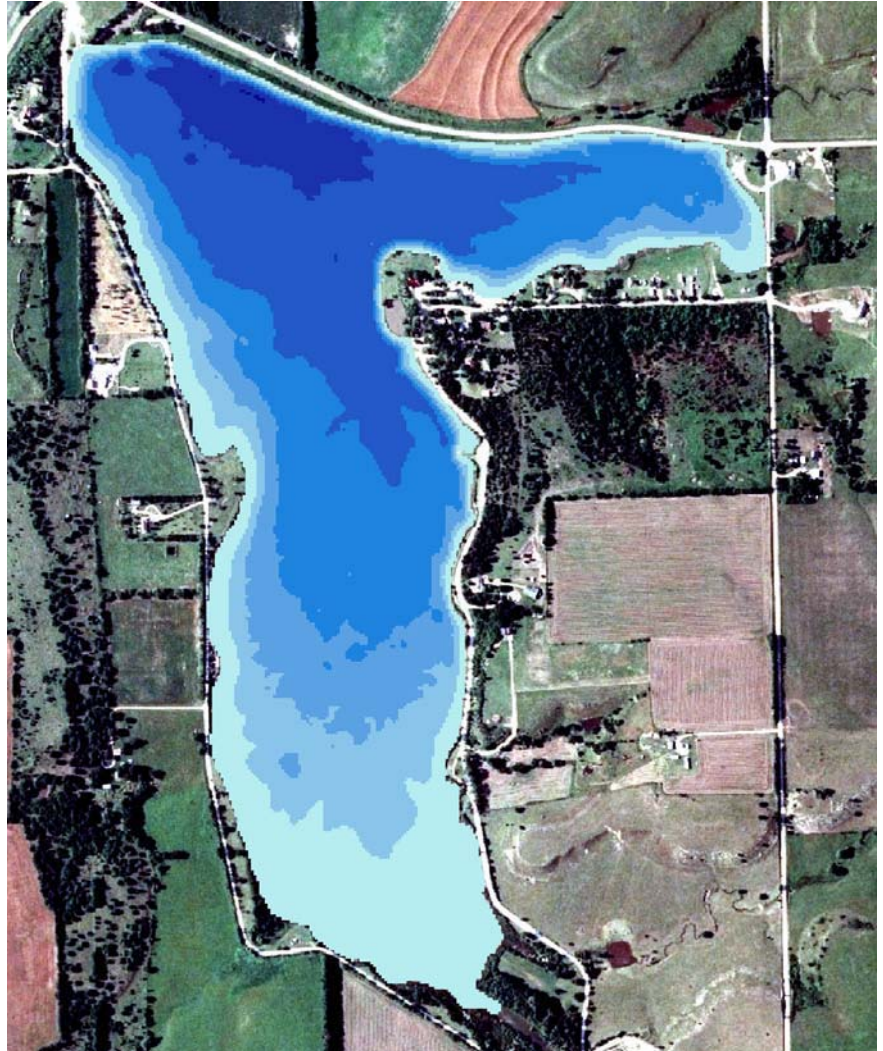


# Bathymetric and Sediment Survey of Herington City Lake, Dickinson County, Kansas



**Kansas Biological Survey**  
*Applied Science and Technology for  
Reservoir Assessment (ASTRA) Program*  
Report 2008-05 (April 2009)



**KANSAS**  

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**WATER**  

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**OFFICE**

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

## SUMMARY

On June 25, 2008, the Kansas Biological Survey (KBS) performed a bathymetric survey of Herington Lake in Dickinson 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 the third in the upper end. Initial sampling was performed on the same day as the bathymetric survey, following completion of the survey. Due to the loss of one sediment sample during shipping, the lake was resampled for sediment on April 8, 2009. Sediment samples were analyzed for particle size distributions.

### Summary Data:

<b>Bathymetric Survey:</b>		
Date of survey:		June 25, 2008
<b>Reservoir Statistics:</b>		
Water elevation on date of survey:		1324.0
Area on date of survey:		199 acres
Volume on date of survey:		1207 acre-feet
Maximum depth:		11 feet
Year constructed:		1923
<b>Elevation Benchmark (if applicable)</b>		
UTM location of elevation benchmark:		674615.1, 4281416.9
UTM Zone:		14N
UTM datum:		NAD83
Elevation of benchmark, from GPS:		1325.4 feet
Vertical datum, all data:		NAVD88
<b>Sediment Survey:</b>		
Date of sediment survey:		June 25, 2008 April 8, 2009

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## LAKE HISTORY AND PERTINENT INFORMATION

(This section summarized from the Kansas Dam Inventory and KDWP)

<http://crunch.tec.army.mil/nidpublic/webpages/nid.cfm>

<http://www.kdwp.state.ks.us/news/Fishing/Where-to-Fish-in-Kansas/Fishing-Locations-Public-Waters/Region-2/Herington-City-Lake-New>



Figure 1. A postcard print of Herington Lake from the 1950s.

**Location and Purpose:** Herington Lake is located about 1 mile west of the town of Herington in Dickinson County, Kansas (Figure 2). Completed in 1923, the rolled earth-fill-type dam is owned locally by the City of Herington, and was constructed for water supply, recreation, and flood control.

