Bathymetric and Sediment Survey of Cedar Valley Lake, Anderson County, Kansas

KANSAS BIOLOGICAL SURVEY

Kansas Biological Survey

Applied Science and Technology for Reservoir Assessment (ASTRA) Program

Report 2009-06 (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 November 6, 2009, the Kansas Biological Survey (KBS) performed a bathymetric survey of Cedar Valley Lake in Anderson 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:	November 6, 2009
Reservoir Statistics:		
	Elevation on survey date	969.26 ft
	Area on survey date:	306 acres
	Volume on survey date:	4456 acre-feet
	Maximum depth:	32.6 ft.
Elevation Benchmark (if applicable)		
	UTM location of elevation benchmark:	296745.8, 4235196.7
	UTM Zone:	15N
	UTM datum:	NAD83
	Elevation of benchmark, from GPS:	977.61 ft.
	Vertical datum, all data:	NAVD88
Sediment Survey:		
	Date of sediment survey:	November 6, 2009

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LAKE HISTORY AND PERTINENT INFORMATION

Figure 1. Cedar Valley Lake, southwest of Garnett, Kansas.

Cedar Valley Reservoir is located approximately 7 miles southwest of the city of Garnett, Kansas, on Cedar Creek. Constructed in 1983 and owned by the City of Garnett, the reservoir provides drinking water for the City and also provides recreational opportunities for area residents.

Anderson County, Kansas

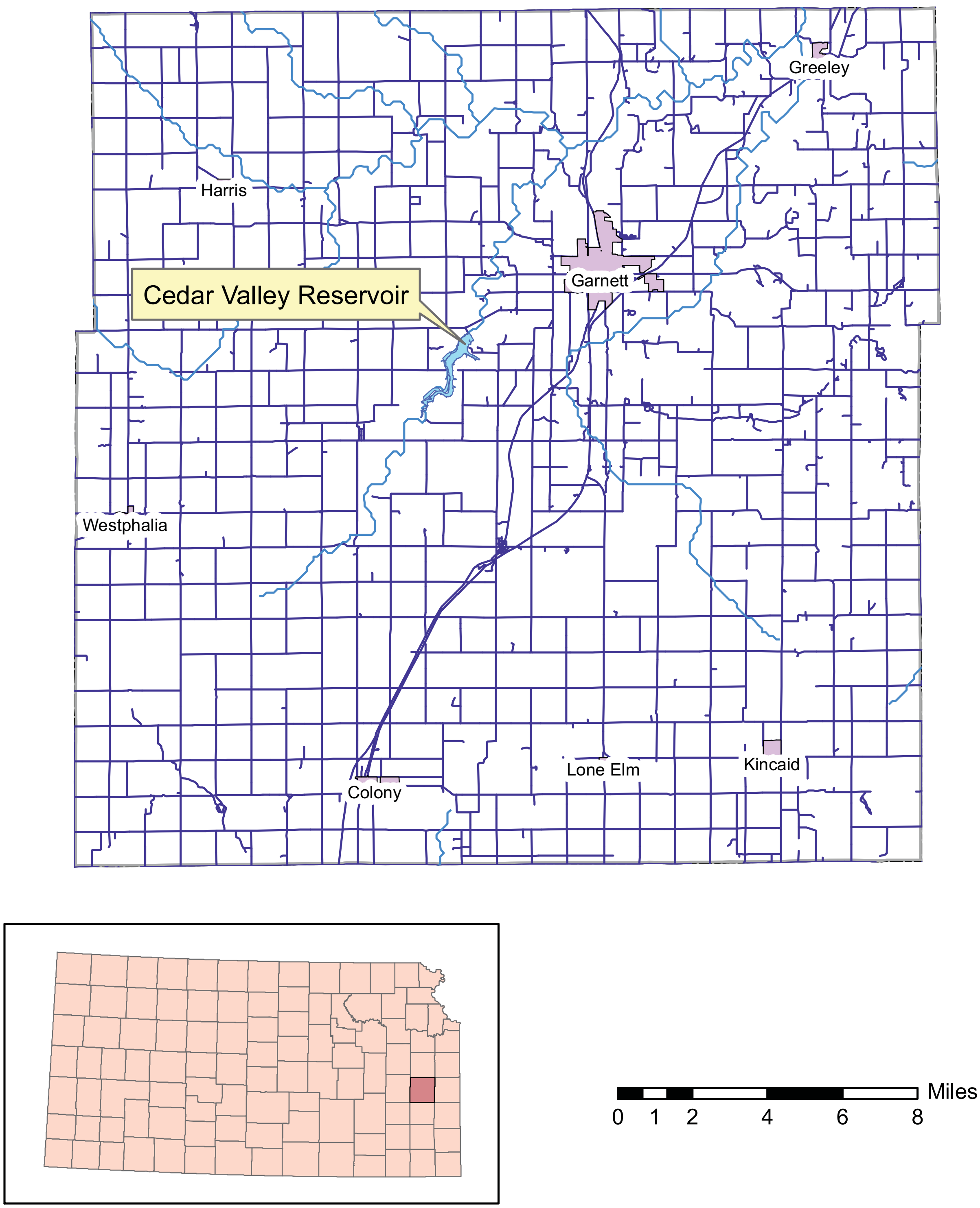

Figure 2. Location of Cedar Valley (Garnett) Reservoir in Anderson County, Kansas

