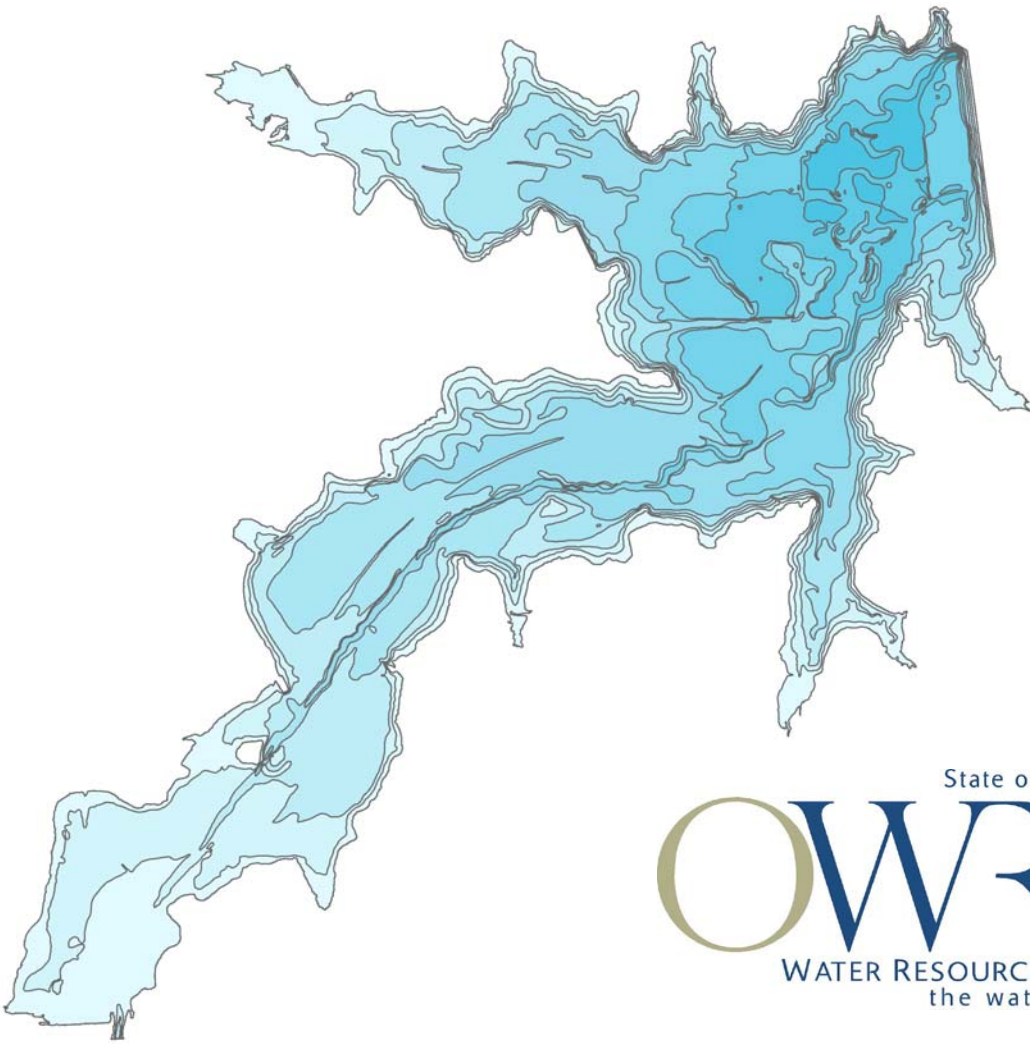
HYDROGRAPHIC SURVEY OF ARCADIA LAKE



State of Oklahoma
OWRB
WATER RESOURCES BOARD
the water agency

Final Report

Prepared by:
Oklahoma Water Resources Board

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ARCADIA LAKE HYDROGRAPHIC SURVEY REPORT

INTRODUCTION

The Oklahoma Water Resources Board (OWRB) conducted a hydrographic survey of Arcadia Lake from February to March of 2007. The purpose of the study was to collect hydrographic data of Arcadia Lake and convert this information into an area-elevation-volume table at the conservation pool elevation. The information produced will serve as a base to establish the location and rate of sedimentation in the conservation pool for future surveys.

LAKE BACKGROUND

History

On December 31, 1970, the Flood Control Act authorized Arcadia Lake (Public Law 91-611). The authorization was modified in 1976 by Section 192 (Public Law 94-587) of the Water Resources Act. The modification deleted water quality control as a stated purpose. Construction began in October of 1980. Diversion began on April 15, 1985 (USACE, 1986).

Lake Information

The Arcadia Dam is located on the Deep Fork River at river mile 218.3 in Oklahoma County. The Lake is approximately 5 miles east of Edmond and 12 miles northeast of Oklahoma City. Arcadia Lake is a multi-purpose project for flood control, water supply, recreation, and fish and wildlife. The lake has drainage area of 105 square miles. The Tulsa District of the Corps of Engineers water control manual lists Arcadia Lake with an area of 1,820 acres and cumulative storage capacity of 27,570 acre-feet at the top of its conservation pool elevation of 1006.0 ft (NGVD) with a reservoir length of 6 miles long and shoreline length of approximately 26 miles (USACE, 1986).

Arcadia Lake is owned by the United States Government. The Tulsa District of the Corps of Engineers is the operating agency for the lake. Recreational development and its associated operation and maintenance are contracted to the City of Edmond through the Edmond Public Works Authority.

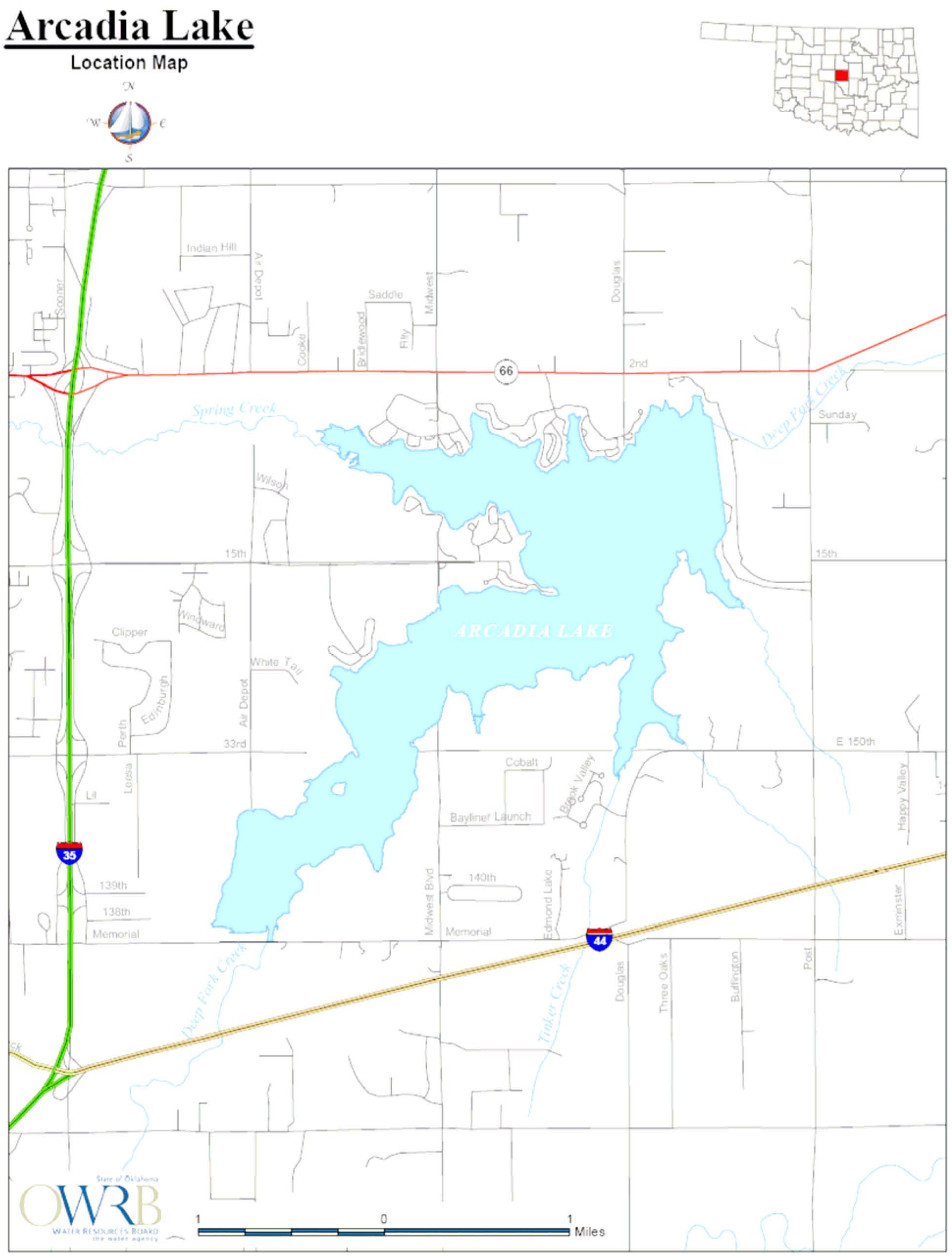

Figure 1: Location map for Arcadia Lake

Previous Surveys

In 1983, volumes and areas for the reservoir were planimetered from topographic maps yielding as an area of 1,820 acres and cumulative storage capacity of 27,570 acre-feet at the top of the conservation pool elevation at 1006.0 ft. In November of 1986 Arcadia Lake was surveyed using predetermined survey lines (**Figure D. 1**). This survey concluded that at its normal pool elevation of 1006 ft (NGVD), Arcadia Lake had an area of 1,765 acres and a capacity of 30,783 acre-feet. A hydrographic survey was also conducted in December of 1997. The 1997 survey, conducted along the same sedimentation range lines of the 1986 survey, indicates that Arcadia Lake had an area of 1,725 acres and a capacity of 29,705 acre-feet at normal pool elevation.

HYDROGRAPHIC SURVEYING PROCEDURES

The process of surveying a reservoir uses a combination of Geographic Positioning System (GPS) and acoustic depth sounding technologies that are incorporated into a hydrographic survey vessel. As the survey vessel travels across the lake's surface, the echosounder gathers multiple readings every second from the lake bottom. The depth readings are stored on the survey vessel's on-board computer along with the positional data generated from the vessel's GPS receiver. The collected data files are downloaded daily from the computer and brought to the office for editing after the survey is completed. During editing, data "noise" is removed or corrected, and average depths are converted to elevation readings based on the daily-recorded lake level elevation on the day the survey was performed. Accurate estimates of area-capacity can then be determined for the lake by building a 3-D model of the reservoir from the collected data. The process of completing a hydrographic survey includes four steps: pre-survey planning, field survey, data processing, and GIS application.

Pre-survey Planning

<u>Boundary File</u>

The digitized boundary of Arcadia Lake was provided to the Oklahoma Water Resources Board by the City of Edmond. The conservation pool elevation for Arcadia Lake is 1006.00 feet (NGVD).

<u>Set-up</u>

HYPACK software from Hypack, Inc. was used to assign geodetic parameters, import background files, and create virtual track lines (transects). The geodetic parameters assigned were State Plane NAD 83 Zone OK-3501 Oklahoma North with distance units and depth as US Survey Feet. The survey transects were spaced according to the accuracy required for the project. The survey transects within the digitized reservoir boundary were at 300 ft increments and ran perpendicular to the original stream channels and tributaries. Approximately 120 virtual transects were created for the Arcadia Lake project not including channel track lines, which were created after the initial surveying of the lake transects.

Field Survey

Method

The procedures followed by the OWRB during the hydrographic survey adhere to U.S. Army Corps of Engineers (USACE) standards (USACE, 2002). The quality control and quality assurance procedures for equipment calibration and operation, field survey, data processing, and accuracy standards are presented in the following sections.

Technology

The Hydro-survey vessel was an 18-ft aluminum Silverstreak hull with cabin, powered by a single 115-Horsepower Mercury outboard motor. Equipment used to conduct the survey included: a ruggedized notebook computer; Syqwest Bathy 1500 Echo Sounder; Trimble Navigation, Inc. Pro XR GPS receiver with differential global positioning system (DGPS) correction; and an Odom Hydrographics, Inc, DIGIBAR-Pro Profiling Sound Velocimeter. A 12V battery and inverter provided the power supply to the equipment. The software used was HYPACK.