# Dickinson County, Kansas

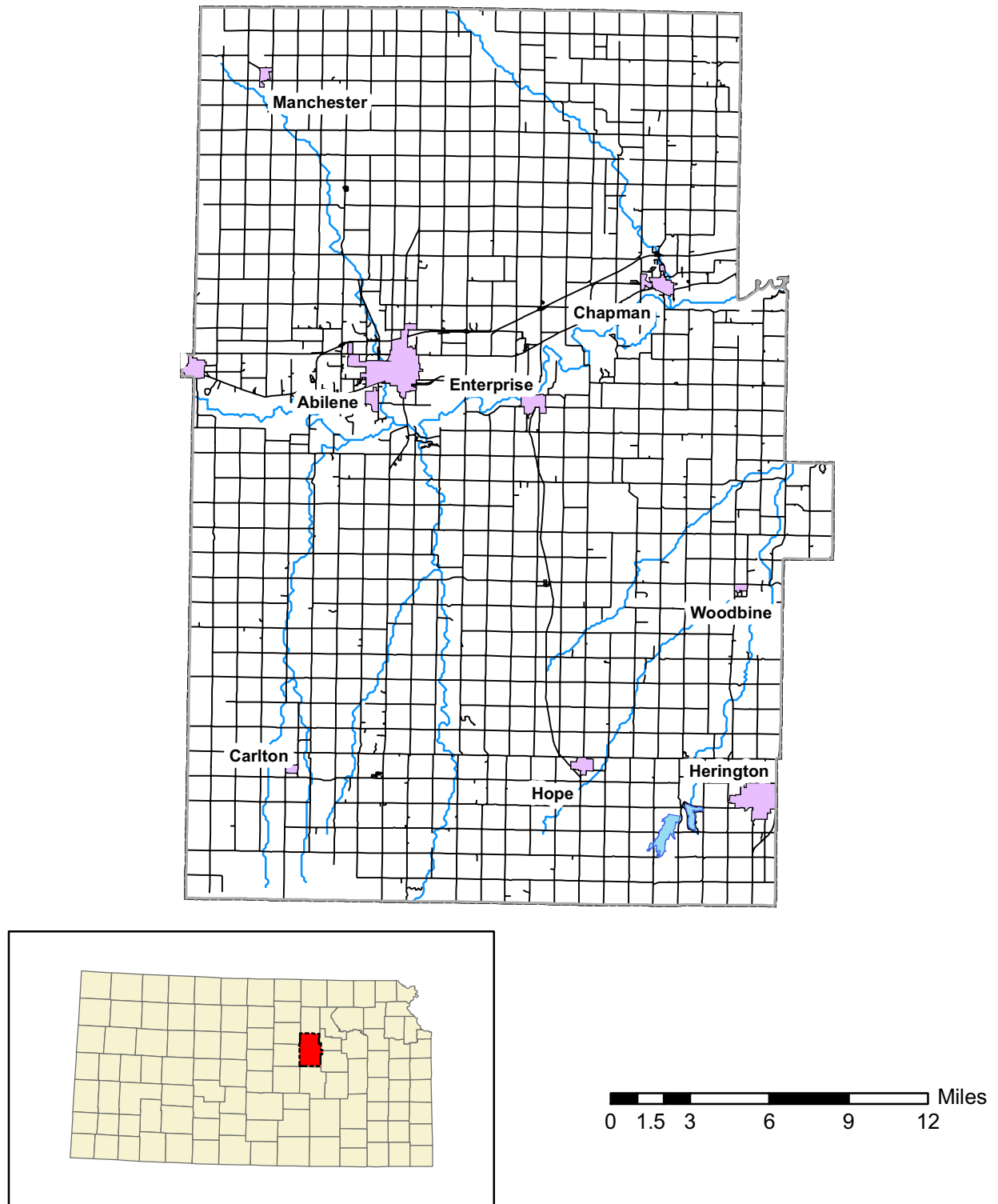


Figure 2. Location of Herington Lake and Herington Reservoir in Dickinson County.

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

KBS operates a Biosonics DT-X acoustic echosounding system ([www.biosonicsinc.com](http://www.biosonicsinc.com)) with a 200 kHz split-beam transducer and a 38-kHz single-beam transducer. In addition to providing basic information on reservoir depth profiles, the Biosonics system also permits the assessment of bottom sediment composition. Latitude-longitude information is provided by a JRC 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) at the Kansas Geological Survey. Prior to the lake survey, a series of transect lines are created as a shapefile in ArcGIS for guiding the boat during the survey. Transect lines are spaced more closely (25-50 meters separation) on smaller state/local lakes, while a spacing of 100-150 meters is used for federal reservoirs.

### **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. To assist the boat operator in navigation, an auxiliary LCD monitor is connected to the computer and placed within the easy view of the boat operator. Transducer face depth on all dates is 0.5 meters below the water surface. 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.

Lake water surface elevation on June 25, 2008 was 1324.0 feet above sea level.

**Location of Lake Elevation Benchmark:**

**Herington Lake (Old Herington lake):** The south side of the concrete dock anchor pad adjacent to the boat ramp on the east side of the lake, off Sun Lane.