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 Cedar Valley Lake is the northeast corner of a concrete pad for a picnic table south of and adjacent to the boat ramp on the west side of the lake (Figure 3a, Figure 3b).

The water surface elevation of Cedar Valley Lake on November 6, 2009 was 969.26 feet AMSL.

Location of Lake Elevation Benchmark:

Cedar Valley Lake: Concrete pad (NE corner) for picnic table immediately south of boat ramp.

UTM (NAD83, Zone 15): Easting (X) [meters] 296745.8, Northing (Y) [meters] 4235196.7

Figure 3a. View east, parallel to west shore boat ramp.

Figure 3b. Lake level was measured from the water surface to the top of the concrete pad..

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FILE: log0001t.09O 000025816 - Cedar Valley Reservoir

 1008   NOTE:  Antenna offsets supplied by the user were zero.  Coordinates
 1008   returned will be for the antenna reference point (ARP).
 1008
                             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.html#accuracy

      USER: mjakub@ku.edu                          DATE: December 03, 2009
RINEX FILE: log0307t.09o                           TIME: 20:41:37 UTC


  SOFTWARE: page5  0909.08 master10.pl 081023      START: 2009/11/03  19:19:00
 EPHEMERIS: igs15562.eph [precise]                  STOP: 2009/11/03  21:46:00
  NAV FILE: brdc3070.09n                        OBS USED:  4124 /  5616   :
73%
  ANT NAME: TPSHIPER_PLUS   NONE             # FIXED AMB:    48 /    60   :
80%
ARP HEIGHT: 0.0                              OVERALL RMS: 0.024(m)

 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)           ITRF00
(EPOCH:2009.8407)

         X:      -465301.703(m)   0.187(m)         -465302.435(m)   0.187(m)
         Y:     -4994440.824(m)   0.104(m)        -4994439.452(m)   0.104(m)
         Z:      3926725.563(m)   0.177(m)         3926725.431(m)   0.177(m)

       LAT:   38 14 30.55156      0.160(m)       38 14 30.57426      0.160(m)
     E LON:  264 40 38.87008      0.194(m)      264 40 38.83488      0.194(m)
     W LON:   95 19 21.12992      0.194(m)       95 19 21.16512      0.194(m)
    EL HGT:          266.528(m)   0.127(m)              265.427(m)   0.127(m)
 ORTHO HGT:          297.976(m)   0.140(m) [NAVD88 (Computed using GEOID09)]

                        UTM COORDINATES    STATE PLANE COORDINATES
                         UTM (Zone 15)         SPC (1502 KS S)
Northing (Y) [meters]     4235196.702           579559.442
Easting (X)  [meters]      296745.807           678098.325
Convergence  [degrees]    -1.43809955           1.95264090
Point Scale                1.00010881           0.99995188
Combined Factor            1.00006699           0.99991006

US NATIONAL GRID DESIGNATOR: 15STC9674535196(NAD 83)

                             BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DJ3673 KST6 TOPEKA 6 CORS ARP              N390239.667 W0960220.831  108762.4
DF9221 ZKC1 KANSAS CTY WAAS 1 CORS ARP     N385248.550 W0944726.964   84671.6
DL2740 MOSB SEILER BELTON CORS ARP         N384948.687 W0943204.448   94796.0