Survey

A two-man survey crew was used during the project. Data collection for Arcadia Lake occurred on Feb 21, 26, and 27, and again on Mar. 8 and 14, 2007. On April 5, 2007, the OWRB returned to Arcadia Lake after the lake level had risen in order to collect additional data in the more shallow areas of the reservoir. The average water level elevation in February and March 2007 was approximately 1006.4 feet. The average water level on April 5 was 1010.4ft. Data collection began at the dam and moved west and southwest down the reservoir. The survey crew followed the parallel transects created during the pre-survey planning while collecting depth soundings and positional data. Data was also collected along a path parallel to the shoreline at a distance that was determined by the depth of the water and the draft of the boat. This was usually in a water depth of two to three feet. Areas with depths less than what could accommodate the boat were avoided.

The survey crew also collected data on the same sedimentation range lines that the U.S. Army Corp of Engineers used in their surveys of the reservoir. The OWRB collected data on the following sedimentation range lines, as they were within the conservation pool elevation: SR-1, SR-2A, SR-3A, SR-4A, SR-5A, SR-6A, SR-16A, and SR-17AB. No surveys were performed above the top of the conservation pool.

Equipment Calibration

While on board the Hydro-survey vessel, the Syqwest Bathy 1500 Echo Sounder with a depth resolution of 0.1 ft was calibrated using A DIGIBAR-Pro Profiling Sound Velocimeter, by Odom Hydrographics. The unit measures the variation in the speed of sound at different depths throughout the water column. The factors that influence the speed of sound—depth, temperature, and salinity—are all taken into account.

This method involved lowering a probe, which measures the speed of sound, into the water to the calibration depth mark to allow for acclimation and calibration of the depth sensor. The unit was then raised to as close to the water's surface as possible, gradually lowered at a controlled speed to a depth just above the lake bottom, and then was raised to the surface. The unit collected sound velocity measurements in feet/seconds (ft/sec) at 1 ft increments on both the deployment and retrieval phases. The data was then reviewed for any erroneous readings, which were then edited out of the sample, and an averaged speed of sound was produced from the final readings. The speed of sound profile was applied to the raw data in the HYPACK editing process.

The speed of sound in the water column ranged from 4,683.8 ft/sec to 4,836.9 ft/sec during the Arcadia Lake survey. The sound velocity profiles for each date are shown in **Appendix A**.

A quality assurance cross-line check was undertaken on intersecting (cross-section) lake transect lines and channel track lines. This is done to verify compliance with the resultant depth accuracy of ±2.0 ft at the 95% confidence level. This simply means that on average, 19 of every 20 observed depths will fall within the specified accuracy tolerance. HYPACK Cross Statistics program was used to assess vertical accuracy and confidence measures of acoustically recorded depths. The program reads the cross-section profile data and longitudinal profile data, computes the intersection, and interpolates a depth from each input file (USACE, 2002). For each cross-section the output file will list the horizontal intersection, the interpolated depths, absolute difference in depth reading, mean difference, and standard deviation. A total of 114 cross-sections points were used for statistical analyses to compute error estimates.

Depth readings will contain both random errors and systematic bias. Biases are often referred to as systematic or external errors and may contain observational errors (USACE, 2002). Examples of bias include a bar check calibration error, tidal errors, or erroneous squat corrections. Random errors are the errors present in the measurement system that cannot be easily reduced by further calibration. Examples of random error include uneven bottom topography, bottom vegetation, positioning error, and speed of sound variation in the water column. The depth accuracy estimate is determined from actual depth comparisons taken over the same terrain and computing the mean difference (MD) which are considered bias errors and the standard deviation (SD) which are considered random errors between single-beam cross-line check comparisons. The two estimates are then combined to compute the Root Mean Square (RMS) error. The RMS error estimate is used to compare relative accuracies of estimates that differ substantially in bias and precision (USACE, 2002). The RMS should not exceed the tolerance of ±2.0 ft.

A mean difference of -0.67 ft and a standard deviation of 0.81 ft were computed from a number of 114 data points. Using the following formulas, a RMS (95%) depth accuracy of ±1.32 ft was calculated.

$$SE = SD / \sqrt{n}$$

$$RMS = \sqrt{MD^2 + SE^2}$$

$$RMS\ (95\%)\ depth\ accuracy = 1.96 \times RMS$$

where:

SE = standard error
SD = standard deviation
n = number of data points

RMS = root mean square error
MD = mean difference

The data plotted in **Figure 2** illustrates that the measurements have high precision, high repeatability, and high absolute accuracy. It must be noted that high precision or repeatability does not necessarily indicate high accuracy. Tightly scattered data may be highly accurate, whereas highly repeatable data could have large undetected biases (USACE, 2002).

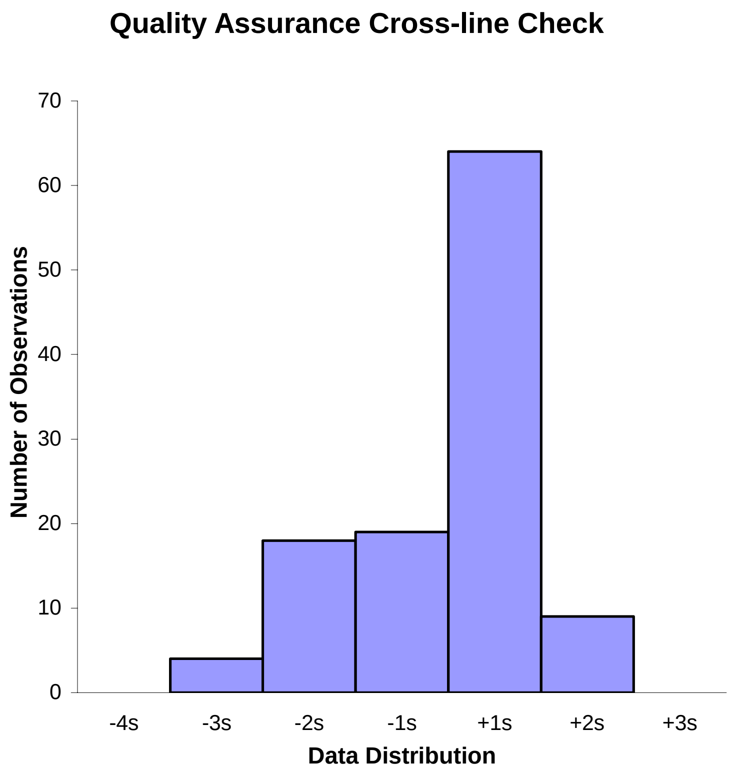

Figure 2: Histogram of relative depth distribution, in standard deviations, at cross-line intersections.

In addition to depth accuracy estimate, error was also estimated for squat. Squat is defined as the change in vessel trim as it moves through the water. Squat corrections are considered positive due to the transducer depressing into the water at acceleration. The estimated error for squat was +0.25 ft. When combined, the two factors give a total estimated error range of -1.07 to +1.57 ft.

The GPS system is an advanced high performance geographic data-acquisition tool that uses Differential Global Positioning System (DGPS) to provide sub-meter positional accuracy on a second-by-second basis. Potential errors are reduced with differential GPS because additional data from a reference GPS receiver at a known position are used to correct positions obtained during the survey. Before the survey, Trimble's Pathfinder Controller software was used to configure the GPS receiver. To maximize the accuracy of the horizontal positioning, the horizontal mask setting was set to 15 degrees and the Position Dilution of Precision (PDOP) limit was set to 6. The position interval was set to 1 second and the Signal to Noise Ratio (SNR) mask was set to 4. The United States Coast Guard (USCG) reference station used in the Arcadia Lake survey is located near Sallisaw, Oklahoma. The reference beacon system transmitted corrected signals in real time, so no post-processing corrections of position data were needed. The collected DGPS positions were converted to state-plane coordinate system using the HYPACK program.

A latency test was performed to determine the fixed delay time between the GPS and single beam echo sounder. The timing delay was determined by running reciprocal survey lines over a channel bank. The raw data files were downloaded into HYPACK, LATENCY TEST program. The program varies the time delay to determine the "best fit" setting. A position latency of 0.3 seconds was produced and adjustments were applied to the raw data in the SINGLE BEAM EDITOR program.

Data Processing

The collected data was downloaded from the field computer onto the OWRB computer network and data burned to a CD as a permanent record. After downloading the data, each raw data file was reviewed for accuracy and completeness using the Single Beam Editor program within HYPACK. The Single Beam Editor program allowed the user to assign transducer offsets, latency corrections, tide corrections, display the raw data profile, and review/edit all raw X, Y, and Z information. Collected data points that have inaccurate or absent depth or positional information were interpolated to be congruent with adjacent accurate points or deleted completely.

Offset correction values of 3.2 ft. starboard, 6.6 ft. forward, and -1.1 ft. vertical were applied to all raw data. This takes into account the differing locations of the transducer and the GPS receiver. A latency correction factor of 0.3 seconds was applied to the raw data. Latency is the lag time between when a depth reading is taken and when the GPS location is assigned. The speed of sound readings, which are documented in **Appendix A,** were also applied to the raw data.

Using HYPACK, Tides program, a tide correction file was produced to account for the variance in lake elevation at the time in which data was collected. Within the Single Beam Editor program, the corrected depths were subtracted from the elevation readings to convert the depth in feet to an elevation.

After editing the data for errors and correcting the spatial attributes (offsets and tide corrections), a data reduction scheme was needed. To accomplish this the data was resampled spatially at a 10 ft interval using the Sounding Selection program in HYPACK. The resultant data was saved and exported out as a xyz.txt file. The HYPACK data file for Arcadia Lake is located at the end of the document on the CD entitled *Arcadia HYPACK/GIS Metadata.*

GIS Application

Geographic Information System (GIS) software was used to process the edited XYZ data collected from the survey. The GIS software used was ArcGIS Desktop and ArcMap, version 9.1, from Environmental System Research Institute (ESRI). All of the GIS datasets created are in Oklahoma State Plane North Coordinate System referenced to the North American Datum

1983. Horizontal and vertical units are in feet. The edited data points in XYZ text file format were converted into ArcMap point format. The point coverage contains the X and Y horizontal coordinates and the elevation and depth values associated with each collected point.

Volumetric and area calculations were derived using a TIN surface model. The TIN model was created in ArcMap, using the collected survey data points and the lake boundary inputs. The TIN consists of connected data points that form a network of triangles representing the bottom surface of the lake. Approximately 37,955 data points were used to create the TIN model. The lake volume was calculated by slicing the TIN horizontally into planes 0.1 ft thick. The volume and area of each slice are shown in **Appendix B**.

Contours, depth ranges, and the shaded relief map were derived from a digital elevation model grid. This grid was created using the ArcMap Topo to Raster Tool and had a spatial resolution of five feet. The contours were created at a 5-ft interval using the ArcMap Contour Tool . The contour lines were edited to allow for polygon topology and to improve accuracy and general smoothness of the lines. The contours were then converted to a polygon coverage and attributed to show 5-ft depth ranges across the lake. The bathymetric map of the lake is shown with 5-ft contour intervals in **Appendix C**.

All geographic datasets derived from the survey contain Federal Geographic Data Committee (FGDC) compliant metadata documentation. The metadata describes the procedures and commands used to create the datasets. The GIS metadata file for Arcadia Lake is located at the end of the document on the CD entitled *ArcadiaHYPACK/GIS Metadata.*

RESULTS

Results from the 2007 OWRB survey indicate Arcadia Lake encompasses 1,678 ac and contains a cumulative capacity of 29,544 ac-ft at the conservation pool elevation of 1006 ft. The maximum depth recorded was 47.8 ft.

SUMMARY AND COMPARISONS

Arcadia Lake was put into use in 1986. **Table 1** summarizes all surveys conducted of Arcadia Lake at the conservation pool elevation.

Table 1: Area and Volume Comparisons of Arcadia Lake at Conservation Pool Elevation (1006.0 ft).

Feature	Survey Years			
	1983	1986	1997	2007
Area (acres)	1,820	1,765	1,725	1,678
Cumulative Volume (acre-feet)	27,570	30,783	29,705	29,544

Because of the difference in survey methods, it is difficult to accurately assess sedimentation rates between the 2007 survey and previous surveys. For example, comparison between the 2007 survey and the original impoundment data suggests a gain of about 7% in capacity while comparison to the 1987 survey suggests a 4% loss in capacity. This apparent variability in capacity is likely the result in measurement error. It is worthwhile to note that any actual sedimentation that has occurred within the last 20 years is masked by the error. This suggests that Arcadia Lake has a relatively low overall sedimentation rate within the conservation pool.