UTM (NAD83, Zone 14): Easting (X) [meters] 674615.1, Northing (Y) [meters] 4281416.9



**Figure 3a. View west toward dock and boat ramp.**



**Figure 3b. Close-up view. Lake level was measured from the water surface to the top of the concrete pad at the southern edge (left in picture) of the concrete.**

herington\_lake\_OPUS\_results.txt

Herington Lake (old)

FILE: her2lake.080 000388821

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](http://www.ngs.noaa.gov/OPUS/Using_OPUS.html#accuracy)

USER: mjakub@ku.edu  
RINEX FILE: her2183w.080

DATE: July 03, 2008  
TIME: 16:43:43 UTC

SOFTWARE: page5 0612.06 master23.pl                    START: 2008/07/01 22:16:00  
EPHEMERIS: igr14862.eph [rapid]                        STOP: 2008/07/01 23:59:00  
NAV FILE: brdc1830.08n                                    OBS USED: 5057 / 5156 : 98%  
ANT NAME: TPSHIPER\_PLUS NONE                            # FIXED AMB: 24 / 33 : 73%  
ARP HEIGHT: .95    OVERALL RMS: 0.018(m)

REF FRAME: NAD\_83 (CORS96) (EPOCH:2002.0000)                    ITRF00 (EPOCH:2008.4999)

X:        -607158.630 (m)    0.120 (m)                    -607159.344 (m)    0.120 (m)  
Y:        -4949901.233 (m)   0.189 (m)                    -4949899.872 (m)   0.189 (m)  
Z:        3963506.072 (m)    0.054 (m)                    3963505.951 (m)    0.054 (m)

LAT:     38 39 50.86805        0.090 (m)                    38 39 50.89060        0.090 (m)  
E LON:   263 0 25.15759        0.096 (m)                    263 0 25.12142        0.096 (m)  
W LON:   96 59 34.84241        0.096 (m)                    96 59 34.87858        0.096 (m)  
EL HGT:                    374.681 (m)    0.188 (m)                    373.618 (m)    0.188 (m)  
ORTHO HGT:                    403.995 (m)    0.198 (m) [NAVD88 (Computed using GEOID03)]

	UTM COORDINATES	STATE PLANE COORDINATES
	UTM (Zone 14)	SPC (1501 KS N)
Northing (Y) [meters]	4281416.901	37209.297
Easting (X) [meters]	674615.172	487641.644
Convergence [degrees]	1.25419040	0.63713616
Point Scale	0.99997548	1.00000889
Combined Factor	0.99991670	0.99995011

US NATIONAL GRID DESIGNATOR: 14SPH7461581417(NAD 83)

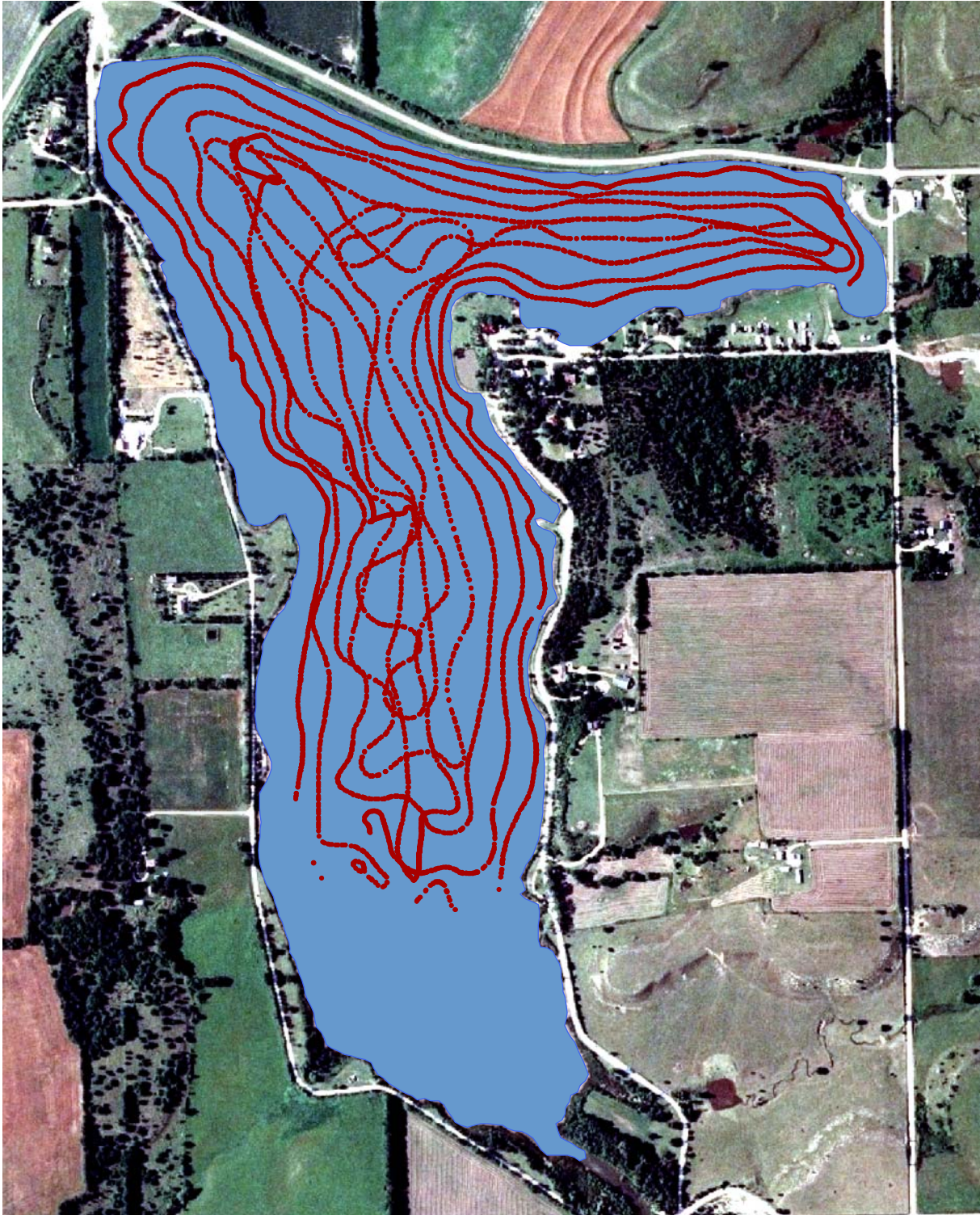
BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE (m)
AH9960	FBYN FAIRBURY CORS ARP	N400436.713	W0971846.120	159253.3
AF9527	HBRK HILLSBORO CORS ARP	N381816.715	W0971736.655	47750.8
DJ3671	KST5 TOPEKA 5 CORS ARP	N390240.554	W0960220.776	92956.2