                NEAREST NGS PUBLISHED CONTROL POINT
JE1055      MADER FIELD                    N381745.    W0951617.       7492.4

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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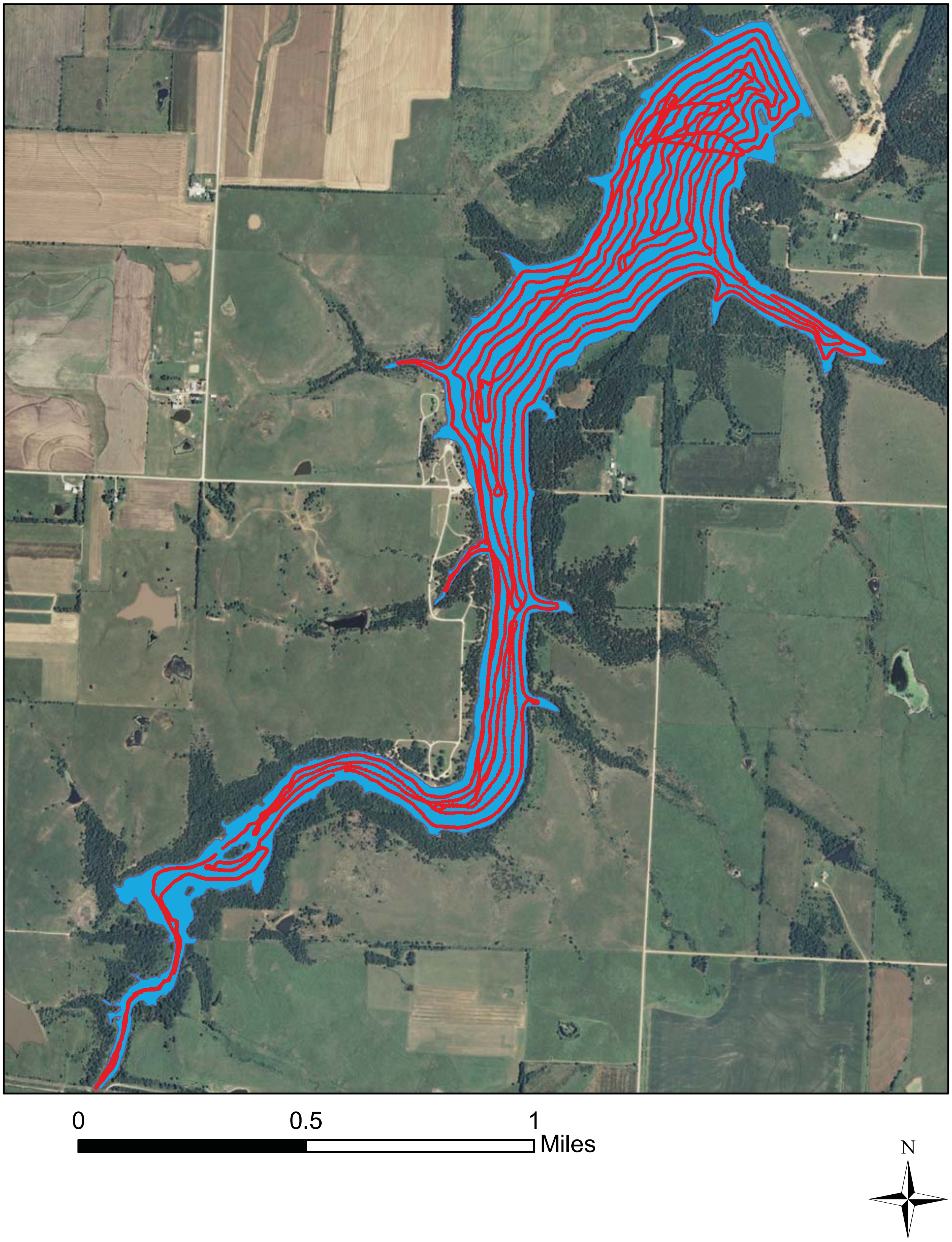

Figure 4. Bathymetric survey transects for Cedar Valley Lake, November 6, 2009.

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.