Although sedimentation rates between survey periods are not conclusive, direct comparison of the different surveys along the sedimentation range lines can yield beneficial information. **Figure E. 1 - Figure E. 9** show comparison profiles along the sedimentation range lines used in the 1986 and 1997 surveys. These lines were also ran in the OWRB's 2007 survey. These profiles do show that sedimentation is occurring in the channels of the lake. The greatest sedimentation within the conservation pool (approximately 3 feet of deposition in the channel) was noted in the Deep Fork arm of the lake (Figure E.6). Changes in elevation along the sedimentation ranges noted outside of the channels lines fall within the 95% depth accuracy.

The OWRB considers the 2007 survey to be a significant improvement over previous survey endeavors and recommends that the same methodology be used in ten years to monitor changes in the lake's storage capacity. The survey and computation methods utilized in the OWRB survey differ from those employed in the previous surveys. When comparing area-capacity between the historical USACE original design and the OWRB hydrographic survey, the new capacity calculation of 29,544 ac-ft will serve as a more accurate number for future comparisons.

REFERENCES

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Arkansas River Basin.

U.S. Army Corps of Engineers (USACE). 1998. Reservoir Sediment Data Summary.

U.S. Army Corps of Engineers (USACE). 2002. Engineering and Design - Hydrographic Surveying, Publication EM 1110-2-1003, 3rd version.

APPENDIX A: Sound Velocity Profile

Table A. 1: Sound Velocity Profile Data for February 21 through March 5, 2007.

Depth	02/21/2007	02/26/2007	02/27/2007	03/08/2007	03/14/2007	04/05/2007
1	4701	4718.7	4722.3	4742.3	4801.7	
2	4695.7	4718.5	4722.2	4741.9	4801.6	4836.5
3	4689.4	4718.5	4722.2	4741.4	4801.5	4836.5
4	4687.3	4718.5	4722.1	4741.3	4801.4	4836.5
5	4686.5	4718.5	4722.1	4741.3	4801.3	4836.5
6	4685.7	4718.5	4722	4741.2	4801.2	4836.5
7	4685.1	4718.5	4722	4741.2	4801	4836.5
8	4684.8	4718.5	4721.9	4741.2	4800.7	4836.5
9	4684.6	4718.4	4721.7	4741.3	4800.5	4836.6
10	4684.4	4718.4	4721.6	4741.3	4800.3	4836.6
11	4684.4	4718.5	4721.6	4741.3	4799.8	4836.6
12	4684.4	4718.5	4721.5	4741.3	4799.1	4836.6
13	4684.3	4718.5	4721.6	4741.3	4797.9	4836.6
14	4684.3	4718.5	4721.5	4741.3	4794.6	4836.6
15	4684.3	4718.5	4721.5	4741.2	4790.7	4836.6
16	4684.3	4718.4	4721.6	4741.3	4785	4836.6
17	4684.2	4718.4	4721.5	4741.2	4779.5	4836.7
18	4684.2	4718.4	4721.6	4741.2	4774	4836.7
19	4684.2	4718.4	4721.5	4741.2	4770.5	4836.7
20	4684.2	4718.4	4721.5	4741.1	4767.1	4836.7
21	4684.1	4718.3	4721.5	4741.1	4766.2	4836.8
22	4684.3	4718.3	4721.5	4741	4765.2	4836.9
23	4684.2	4718.3	4721.5	4741	4764.6	
24	4684.2	4718.3	4721.4	4741	4763.6	
25	4684.2	4718.3	4721.4	4740.9	4762.9	
26	4684.2	4718.3	4721.3	4740.7	4762.3	
27	4684.2	4718.3	4721.2	4740.6	4762	
28	4684	4718.3	4721.1	4740.4	4761.9	
29	4683.9	4718.3	4720.9	4740.2	4761.9	
30	4683.9	4718.2	4720.7	4739.9	4761.9	
31	4684	4718.2	4720.5	4739.8	4761.9	
32	4684.1	4718.3	4720.2	4739.7	4761.9	
33	4683.8	4718.3	4719.7	4739.7	4761.8	
34		4718.3	4719.4	4739.7	4761.6	
35		4718.3	4719.2	4739.5	4761.2	
36		4718.3	4719.1	4739.5	4760.9	
37		4718.3	4719	4739.4	4760.7	
38		4718.3	4719.2	4739.3	4760.9	
39		4718.4				
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41						
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44						
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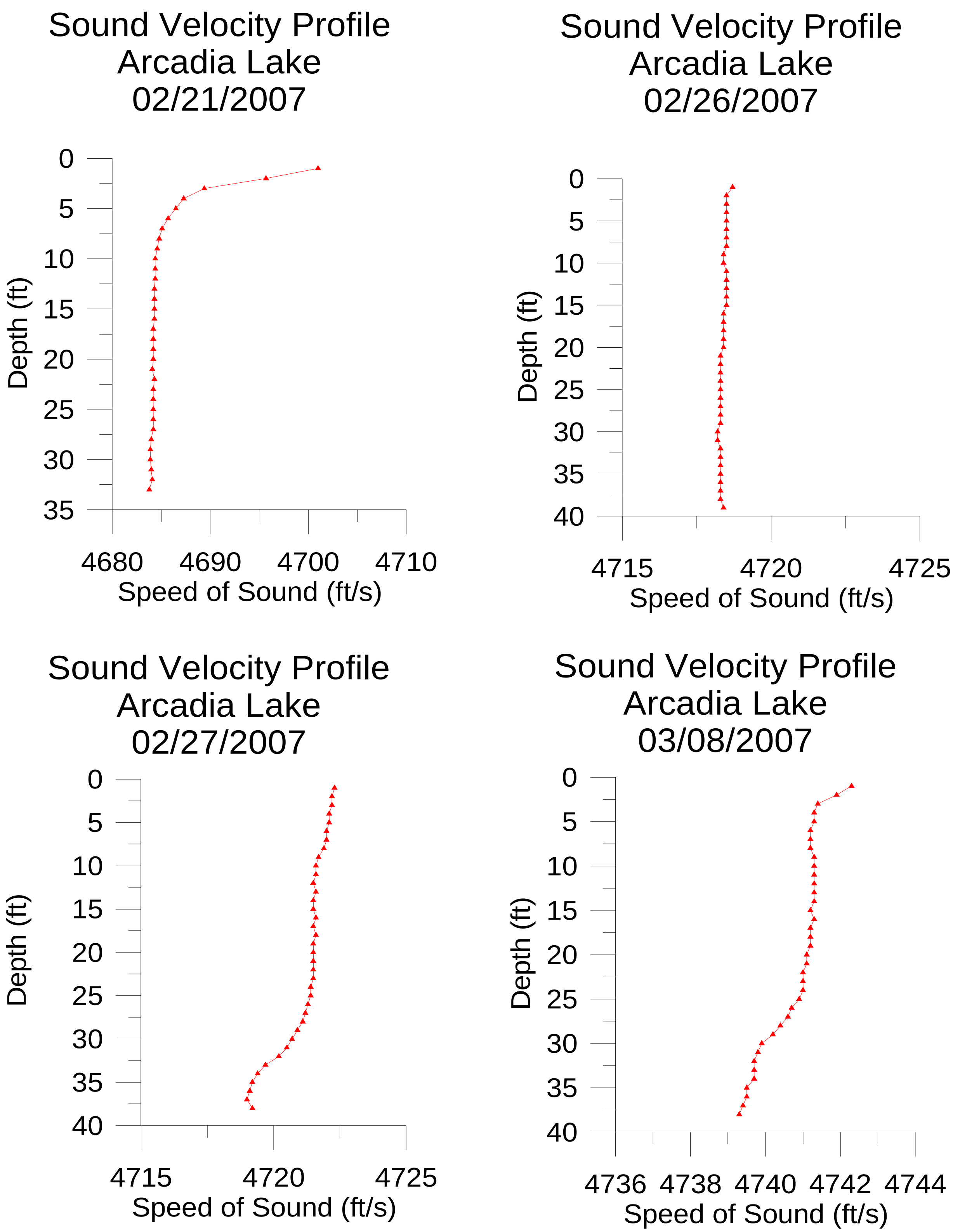


Figure A. 1: Sound Velocity Profiles for February 21, 26, 27 and March 8, 2007.

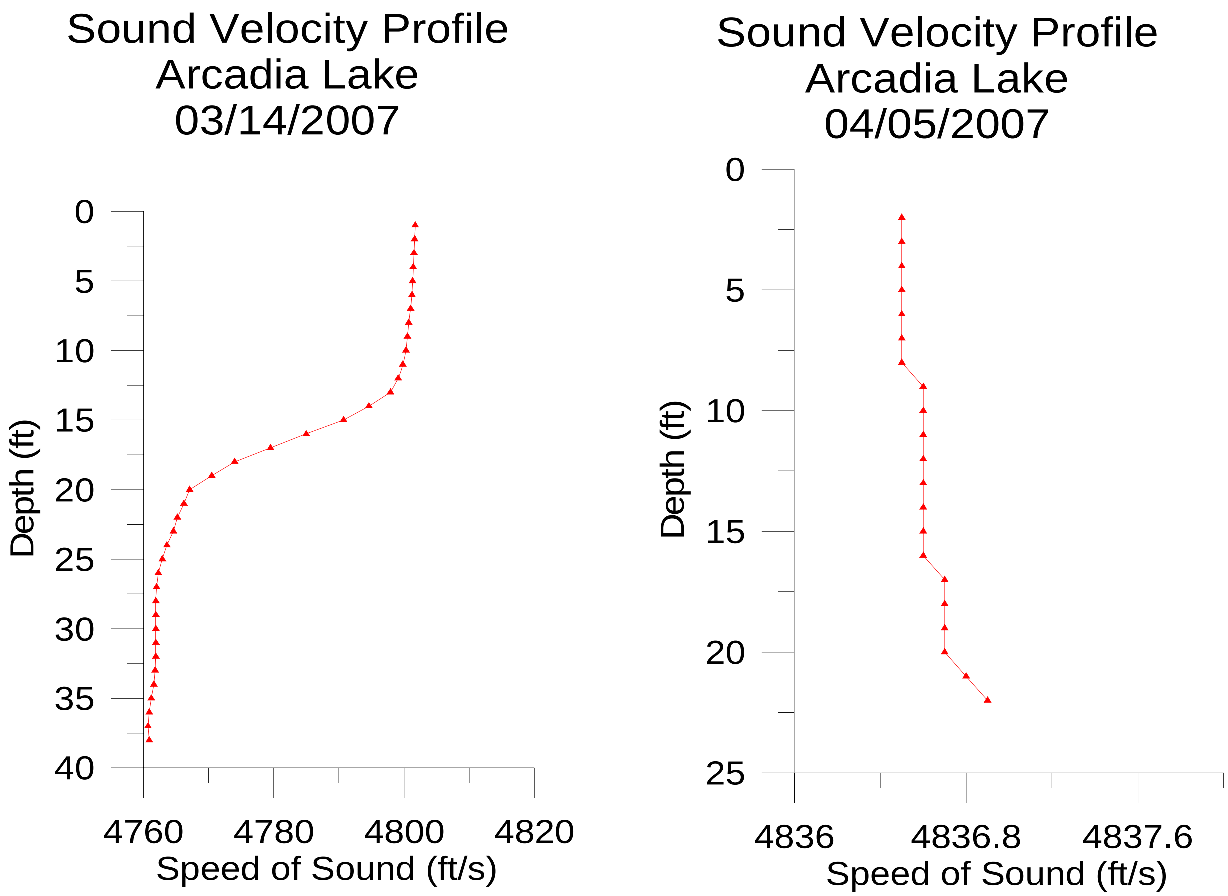


Figure A. 2: Sound Velocity Profiles for March 14 and April 15, 2007.

APPENDIX B: Area-Capacity Data

Table B. 1: Arcadia Lake Cumulative Capacity by 0.1-ft Increments.