NEAREST NGS PUBLISHED CONTROL POINT

JF1479        ALBRECHT                    N384017.130 W0965809.581        2212.9

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.



0 0.1 0.2 0.3 0.4 0.5 Miles



Figure 4. Bathymetric Survey Transects for Herington 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 7 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 (typically 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 0.5 meters). Four values are computed in Excel: DepthM, DepthFt, ElevM and ElevFt, where:

$$\text{DepthM} = \text{Adj\_Depth}$$
$$\text{DepthFt} = \text{Adj\_Depth} * 3.28084$$

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, another field is added to the attribute table of the point shapefile, ElevM. The value for this attribute is then computed as  $\text{Depth\_ElevM} = (\text{Elevation of the Water Surface in meters above sea level}) - \text{Adj\_Depth}$ . Elevation of the water surface in feet above sea level is also computed by converting ElevM to elevation in feet ( $\text{ElevM} * 3.28084$ ).

Particularly for multi-day surveys, ADJ\_DEPTH, Depth\_M, 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.

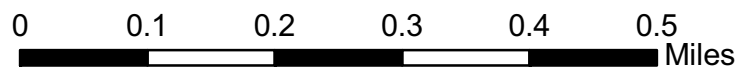
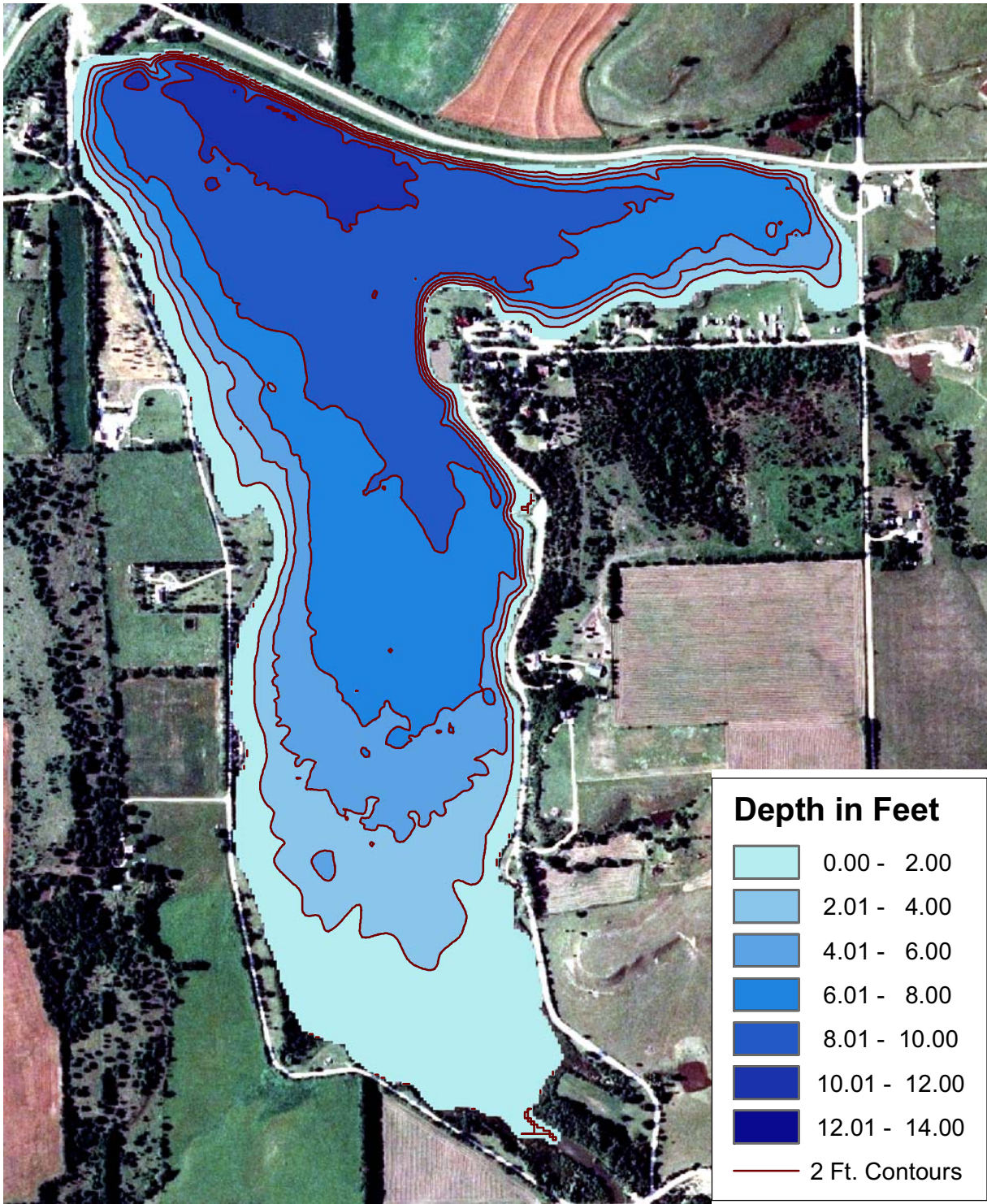