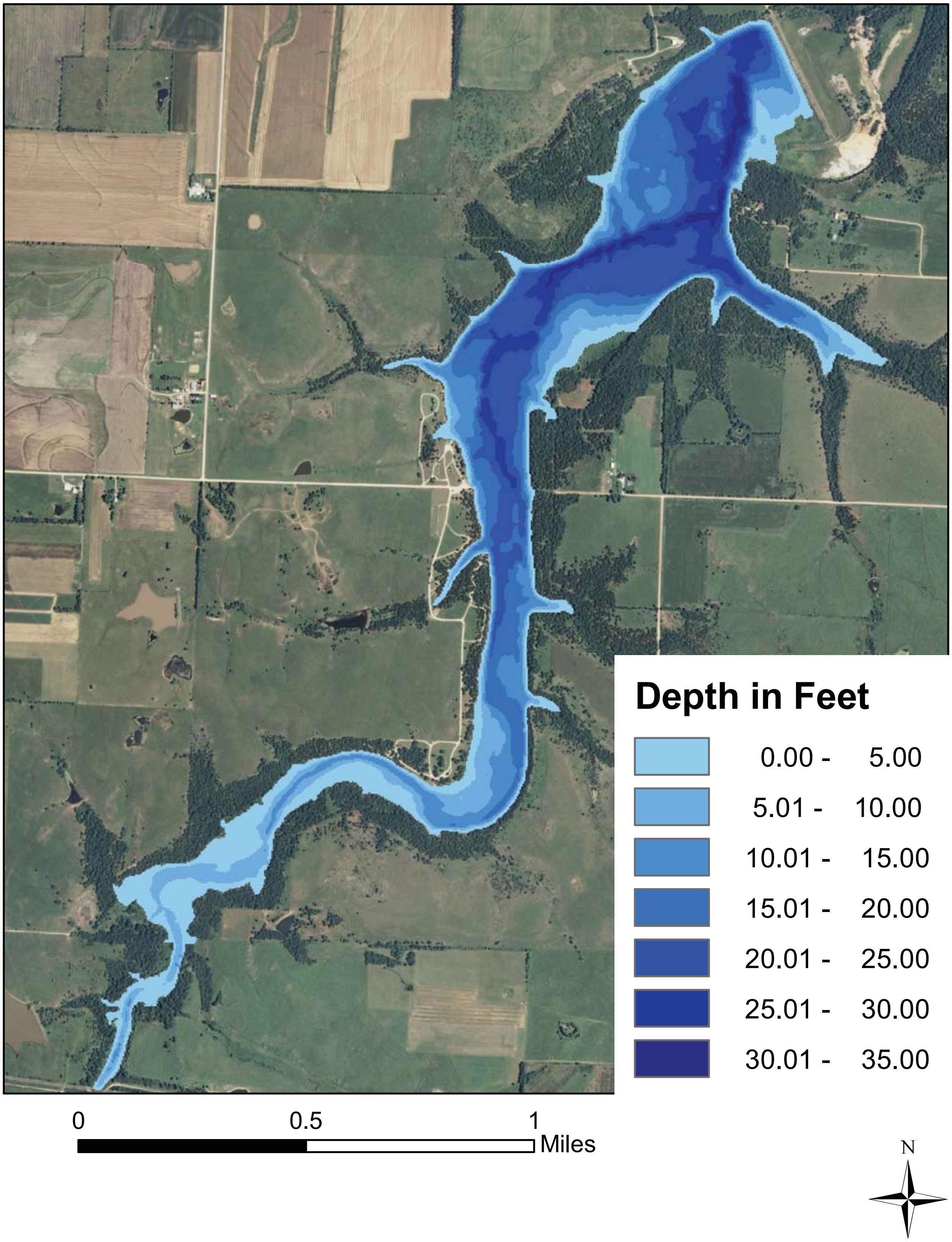

Figure 5. Water depth based on November 6, 2009 bathymetric survey.for Cedar Valley Lake. Depths are based on a pool elevation of 969.26 feet.

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
936							1	1	1	1
937	1	1	1	1	1	1	2	2	2	2
938	2	2	3	3	3	3	3	4	4	4
939	4	5	5	5	6	6	6	6	7	7
940	7	8	8	8	9	9	9	10	10	11
941	11	12	12	13	13	14	15	15	16	16
942	17	18	18	19	20	20	21	22	22	23
943	24	25	26	27	28	29	29	30	31	32
944	33	34	35	36	37	38	39	40	41	42
945	43	44	45	47	48	49	50	52	53	54
946	56	57	58	59	61	62	64	66	67	69
947	71	73	75	76	78	80	82	84	85	86
948	87	89	90	91	92	94	95	96	98	99
949	100	101	102	103	104	105	106	107	108	109
950	110	111	112	113	114	115	116	117	118	119
951	120	121	122	123	125	126	127	128	129	130
952	131	132	133	134	135	136	137	138	139	140
953	141	142	143	145	146	147	148	149	150	152
954	153	154	155	156	157	158	159	160	161	162
955	163	164	165	166	167	168	169	170	171	172
956	172	173	174	175	176	177	178	178	179	180
957	181	182	183	183	184	185	186	187	187	188
958	189	190	191	192	193	193	194	195	196	197
959	198	199	200	201	202	203	204	205	206	207
960	208	208	209	210	211	212	213	214	215	216
961	216	217	218	219	220	221	222	223	224	225
962	226	227	228	229	229	230	231	232	233	234
963	235	236	237	238	239	240	241	242	244	245
964	246	247	249	250	251	252	253	254	256	257
965	258	259	260	261	262	263	264	265	266	267
966	268	269	271	272	273	274	275	276	277	278
967	279	280	281	283	284	285	286	287	288	289
968	290	291	292	293	295	296	297	298	299	301
969	302	304	306							