ARCADIA LAKE CAPACITY TABLE Volume in acre-feet by tenth foot elevation increments 2007 Survey OKLAHOMA WATER RESOURCES BOARD										
Elevation (ft NGVD)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
958			0	0	0	0	0.0001	0.0003	0.0005	0.0008
959	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.009	0.012	0.014
960	0.017	0.020	0.023	0.027	0.031	0.036	0.041	0.046	0.052	0.058
961	0.07	0.09	0.12	0.14	0.17	0.20	0.23	0.27	0.30	0.34
962	0.38	0.43	0.48	0.54	0.60	0.66	0.72	0.78	0.85	0.92
963	1.0	1.1	1.2	1.3	1.5	1.8	2.1	2.5	2.9	3.5
964	4.2	5.0	5.8	6.8	7.8	8.8	10.0	11	12	14
965	15	17	19	21	23	25	28	31	34	37
966	41	45	49	54	59	63	68	74	79	84
967	90	96	102	109	115	122	128	135	142	149
968	156	163	170	178	185	193	201	210	219	227
969	237	246	255	265	275	285	295	305	316	327
970	338	349	360	372	384	397	410	423	436	450
971	464	479	494	509	525	541	557	573	590	607
972	626	645	665	684	704	724	745	765	786	807
973	828	849	871	893	915	937	960	983	1007	1030
974	1054	1079	1103	1128	1153	1178	1203	1229	1255	1281
975	1307	1334	1361	1388	1416	1445	1473	1502	1532	1561
976	1592	1623	1655	1687	1719	1752	1785	1818	1852	1886
977	1920	1955	1989	2024	2060	2095	2131	2166	2202	2239
978	2275	2312	2348	2385	2423	2460	2498	2536	2575	2613
979	2652	2692	2732	2772	2813	2854	2895	2936	2977	3019
980	3061	3104	3147	3190	3234	3278	3323	3368	3413	3459
981	3504	3552	3599	3648	3696	3745	3795	3845	3895	3947
982	3998	4050	4103	4156	4208	4262	4315	4368	4422	4476
983	4530	4584	4639	4694	4749	4805	4861	4917	4975	5032
984	5090	5148	5207	5266	5326	5385	5445	5505	5566	5627
985	5688	5751	5814	5879	5943	6008	6074	6140	6206	6273
986	6340	6409	6478	6547	6618	6688	6759	6830	6902	6974
987	7047	7120	7194	7268	7343	7417	7492	7568	7643	7719
988	7796	7873	7950	8028	8106	8185	8265	8345	8426	8508
989	8590	8673	8756	8839	8923	9007	9092	9177	9262	9348
990	9435	9523	9612	9701	9792	9882	9974	10066	10158	10250
991	10343	10438	10533	10628	10724	10820	10917	11014	11111	11209
992	11307	11406	11505	11605	11704	11804	11905	12005	12106	12207
993	12309	12411	12514	12617	12721	12826	12931	13037	13144	13251
994	13358	13465	13573	13681	13790	13899	14008	14118	14227	14338
995	14449	14560	14672	14785	14898	15011	15125	15240	15355	15470
996	15585	15702	15818	15935	16053	16171	16289	16408	16527	16647

ARCADIA LAKE CAPACITY TABLE Volume in acre-feet by tenth foot elevation increments 2007 Survey OKLAHOMA WATER RESOURCES BOARD										
Elevation (ft NGVD)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
997	16768	16889	17010	17132	17254	17376	17498	17621	17745	17868
998	17992	18116	18241	18366	18491	18616	18742	18869	18996	19123
999	19250	19378	19506	19635	19764	19894	20024	20155	20286	20418
1000	20550	20682	20816	20950	21085	21221	21357	21493	21630	21768
1001	21907	22047	22188	22329	22470	22612	22754	22897	23041	23185
1002	23329	23474	23619	23765	23911	24058	24205	24352	24500	24649
1003	24798	24947	25097	25247	25398	25550	25702	25855	26009	26163
1004	26317	26472	26628	26785	26942	27100	27259	27418	27578	27738
1005	27899	28061	28224	28387	28551	28715	28880	29045	29211	29377
1006	29544									

Table B. 2: Arcadia Lake Area by 0.1-ft Increments.

ARCADIA LAKE AREA TABLE Area in acres by tenth foot elevation increments 2007 Survey OKLAHOMA WATER RESOURCES BOARD										
Elevation (ft NGVD)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
958					0.0002	0.0006	0.001	0.002	0.003	0.004
959	0.005	0.007	0.008	0.01	0.01	0.01	0.02	0.02	0.02	0.03
960	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06
961	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4
962	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7
963	0.9	1.0	1.2	1.6	2.1	2.7	3.5	4.3	5.2	6.3
964	7.7	8.3	9.0	9.6	10	11	12	12	13	14
965	15	17	19	21	23	25	27	30	32	35
966	41	43	44	46	47	49	51	53	55	57
967	59	61	62	63	64	65	66	68	69	70
968	71	72	74	75	78	80	83	87	89	90
969	92	94	95	97	99	101	103	104	107	109
970	111	114	117	120	123	127	130	133	136	138
971	148	150	152	154	157	159	162	165	171	180
972	191	194	196	198	200	202	204	206	208	210
973	213	215	218	220	223	227	230	232	235	238
974	242	244	246	248	251	253	255	257	260	262

ARCADIA LAKE AREA TABLE Area in acres by tenth foot elevation increments 2007 Survey OKLAHOMA WATER RESOURCES BOARD										
Elevation (ft NGVD)	**0**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
975	265	269	272	277	281	285	288	292	296	299
976	312	316	319	322	325	328	331	335	338	341
977	345	347	349	351	353	355	357	359	361	363
978	365	367	369	372	374	377	380	382	385	388
979	397	399	402	404	406	409	411	414	416	419
980	423	427	431	437	441	444	448	451	454	457
981	470	475	480	484	489	493	498	502	507	514
982	521	523	525	528	530	532	534	536	538	540
983	542	545	547	550	554	558	564	568	573	577
984	584	587	589	592	595	597	600	603	606	611
985	625	632	638	644	649	653	657	662	666	670
986	684	688	693	698	702	707	711	715	720	724
987	733	736	739	742	746	749	752	755	758	762
988	767	771	775	780	786	793	801	808	813	818
989	824	828	832	836	840	844	848	852	858	864
990	874	883	892	901	906	911	915	920	924	929
991	942	947	951	955	959	964	968	973	977	981
992	986	989	992	995	998	1001	1004	1007	1010	1013
993	1019	1024	1030	1037	1044	1051	1057	1062	1066	1070
994	1074	1077	1080	1084	1087	1090	1094	1097	1101	1105
995	1111	1116	1123	1130	1134	1138	1142	1146	1149	1153
996	1161	1165	1169	1173	1177	1181	1186	1191	1197	1203
997	1208	1211	1214	1217	1220	1223	1227	1231	1234	1237
998	1240	1243	1246	1250	1253	1257	1263	1266	1270	1273
999	1277	1280	1284	1289	1296	1300	1305	1309	1313	1318
1000	1323	1331	1338	1346	1352	1358	1363	1369	1375	1384
1001	1395	1403	1408	1412	1417	1421	1426	1431	1436	1442
1002	1447	1451	1455	1459	1463	1468	1472	1477	1482	1486
1003	1492	1497	1501	1506	1513	1519	1526	1531	1537	1542
1004	1551	1557	1563	1569	1575	1582	1588	1594	1601	1607
1005	1617	1623	1628	1634	1640	1645	1651	1656	1662	1667
1006	1677									

