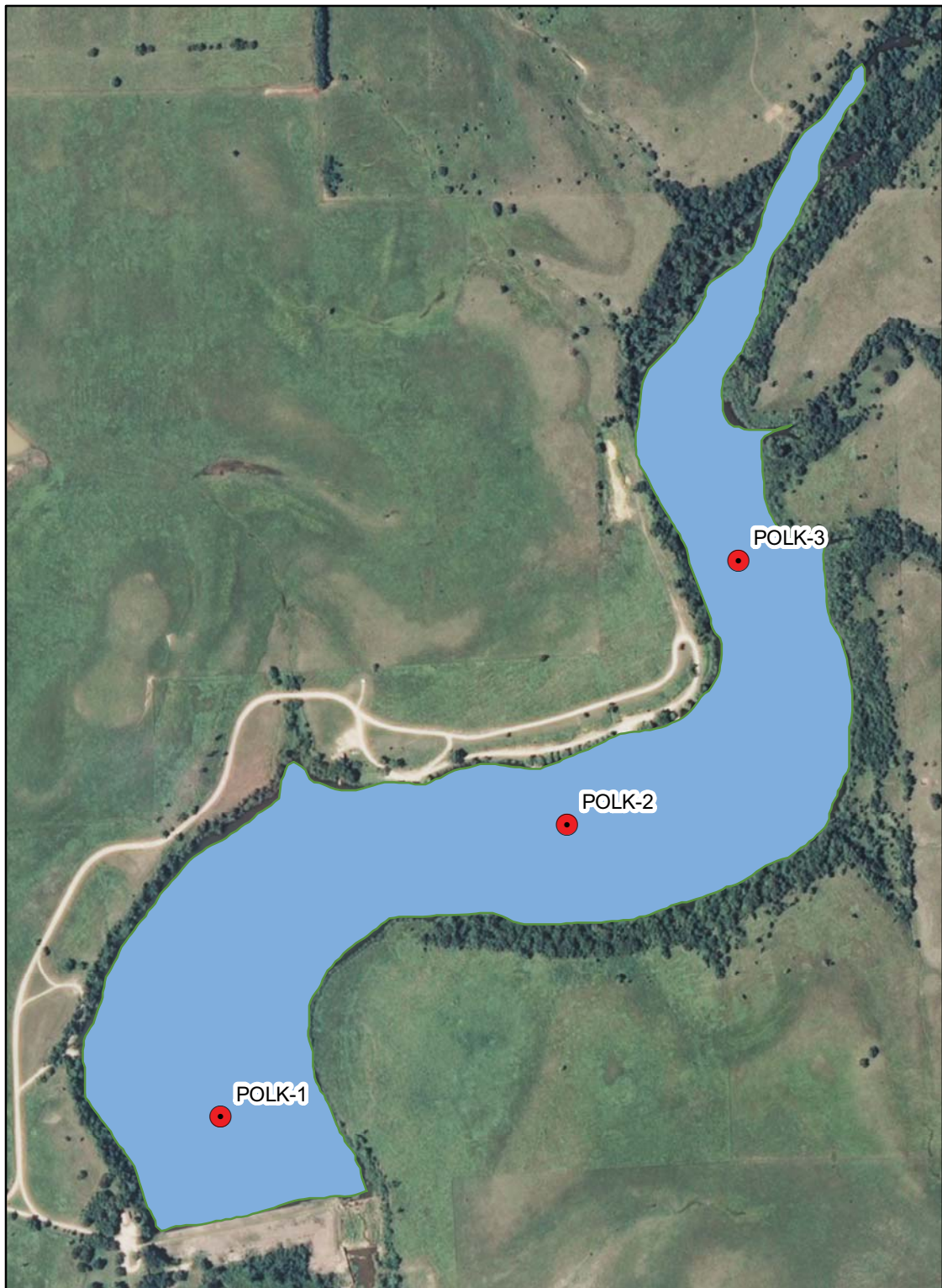


Figure 8. Location of sediment samples in Polk Daniels Lake

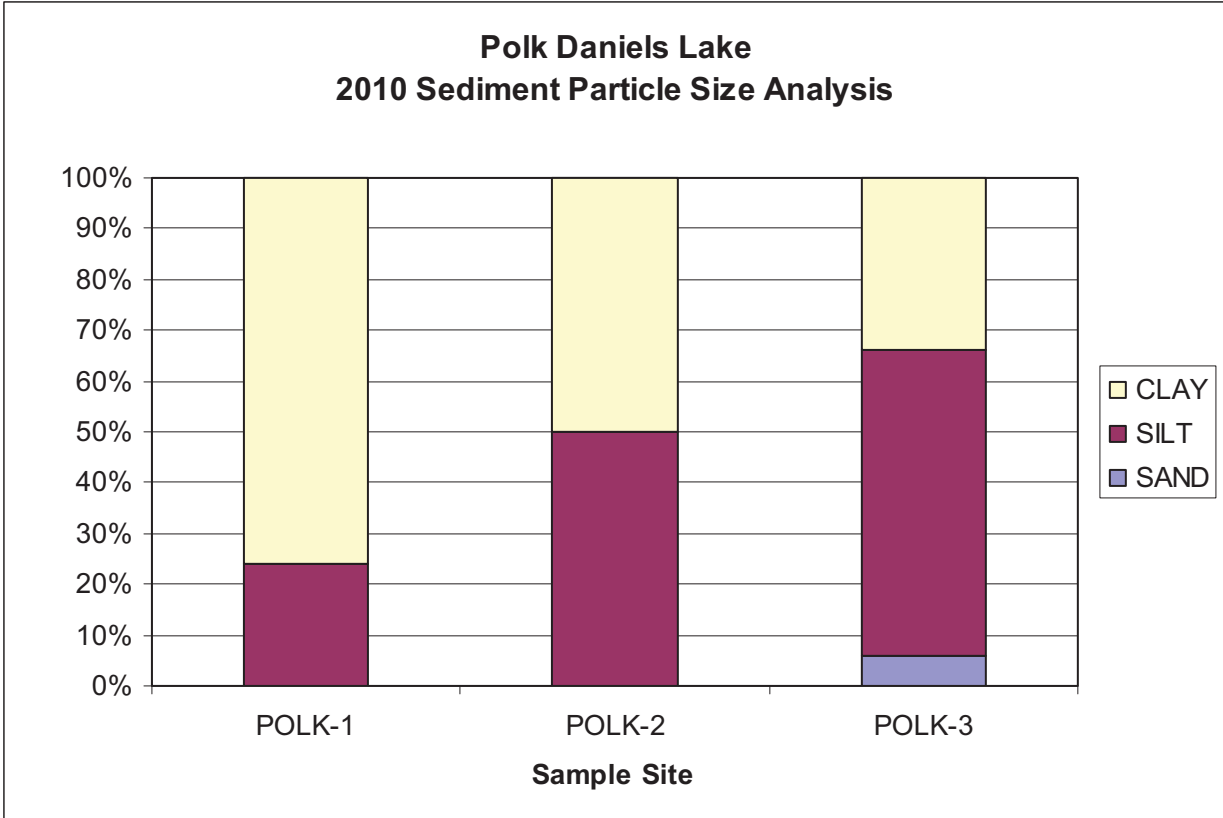