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
936							<1	<1	<1	<1
937	1	1	1	1	1	1	1	1	2	2
938	2	2	2	3	3	3	4	4	4	5
939	5	6	6	7	7	8	8	9	10	10
940	11	12	12	13	14	15	16	17	18	19
941	20	21	22	24	25	26	28	29	31	32
942	34	36	37	39	41	43	45	47	50	52
943	54	57	59	62	64	67	70	73	76	79
944	83	86	89	93	97	100	104	108	112	116
945	121	125	130	134	139	144	149	154	159	164
946	170	175	181	187	193	199	206	212	219	225
947	232	240	247	255	262	270	278	287	295	304
948	312	321	330	339	348	357	367	376	386	396
949	406	416	426	436	447	457	468	478	489	500
950	511	522	533	544	556	567	579	590	602	614
951	626	638	650	663	675	687	700	713	726	739
952	752	765	778	791	805	818	832	846	860	874
953	888	902	916	930	945	959	974	989	1004	1019
954	1034	1050	1065	1081	1096	1112	1128	1144	1160	1176
955	1192	1209	1225	1242	1258	1275	1292	1309	1326	1343
956	1360	1377	1395	1412	1430	1448	1465	1483	1501	1519
957	1537	1555	1573	1592	1610	1628	1647	1666	1684	1703
958	1722	1741	1760	1779	1798	1818	1837	1856	1876	1896
959	1915	1935	1955	1975	1995	2016	2036	2056	2077	2098
960	2118	2139	2160	2181	2202	2223	2244	2266	2287	2309
961	2330	2352	2374	2395	2417	2439	2462	2484	2506	2529
962	2551	2574	2597	2619	2642	2665	2688	2712	2735	2758
963	2782	2805	2829	2853	2877	2901	2925	2949	2973	2998
964	3022	3047	3072	3097	3122	3147	3172	3197	3223	3249
965	3274	3300	3326	3352	3378	3405	3431	3458	3484	3511
966	3538	3565	3592	3619	3646	3673	3701	3729	3756	3784
967	3812	3840	3868	3896	3925	3953	3982	4011	4039	4068
968	4097	4126	4156	4185	4215	4244	4274	4304	4334	4364
969	4395	4425	4456							