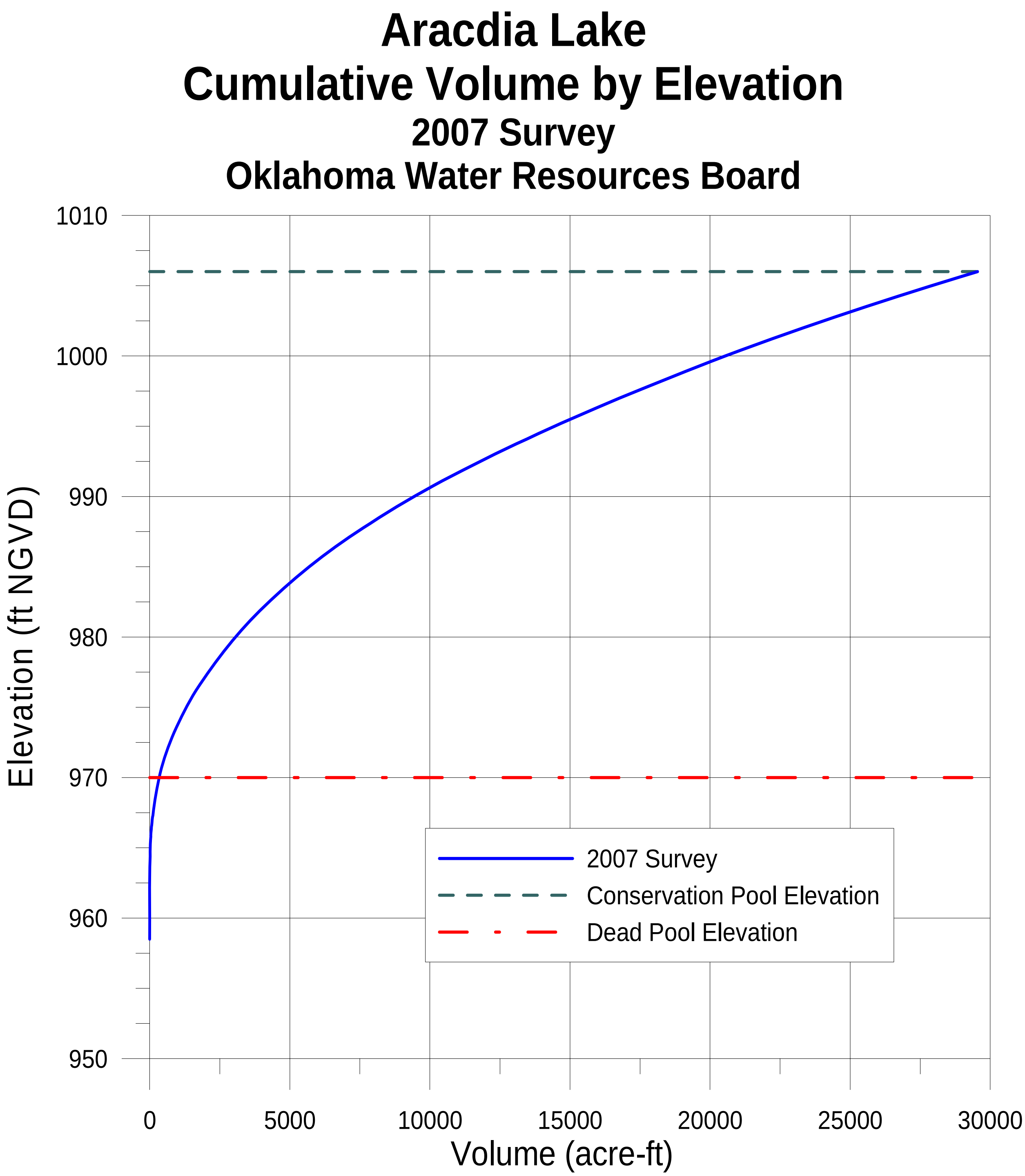


Figure B. 1: Arcadia Lake Volume-Elevation Curve

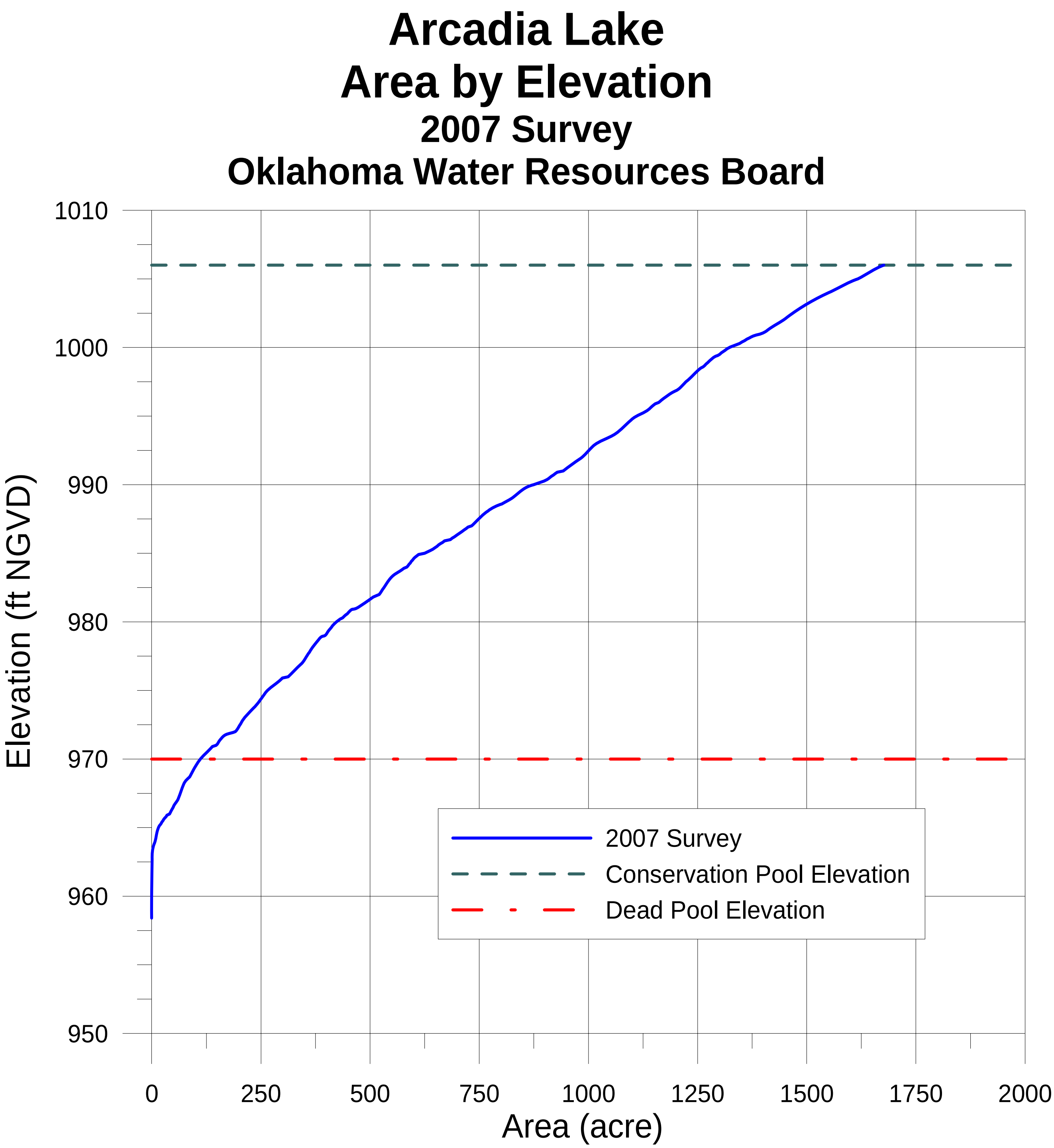


Figure B. 2: Arcadia Lake Area-Elevation Curve

APPENDIX C: Arcadia Lake Bathymetric Maps

Figure C. 1: Arcadia Lake Bathymetric Map with 5-foot Contour Intervals.

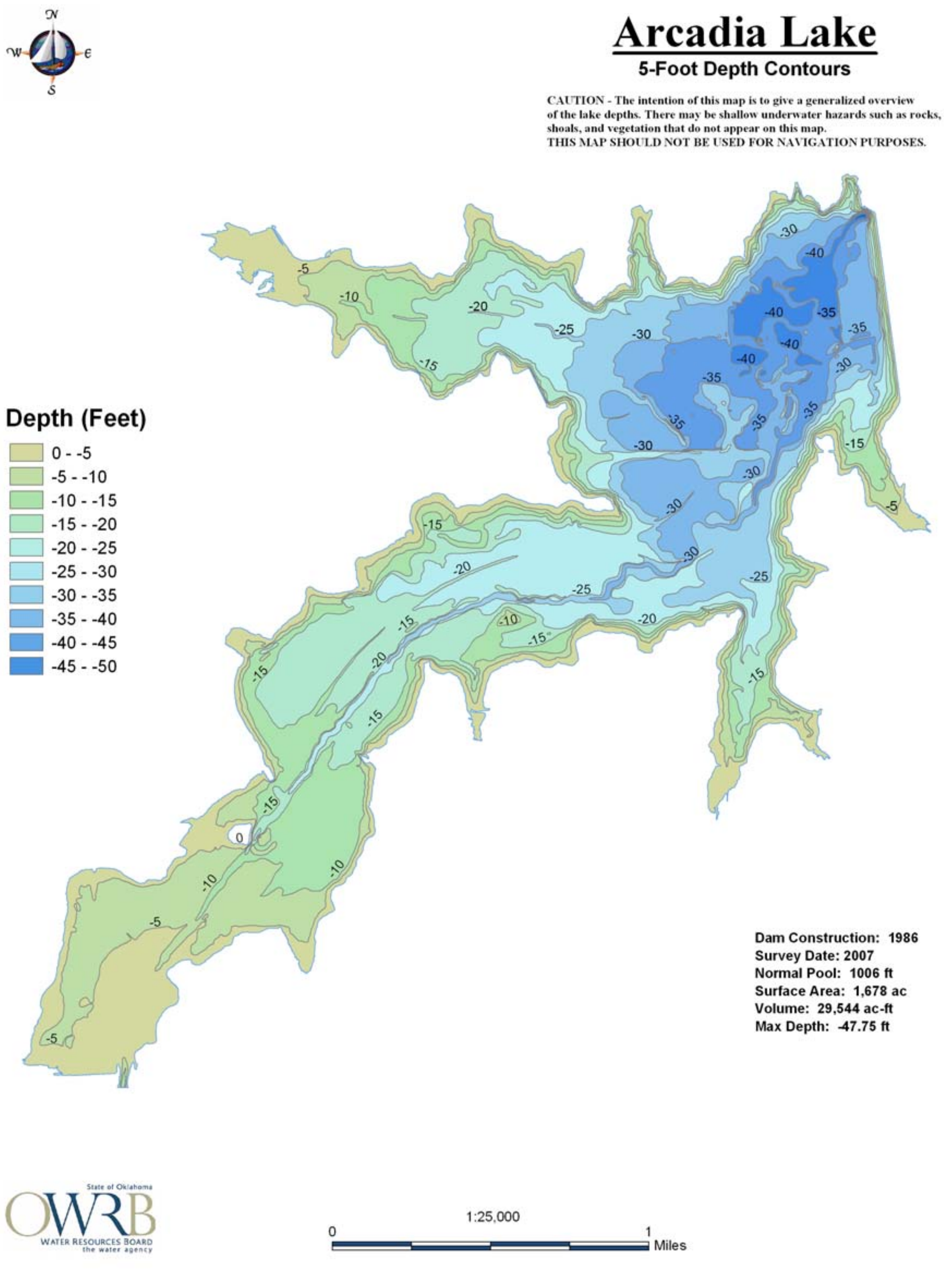
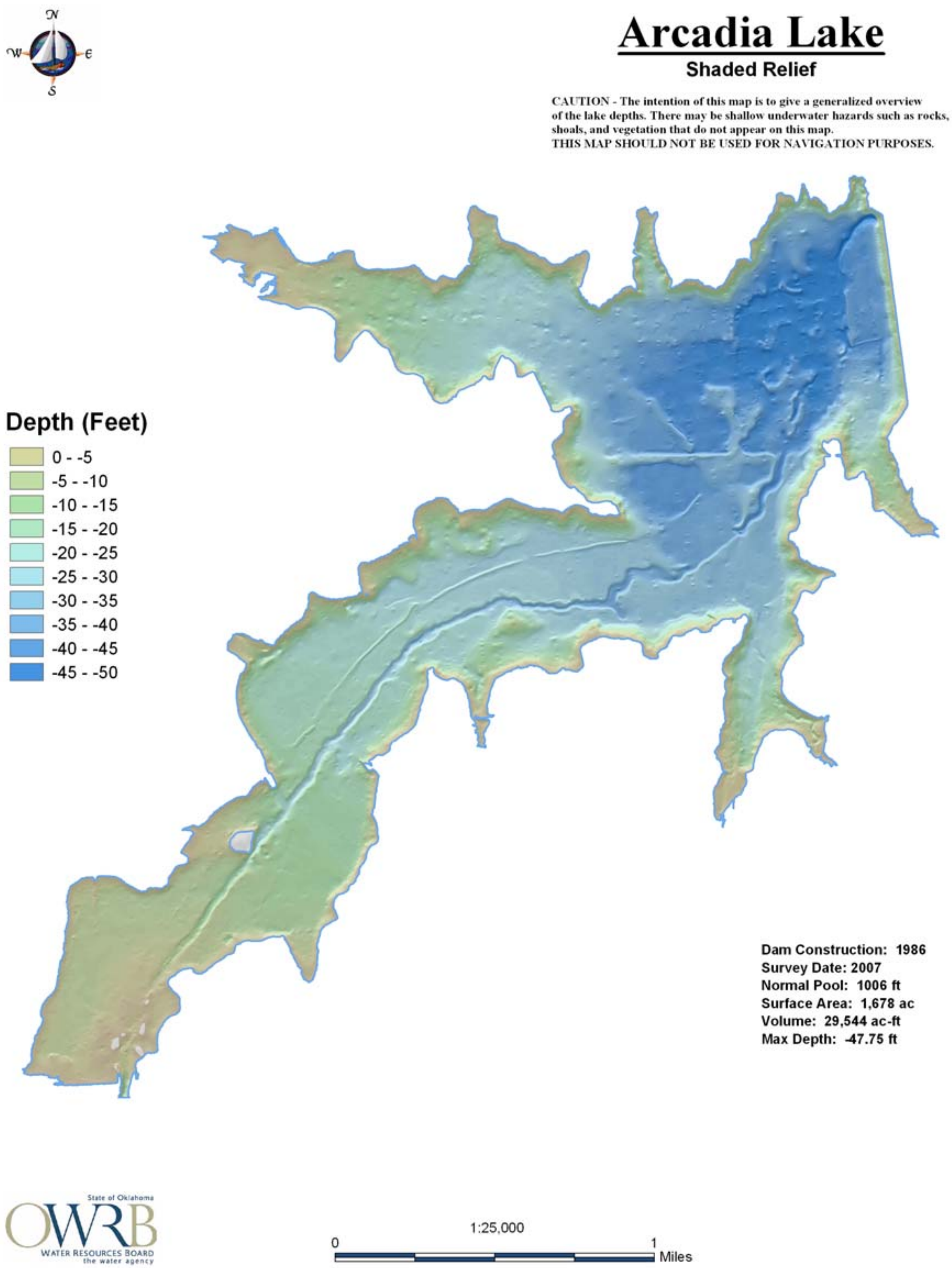


Figure C. 2: Arcadia Lake Shaded Relief Bathymetric Map.