Figure 5. Water depth based on June 2008 bathymetric survey. Depths are based on a pool elevation of 1324.0 feet.

**Table 1**

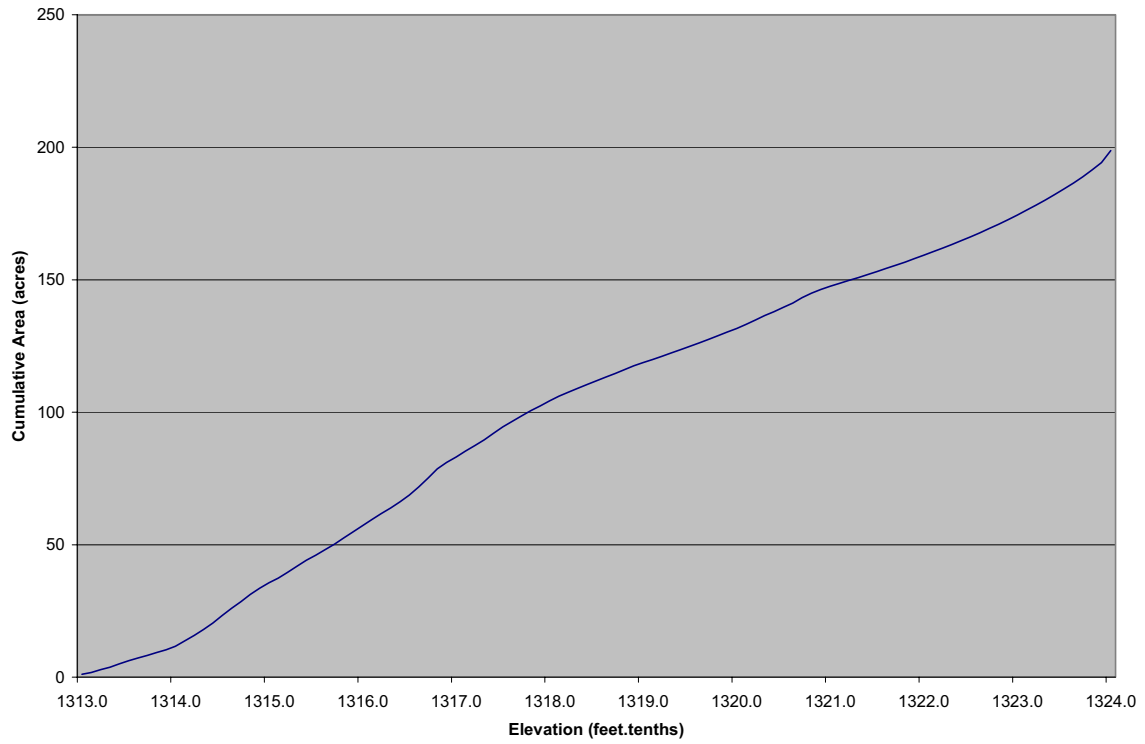
**Cumulative area in acres by tenth foot elevation increments**

<b><u>Elevation (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>1313</b>	1	2	3	4	5	6	7	8	9	10
<b>1314</b>	12	14	16	18	20	23	26	28	31	34
<b>1315</b>	36	37	40	42	44	46	48	50	53	55
<b>1316</b>	57	60	62	64	66	69	72	75	79	81
<b>1317</b>	83	85	87	90	92	94	96	99	101	102
<b>1318</b>	104	106	108	109	110	112	113	115	116	118
<b>1319</b>	119	120	121	122	124	125	126	128	129	130
<b>1320</b>	132	133	135	137	138	140	141	143	145	146
<b>1321</b>	148	149	150	151	152	153	154	155	157	158
<b>1322</b>	159	161	162	163	165	166	168	169	171	173
<b>1323</b>	174	176	178	180	182	184	187	189	191	194
<b>1324</b>	199									