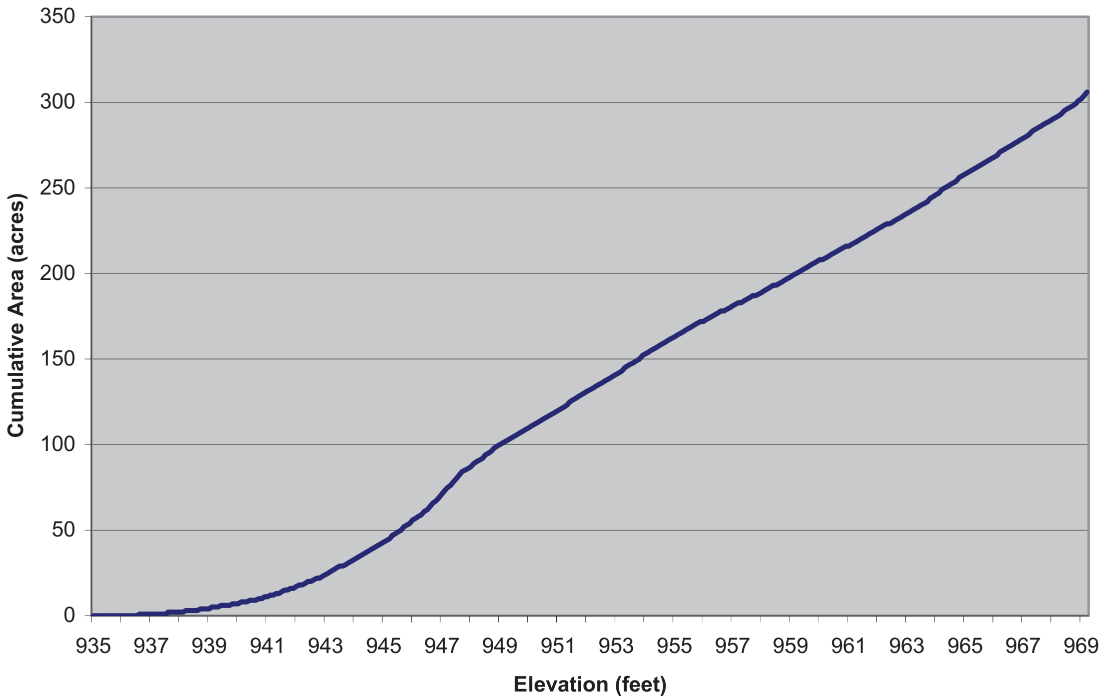

Figure 6. Cumulative area-elevation curve

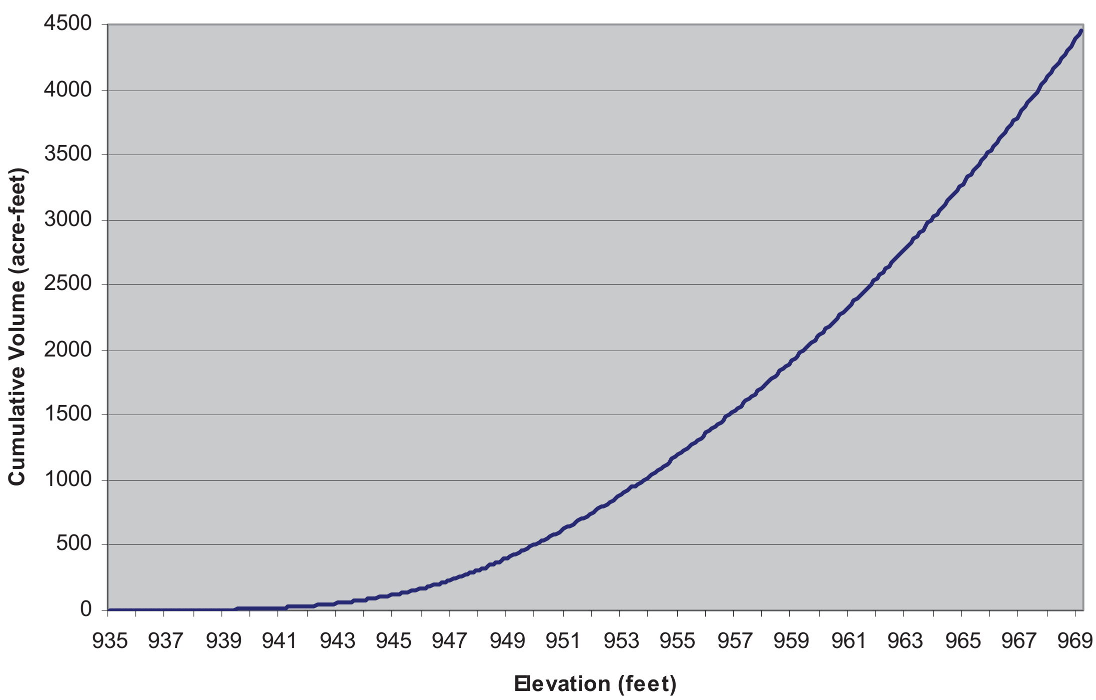

Figure 7. Cumulative volume-elevation curve

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 Cedar Valley Reservoir.

SEDIMENT SAMPLING RESULTS:

Sampling sites were distributed across the length of the reservoir (Figure 8). Silt percentages were highest at the inflow end (CV-3, 60%). No sand was detected in any of the three samples (Table 3; Figure 9; Figure 10).

Table 3
Cedar Valley Reservoir Sediment Sampling Site Data

CODE	UTMX	UTMY	%Sand	% Silt	% Clay
CV-1	297405.1	4236457.4	0	46	54
CV-2	296800.8	4235581.0	0	32	68
CV-3	296767.3	4234121.6	0	60	40