APPENDIX D: Sedimentation Range Lines

Figure D. 1: Collected Data Points and Historical Survey Range Lines

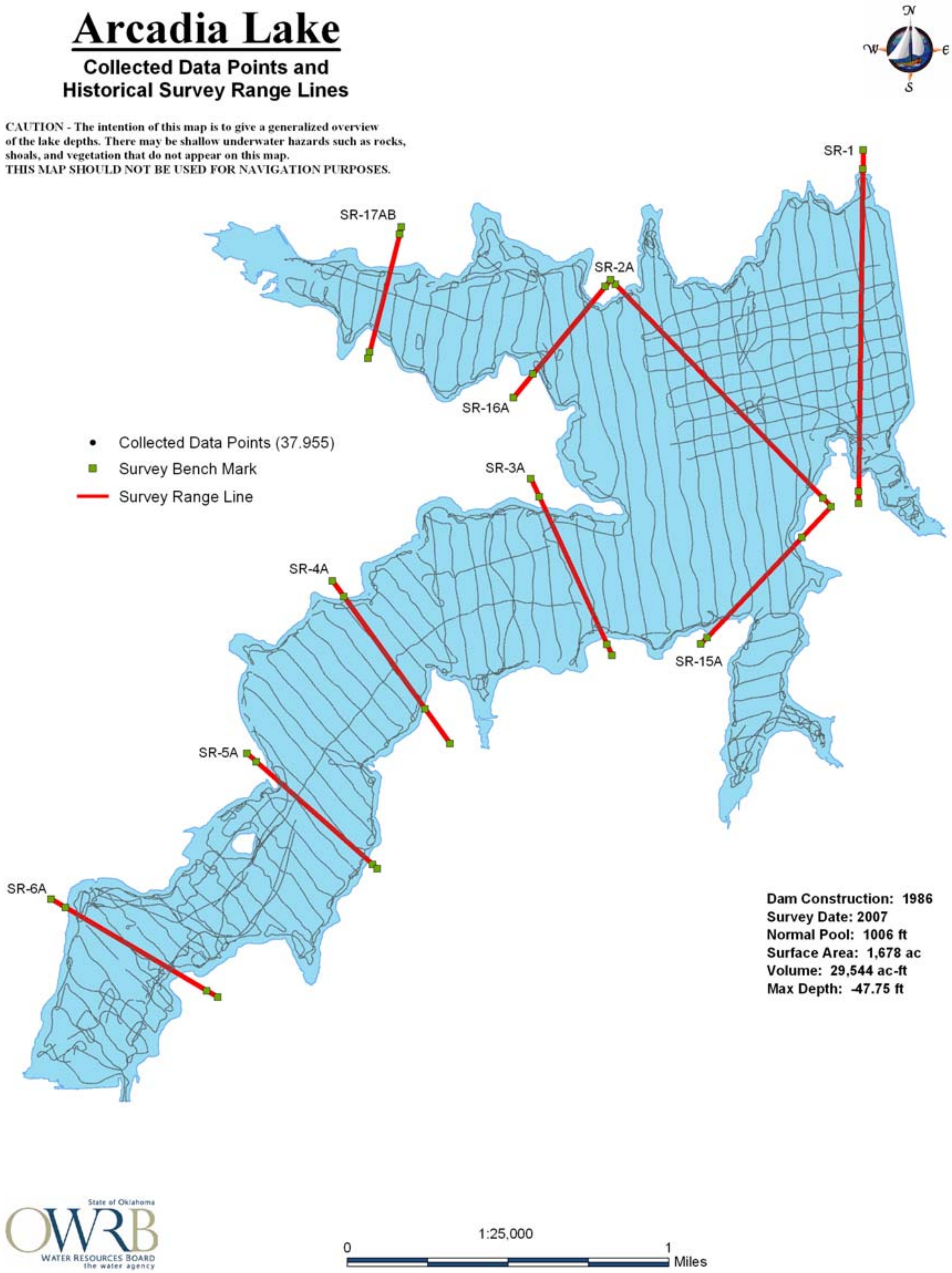


Table D. 1: X, Y Coordinates for USACE Sedimentation Range Lines

BENCHMARK	X Coordinate	Coordinate
SR-1	2188871.64	237903.49
SR-1	2188867.49	237588.27
SR-1	2188797.60	232288.86
SR-1	2188795.04	232099.86
SR-2A	2184729.26	235772.30
SR-2A	2184801.89	235697.45
SR-2A	2188211.05	232183.83
SR-2A	2188347.04	232043.69
SR-3A	2183415.77	232500.90
SR-3A	2183553.58	232200.96
SR-3A	2184667.11	229776.38
SR-3A	2184750.64	229594.69
SR-4A	2180157.19	230818.73
SR-4A	2180344.60	230559.25
SR-4A	2181678.62	228714.21
SR-4A	2182090.55	228144.38
SR-5A	2178750.12	227985.72
SR-5A	2178905.06	227848.50
SR-5A	2180814.91	226158.79
SR-5A	2180890.17	226092.20
SR-6A	2175535.15	225591.03
SR-6A	2175771.49	225451.53
SR-6A	2178089.99	224084.05
SR-6A	2178271.87	223976.71
SR-7A	2174276.57	221824.22
SR-7A	2174670.65	221825.60
SR-7A	2177090.62	221834.12
SR-7A	2177301.39	221834.84
SR-8AB	2172934.44	218684.85
SR-8AB	2173322.18	218729.33
SR-8AB	2175627.80	218993.82
SR-8AB	2175880.97	219022.84
SR-9AB	2172234.69	217055.50
SR-9AB	2172579.76	216863.59
SR-9AB	2173971.74	216089.52
SR-9AB	2174217.79	215952.62
SR-10B	2169741.33	214428.33
SR-10B	2169853.33	214430.52
SR-10B	2171999.24	214471.47
SR-10B	2172182.83	214475.04
SR-11B	2169582.83	211612.27
SR-11B	2169979.90	211316.04
SR-11B	2170152.20	211187.50
SR-11B	2170309.46	211070.17

BENCHMARK	X Coordinate	Coordinate
SR-12B	2168999.72	210428.51
SR-12B	2169041.57	210308.53
SR-12B	2169504.26	208981.81
SR-12B	2169559.69	208822.14
SR-14B	2165136.26	210489.63
SR-14B	2165101.66	210388.67
SR-14B	2165026.79	210170.27
SR-14B	2164988.39	210057.87
SR-15A	2186204.76	229781.11
SR-15A	2186308.93	229890.44
SR-15A	2187864.61	231534.41
SR-15A	2188347.04	232043.69
SR-16A	2184729.26	235772.30
SR-16A	2184635.70	235659.06
SR-16A	2183450.30	234225.33
SR-16A	2183126.50	233833.81
SR-17AB	2181286.49	236640.12
SR-17AB	2181257.47	236525.06
SR-17AB	2180766.39	234585.52
SR-17AB	2180739.93	234481.36
SR-18B	2176380.78	237444.42
SR-18B	2176368.72	237328.16
SR-18B	2176277.59	236452.23
SR-18B	2176267.20	236352.49
SR-19B	2172130.88	236400.70
SR-19B	2172216.24	236212.53
SR-19B	2172480.28	235632.26
SR-19B	2172547.61	235484.41
DR-1C	2190895.96	236472.94
DR-1C	2191374.00	235930.66
DR-3C	2197289.35	239240.53
DR-3C	2197321.34	239051.62
DR-4C	2202528.70	239823.11
DR-4C	2202520.46	239598.16
DR-5C	2207821.60	239925.58
DR-5C	2207823.74	239537.88

APPENDIX E: 1986, 1997 & 2007 Sedimentation Range Line Profiles

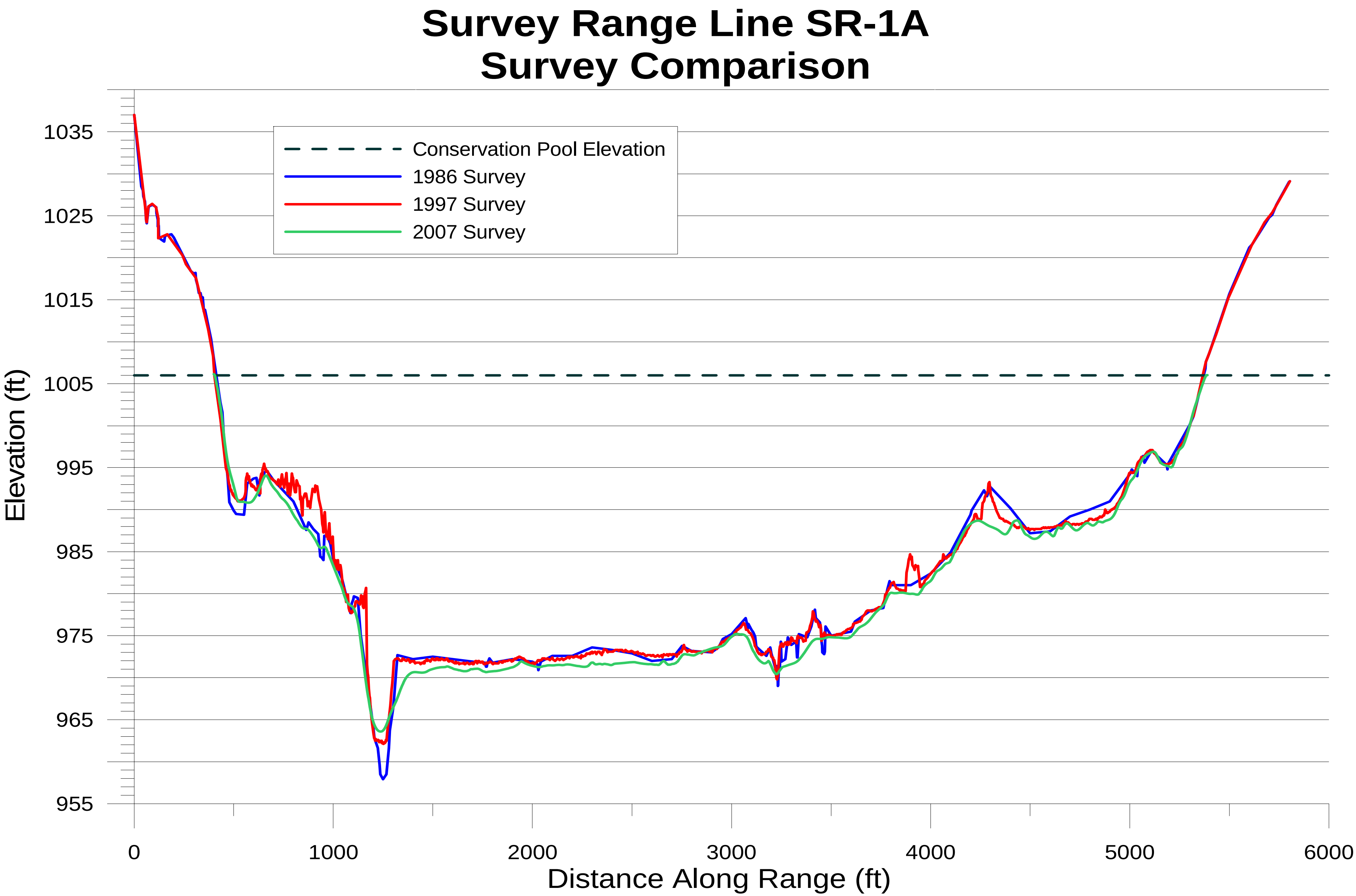


Figure E. 1: Comparison of 1986, 1997, and 2007 Surveys along Line SR-1A.

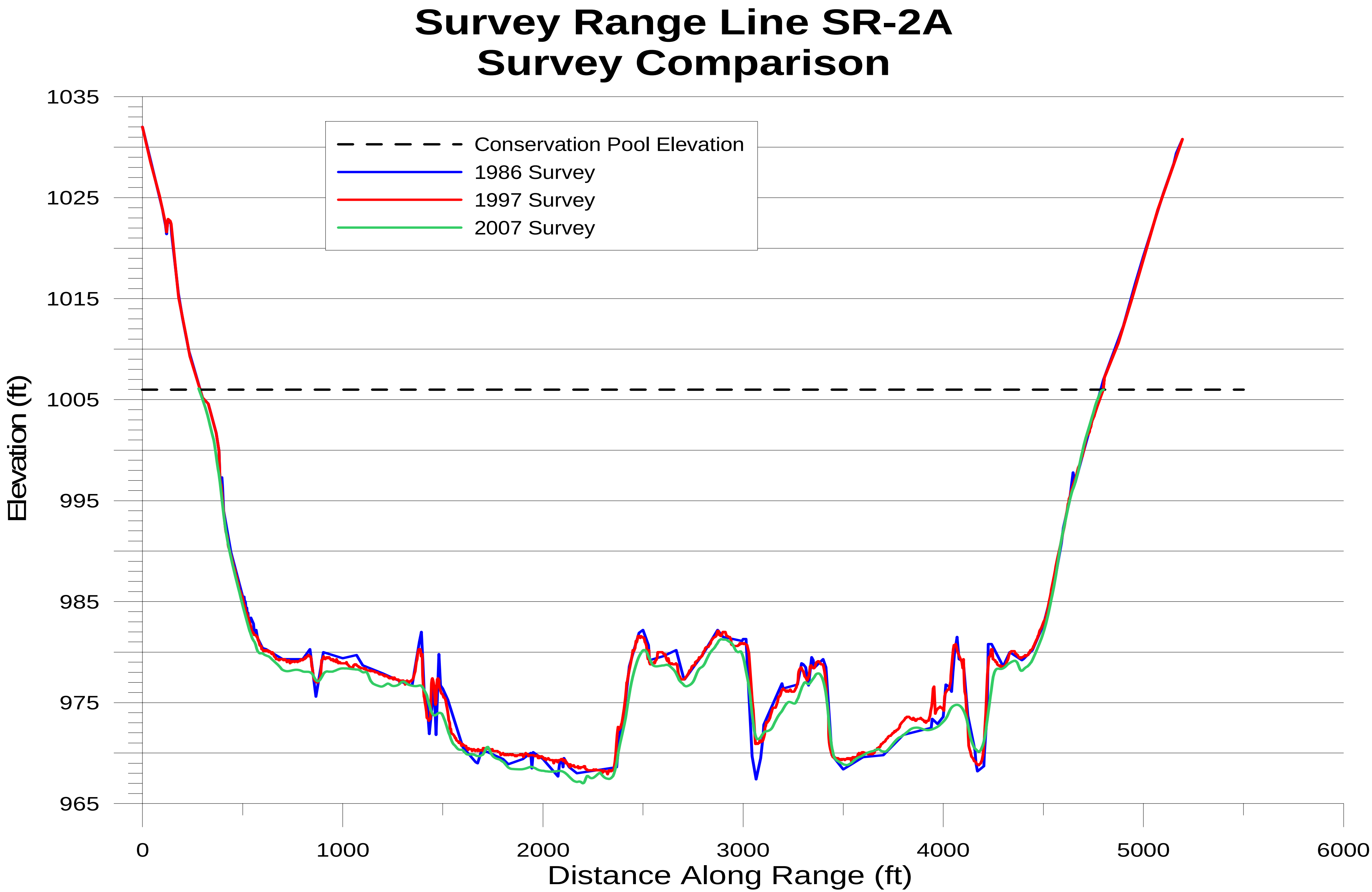


Figure E. 2: Comparison of 1986, 1997, and 2007 Surveys along Line SR-2A.