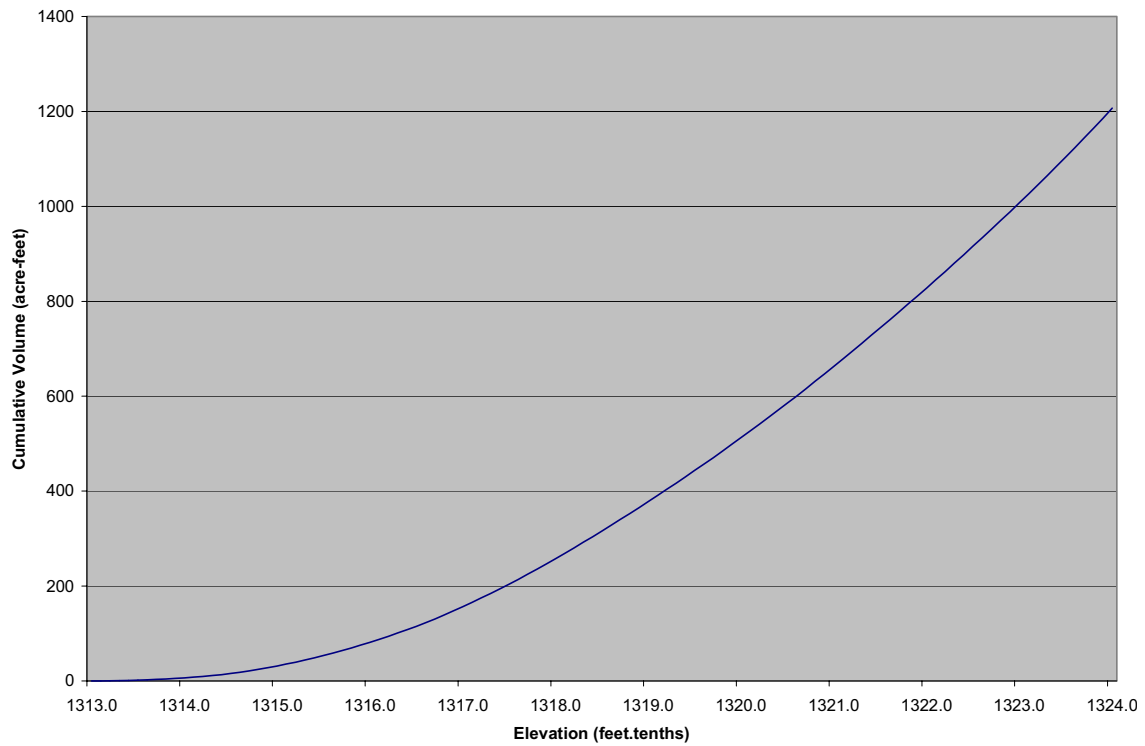
**Table 2**

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

<b><u>Elevation (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>1313</b>	0	0	0	1	1	2	3	3	4	5
<b>1314</b>	7	8	10	11	13	16	18	21	25	28
<b>1315</b>	32	36	40	44	49	54	59	64	70	75
<b>1316</b>	81	88	94	101	108	115	123	131	139	148
<b>1317</b>	156	165	175	184	194	204	214	225	236	246
<b>1318</b>	258	269	280	292	304	316	328	340	353	365
<b>1319</b>	378	391	404	417	430	444	457	471	485	498
<b>1320</b>	513	527	541	556	571	586	601	616	632	647
<b>1321</b>	663	679	695	711	728	744	761	777	794	811
<b>1322</b>	828	845	863	880	898	916	934	952	970	989
<b>1323</b>	1008	1026	1046	1065	1084	1104	1124	1144	1165	1186
<b>1324</b>	1207									



**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. Samples are then shipped to MidWest Laboratories (Omaha, NE), for texture, bulk density, and other analyses.

**Sediment re-sampling:** The original sample from site HL-3 was damaged in shipping for analysis. On April 8, 2009, the site was re-sampled. A GPS linked to ArcGIS and the map of original sampling sites was used to locate the boat within  $\pm 5$  meters of the original site. At the location, a Ponar dredge was used to take a sediment sample from the top 3-5 inches of sediment. The sample was manually mixed to ensure uniformity and a sample amount of 32 volumetric ounces (~940 cubic centimeters) was taken. This sample was then sealed and shipped to MidWest Laboratories for texture analysis.

## **SEDIMENT SAMPLING RESULTS:**

Sampling sites were distributed across the length of the reservoir (Figure 8). Silt percentages decreased from 56% at the inflow end (HL#1) to 32% near the dam (HL#3). Conversely, the clay fractions increased from the inflow end to the dam (Table 3; Figure 9; Figure 10).

**Table 3**  
**Herington Lake Sediment Sampling Site Data**

<b>CODE</b>	<b>UTMX</b>	<b>UTMY</b>	<b>Sand %</b>	<b>Silt %</b>	<b>Clay %</b>
HL#1	674504.4	4280685.1	30	56	14
HL#2	674494.1	4281254.7	38	34	28
HL#3	674295.7	4281759.2	20	32	48