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

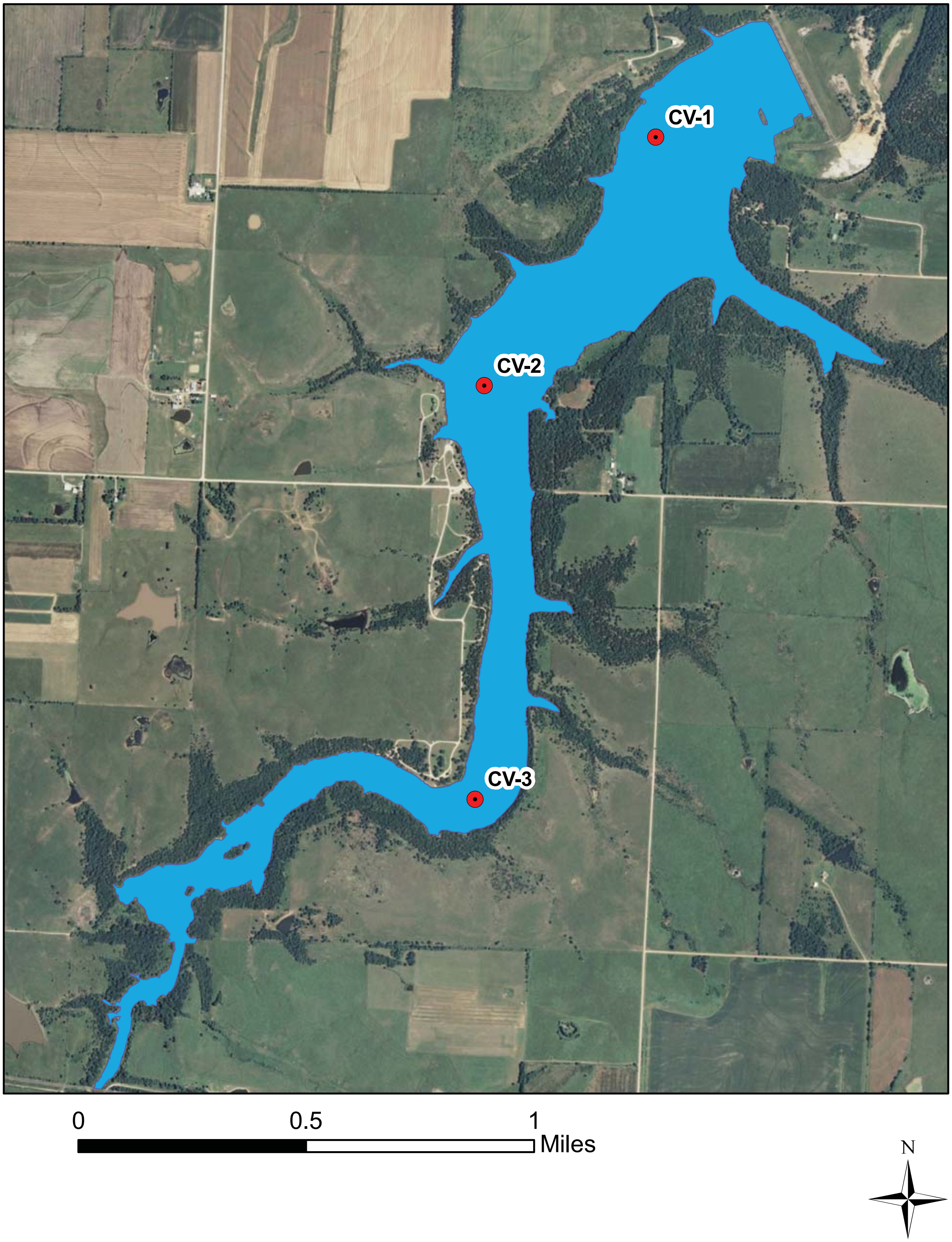

Figure 8. Location of sediment samples in Cedar Valley Lake, November 6, 2009.