Figure 9. Sediment particle size analysis.

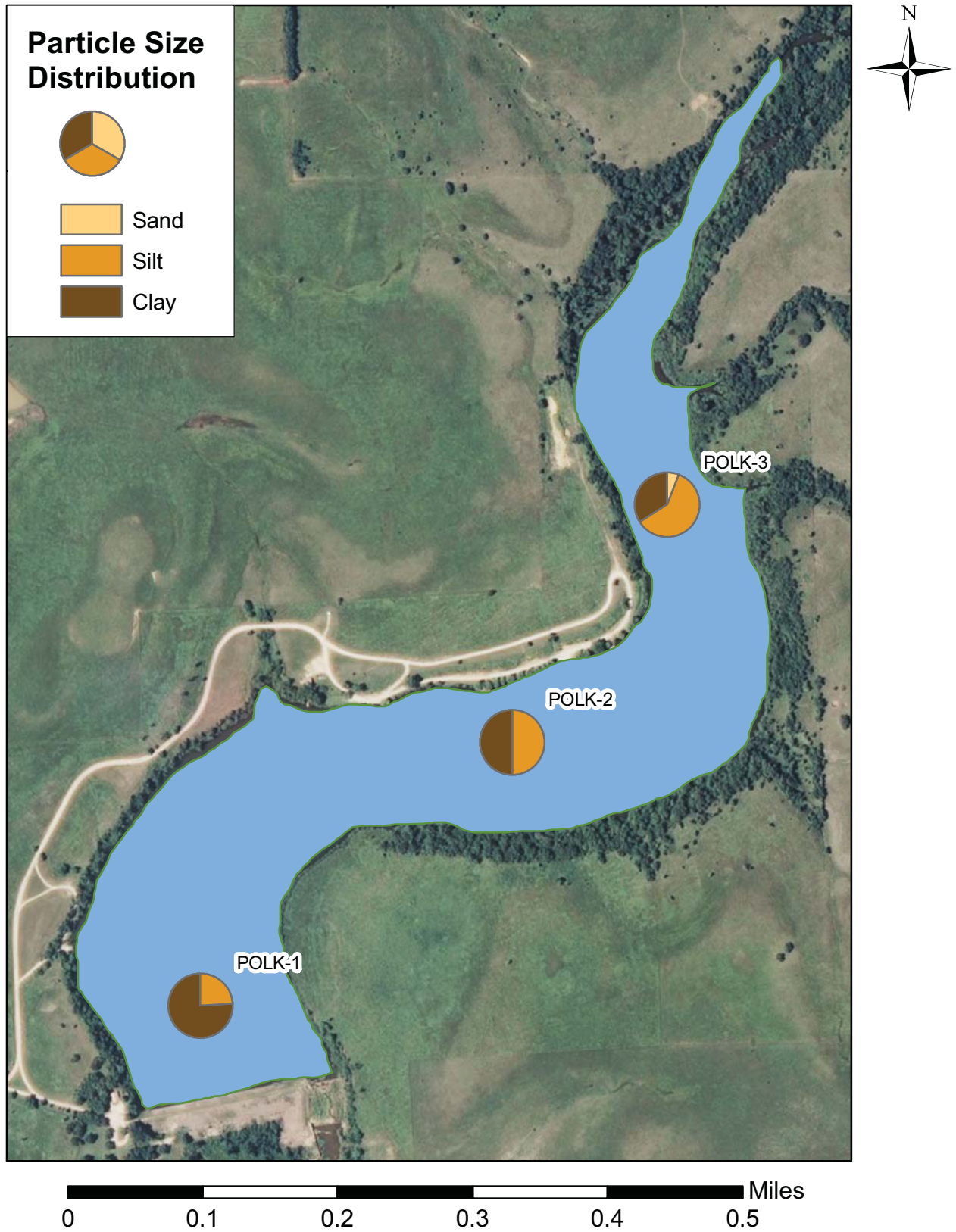


Figure 10. Particle size distribution of sediment samples in Polk Daniels Lake