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

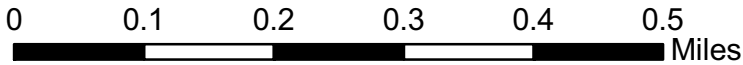
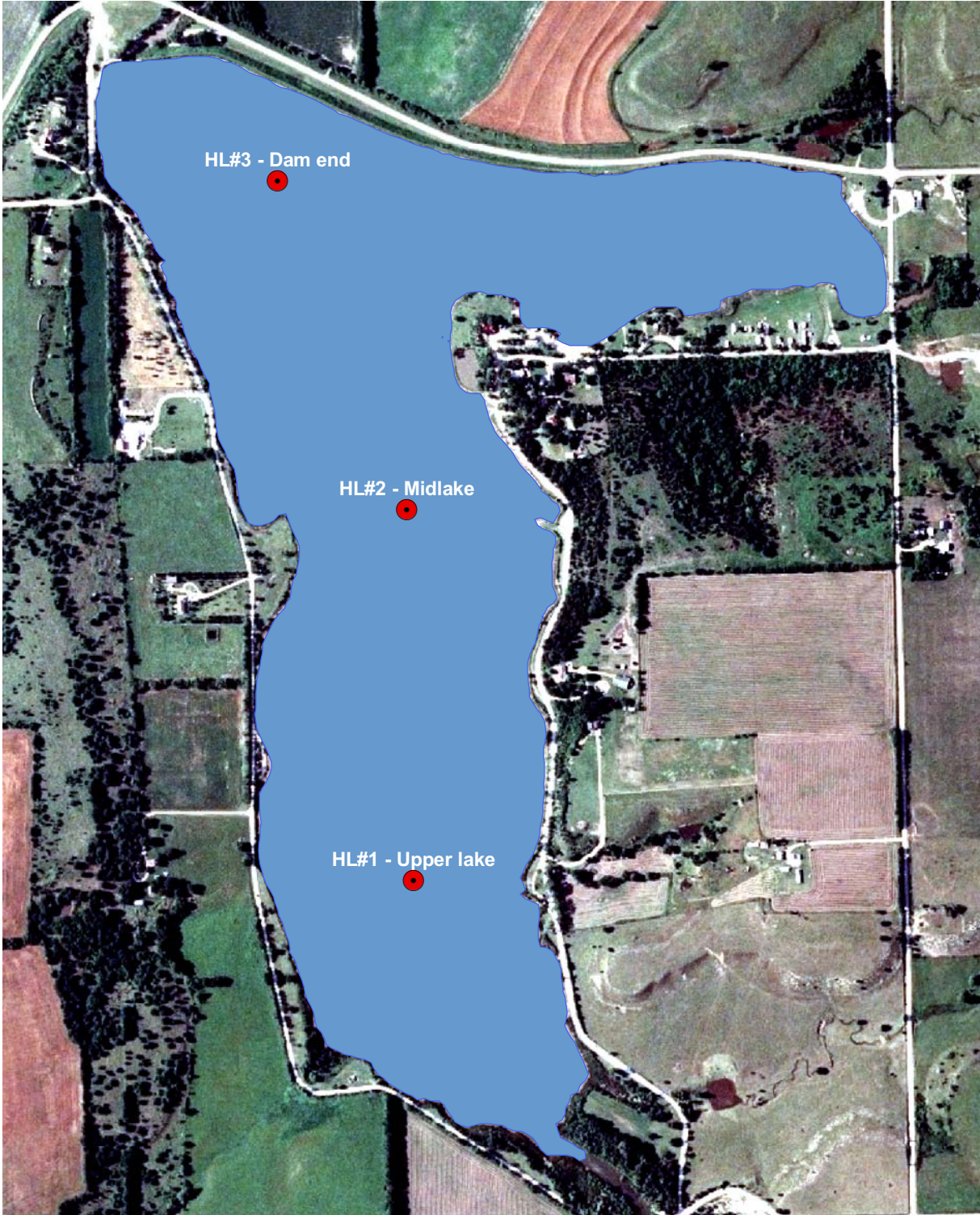