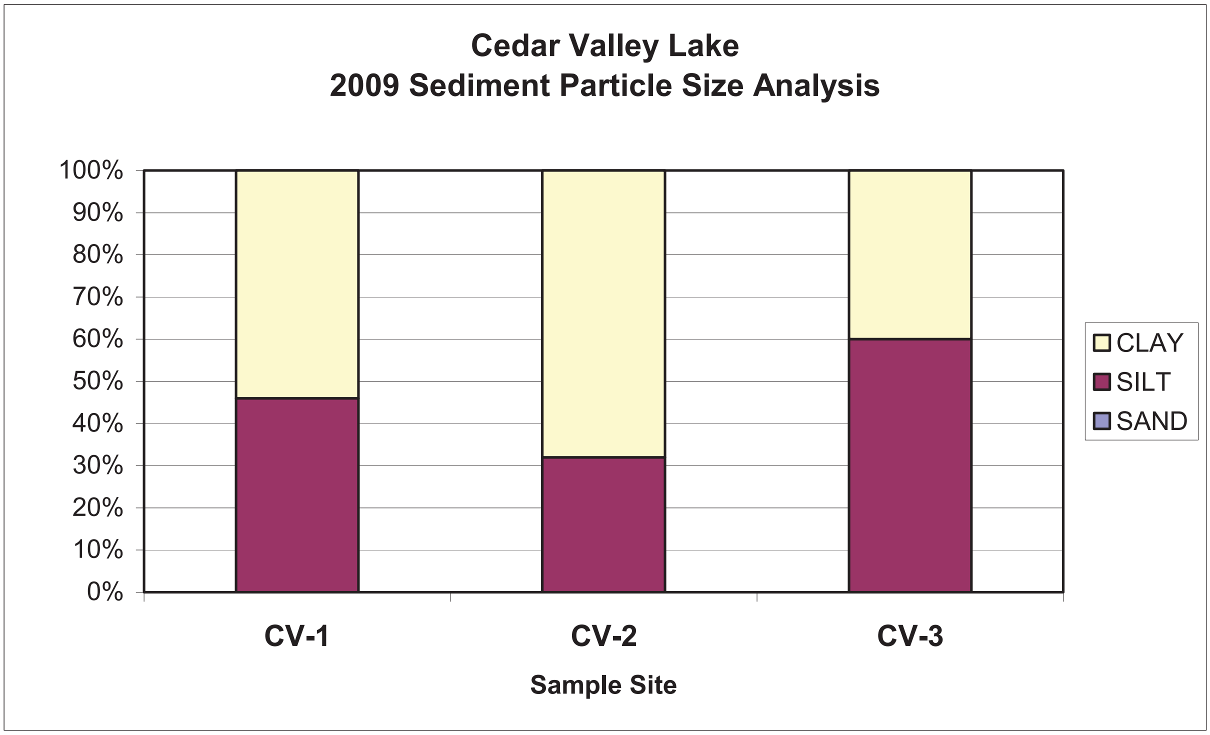

Figure 9. Sediment particle size analysis.

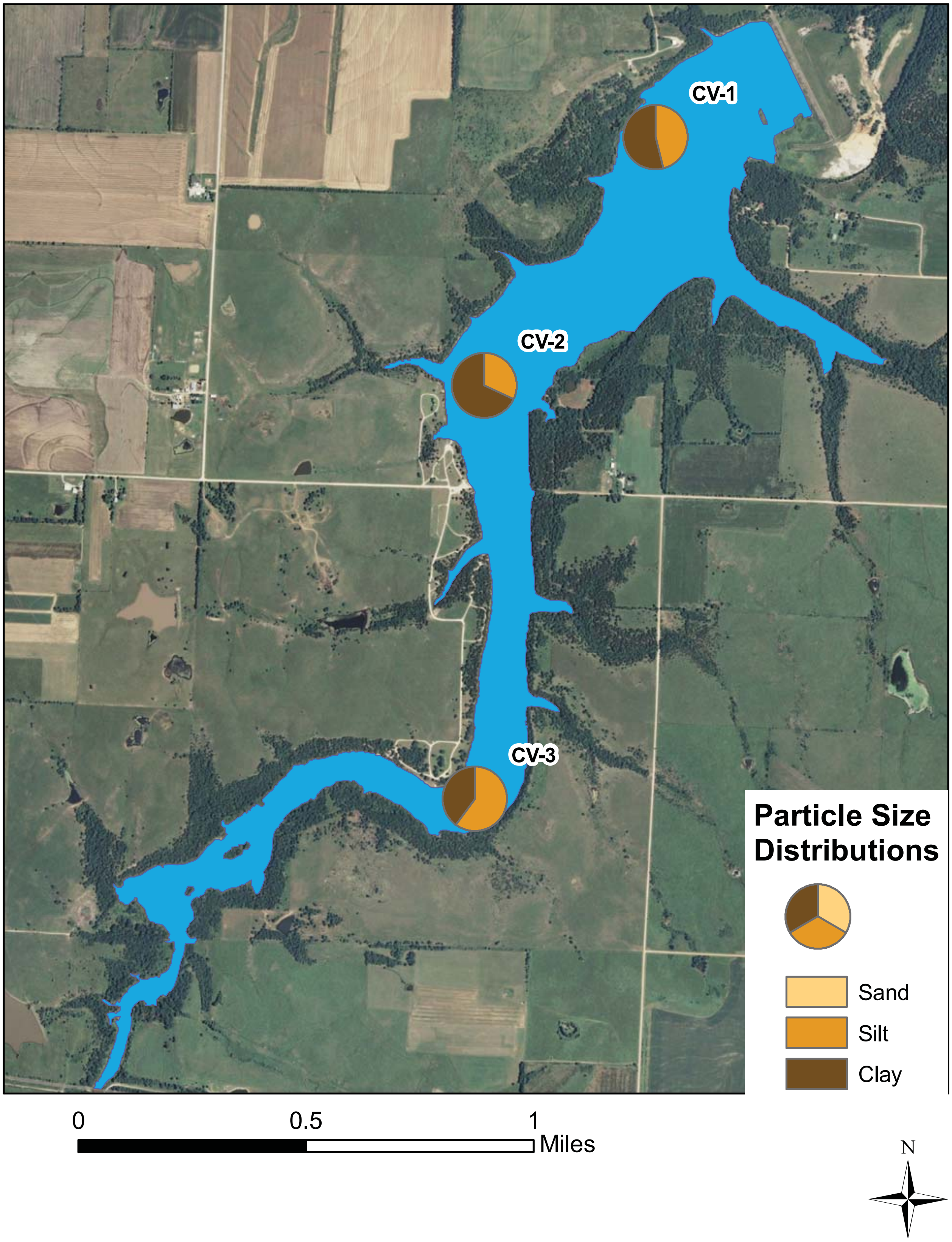

Figure 10. Particle size distribution of sediment samples in Cedar Valley Lake.