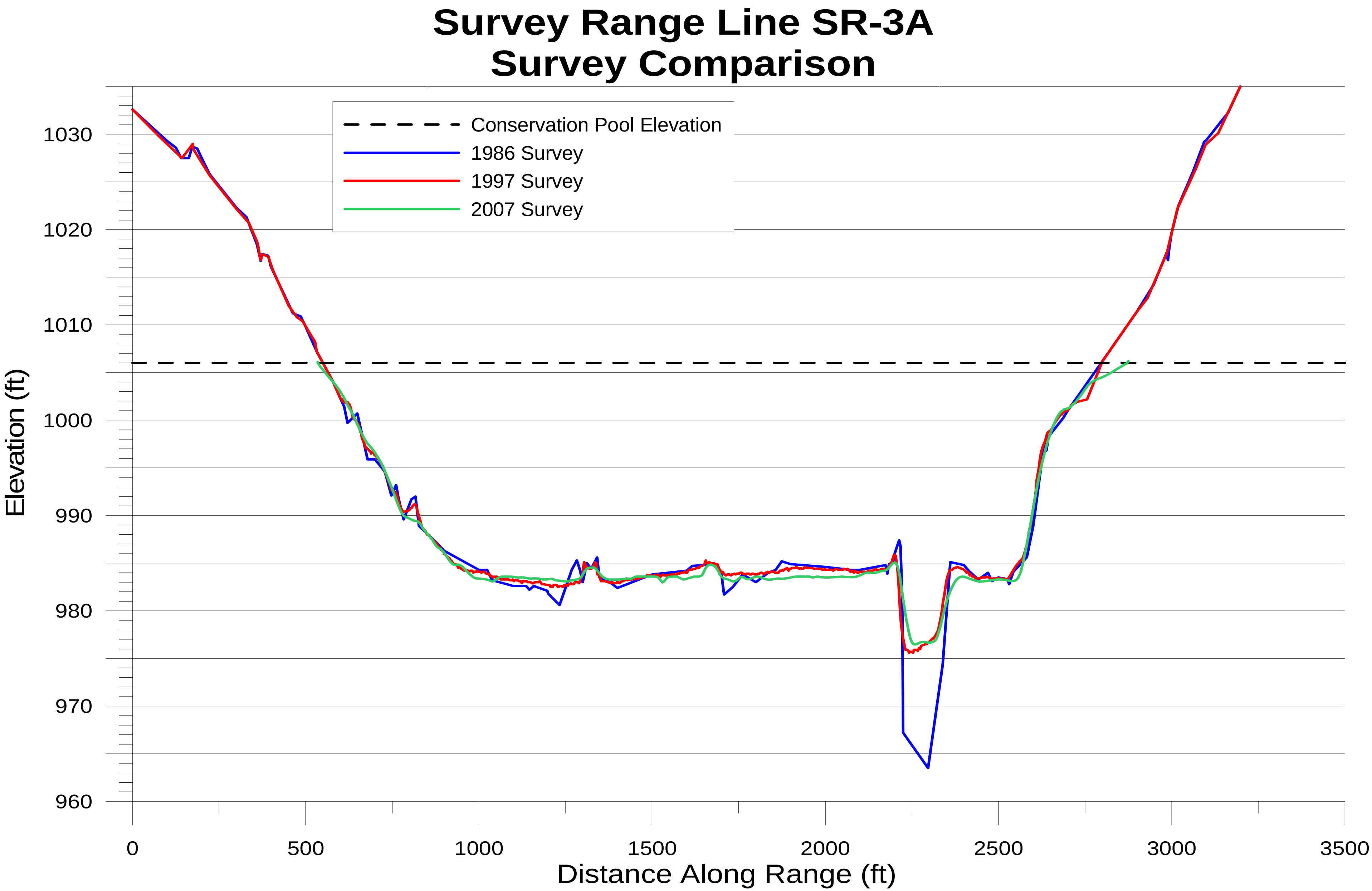


Figure E. 3: Comparison of 1986, 1997, and 2007 Surveys along Line SR-3A.

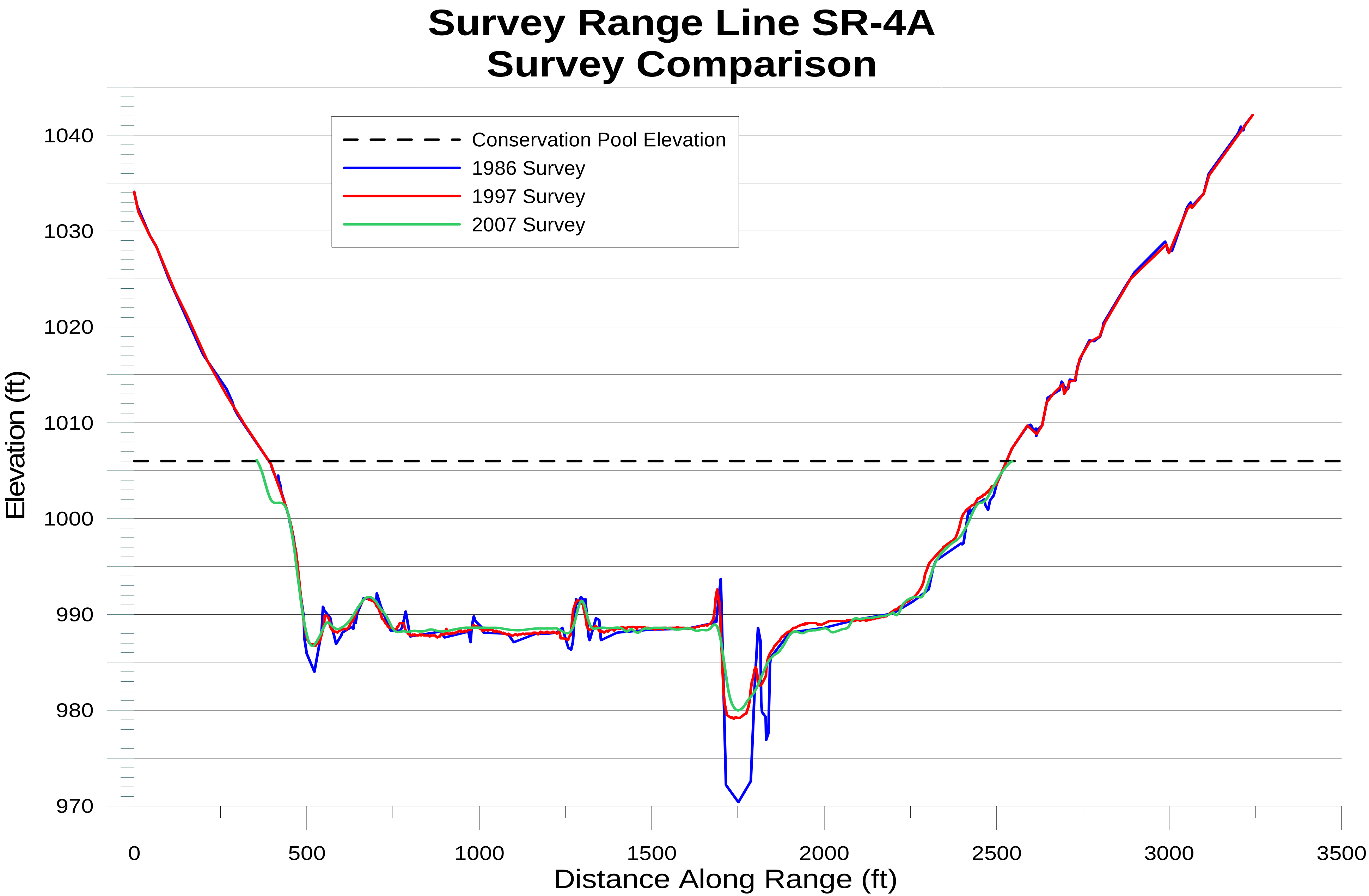


Figure E. 4: Comparison of 1986, 1997, and 2007 Surveys along Line SR-4A.

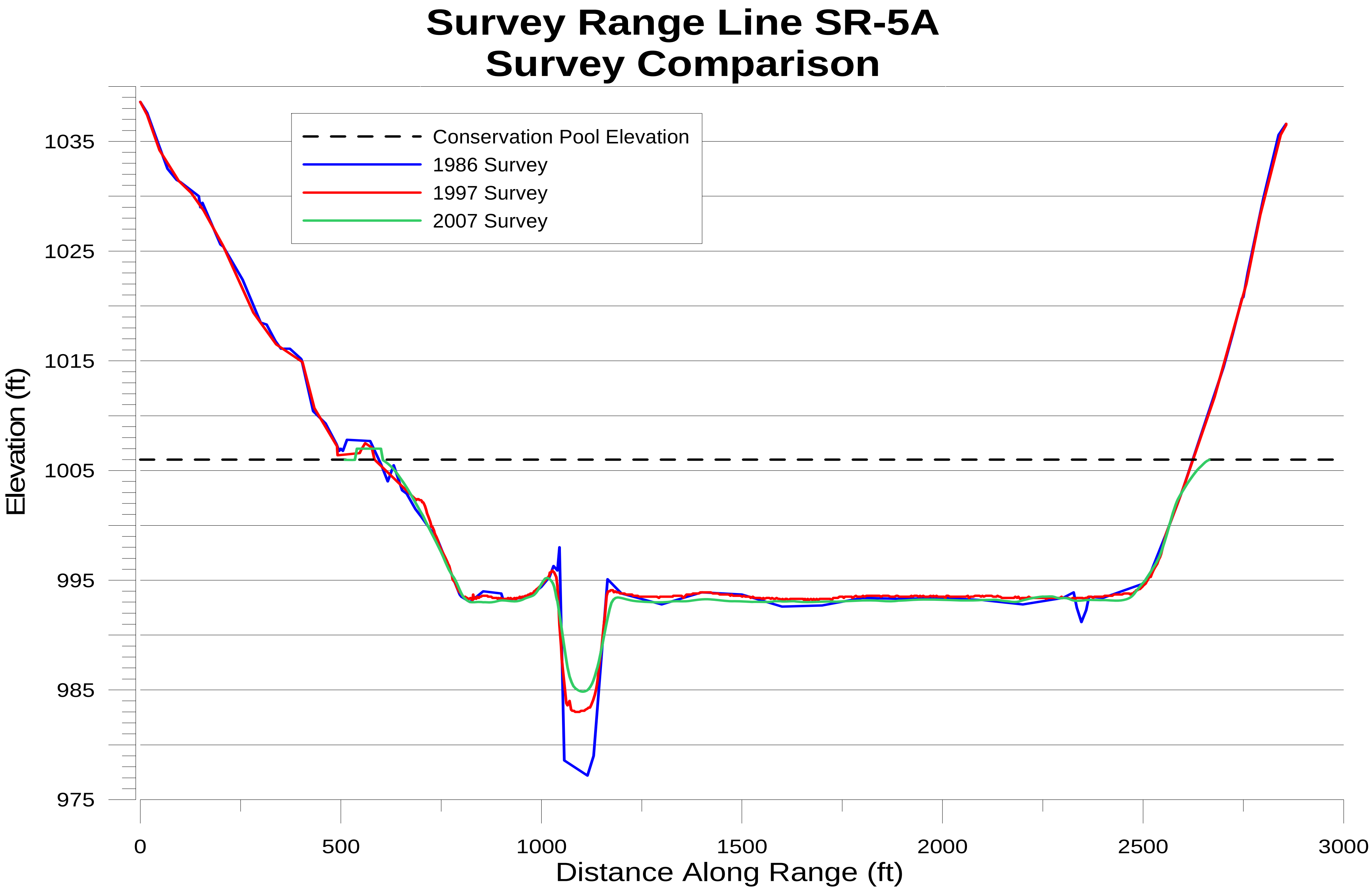


Figure E. 5: Comparison of 1986, 1997, and 2007 Surveys along Line SR-5A.