Figure 8. Sediment Sampling Sites in Herington Lake

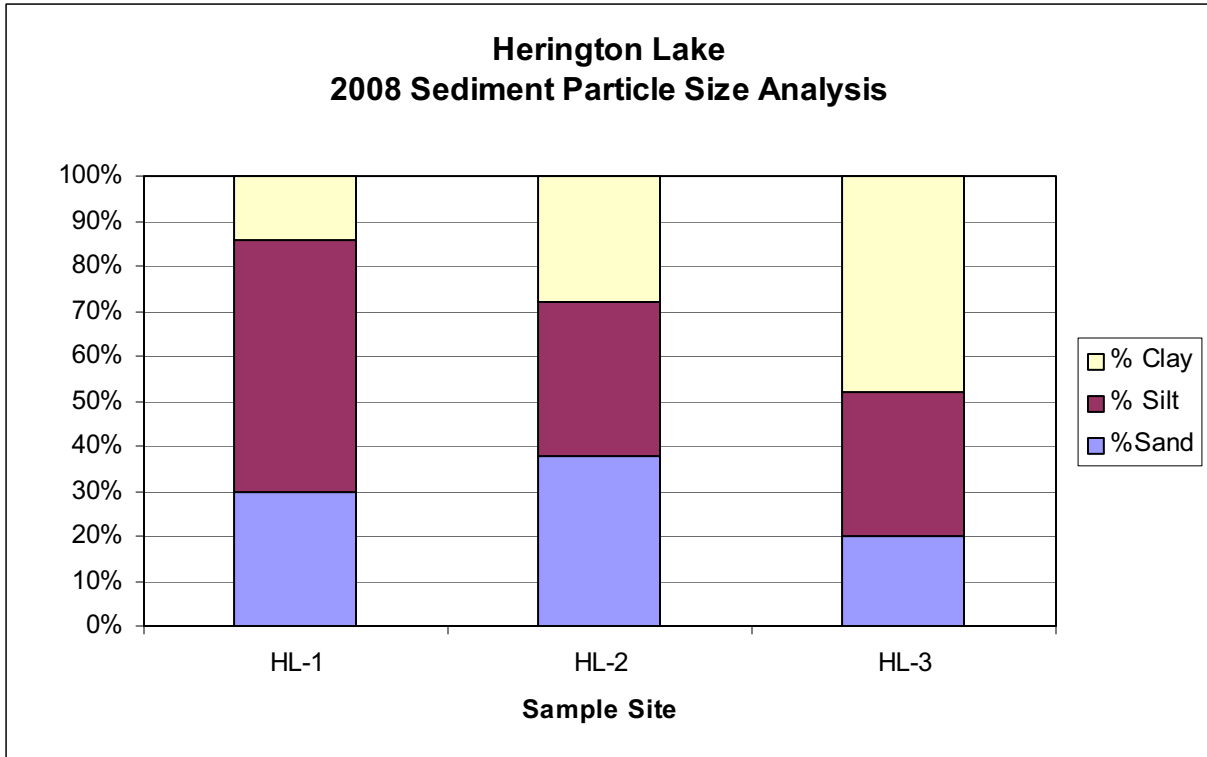
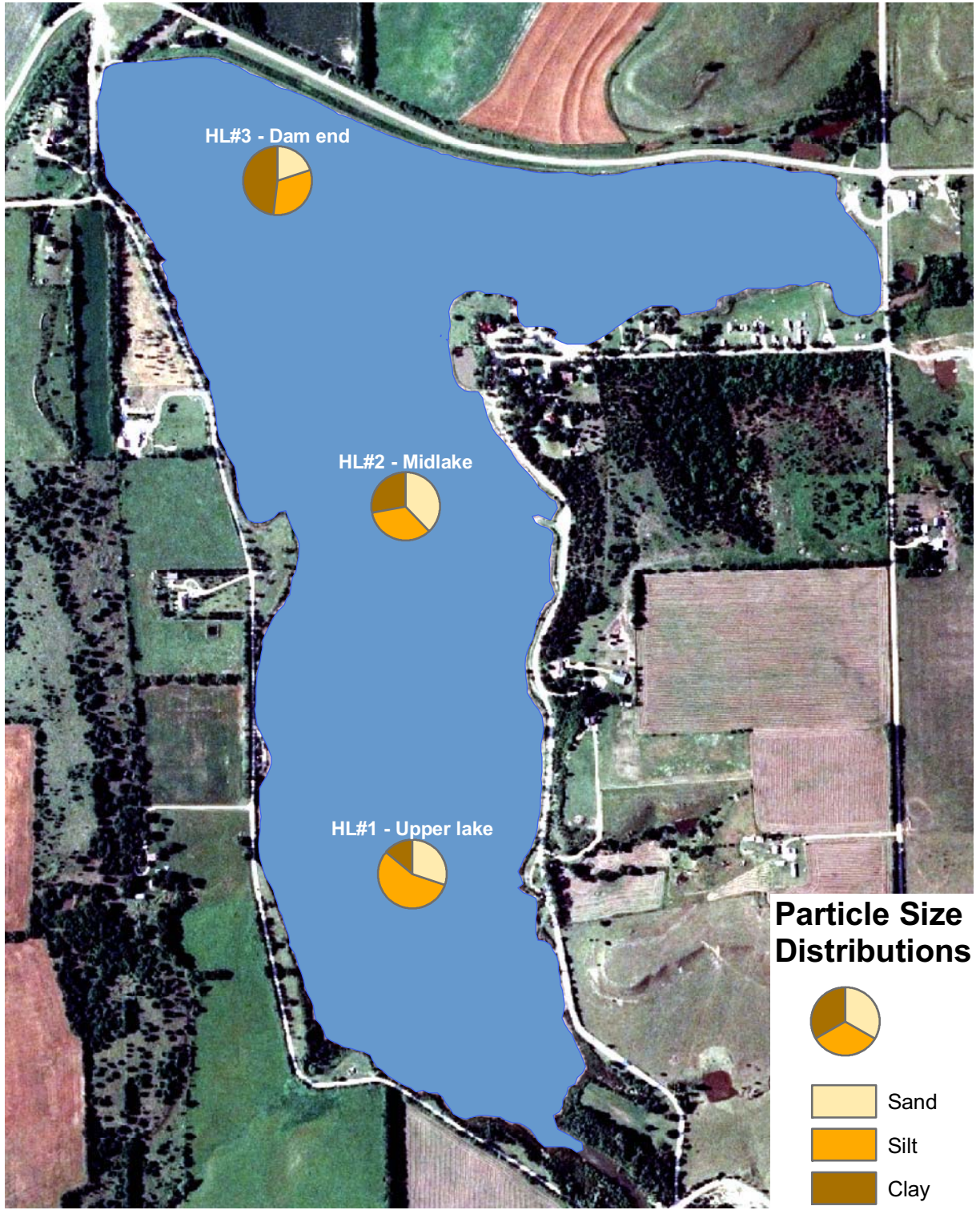


Figure 9. Sediment particle size analysis.



0 0.1 0.2 0.3 0.4 0.5 Miles



Figure 10. Particle size distribution of sediment samples in Herington Lake