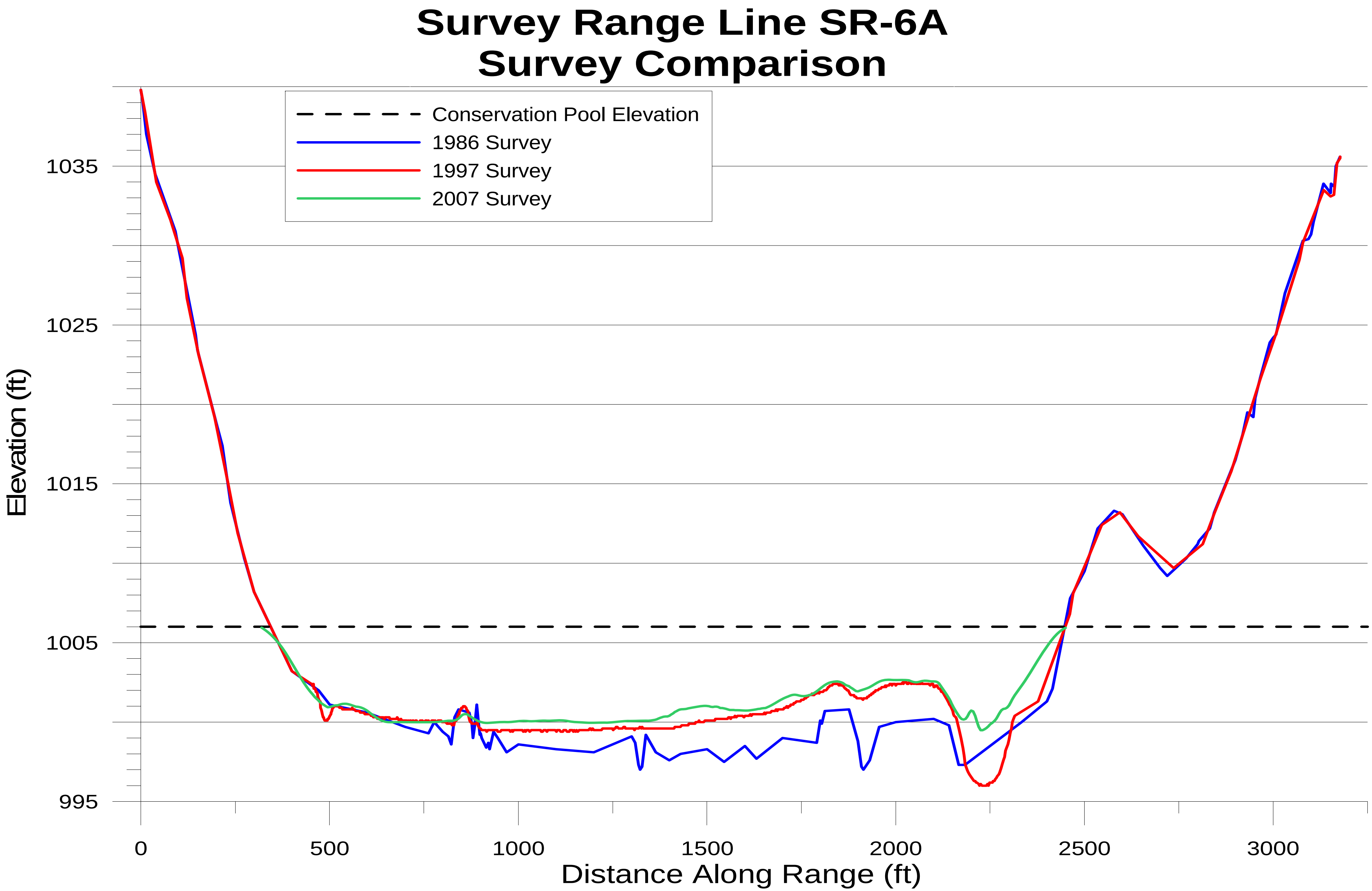


Figure E. 6: Comparison of 1986, 1997, and 2007 Surveys along Line SR-6A.

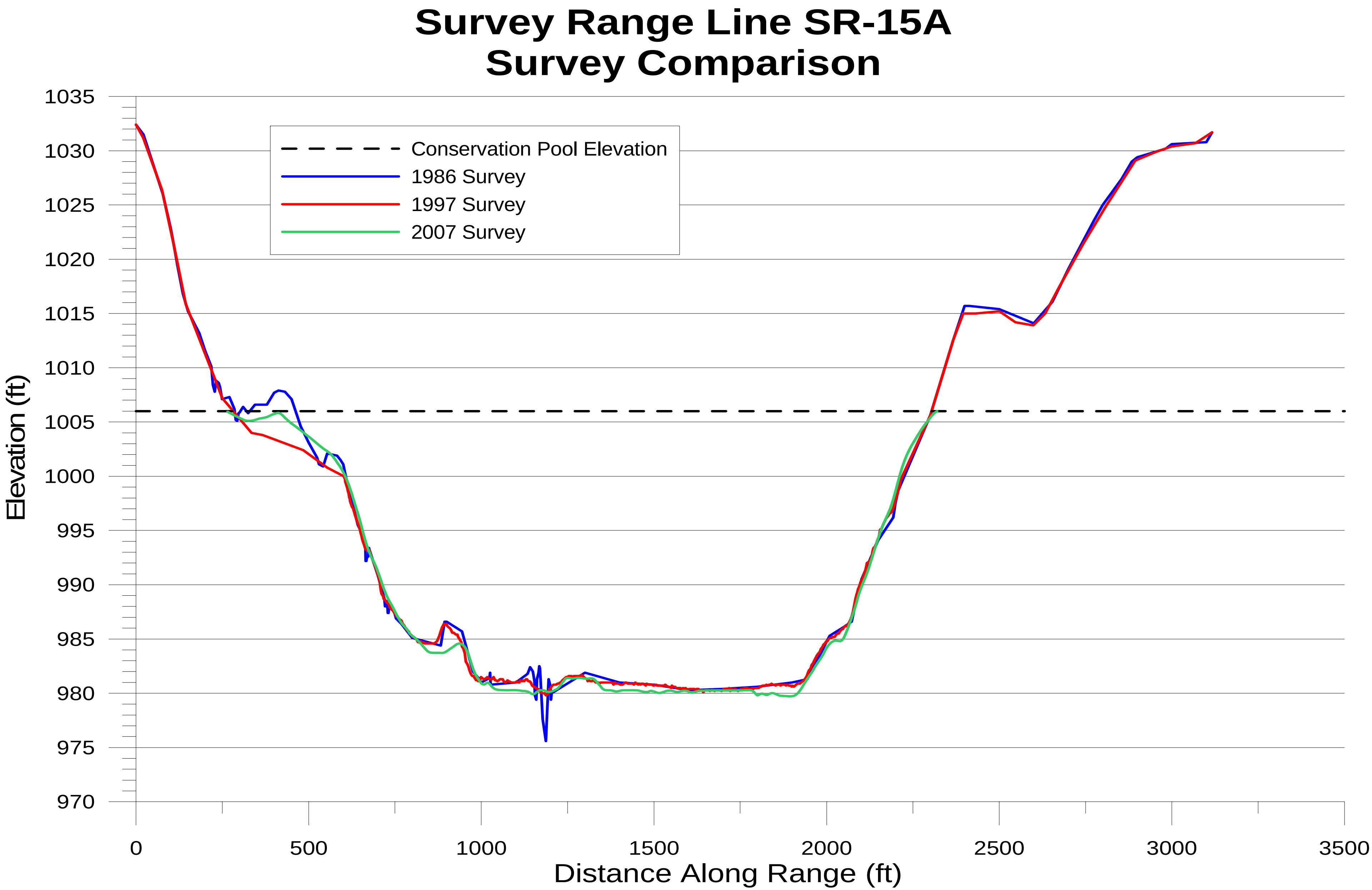


Figure E. 7: Comparison of 1986, 1997, and 2007 Surveys along Line SR-15A.

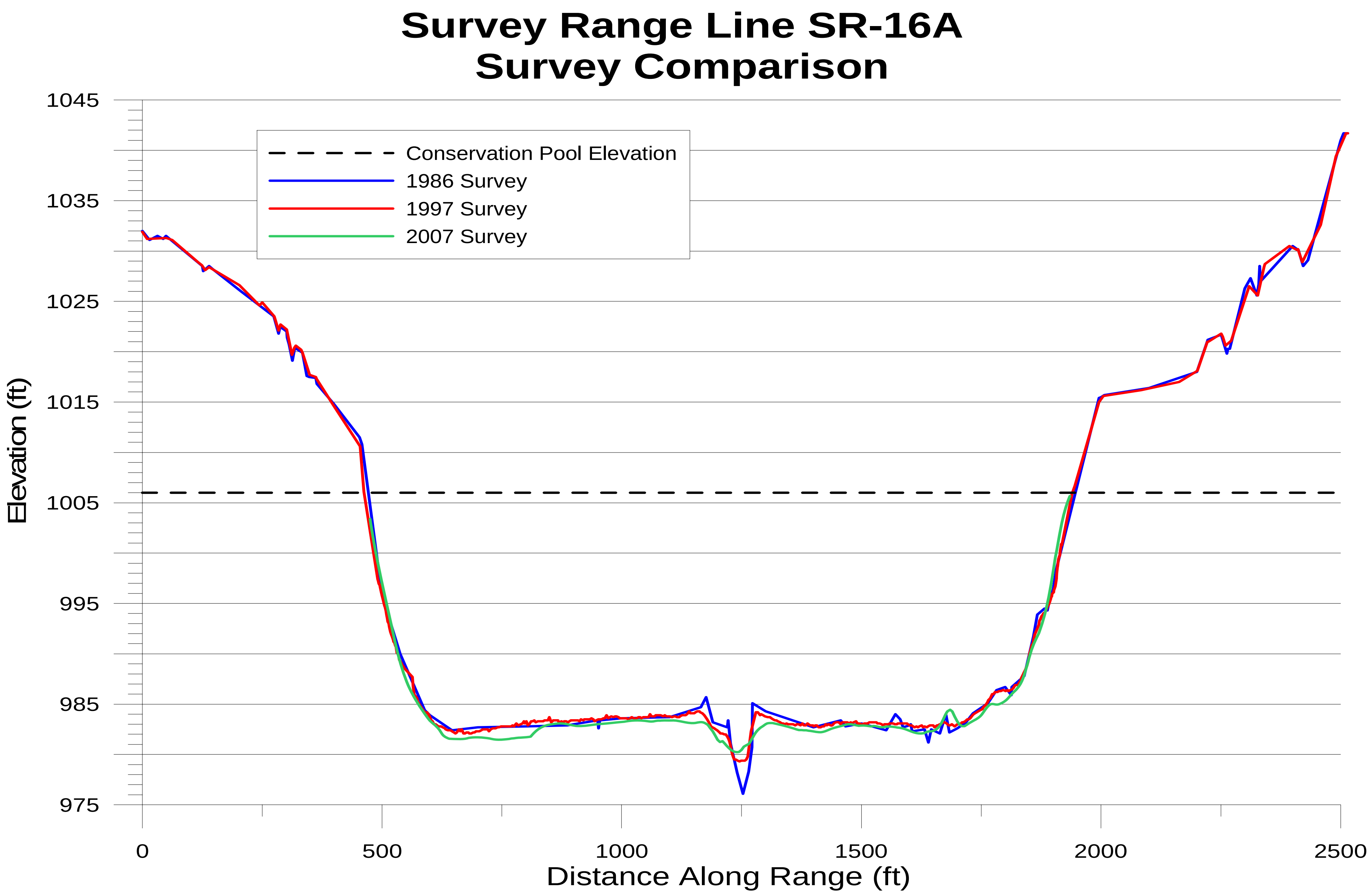


Figure E. 8: Comparison of 1986, 1997, and 2007 Surveys along Line SR-16A.

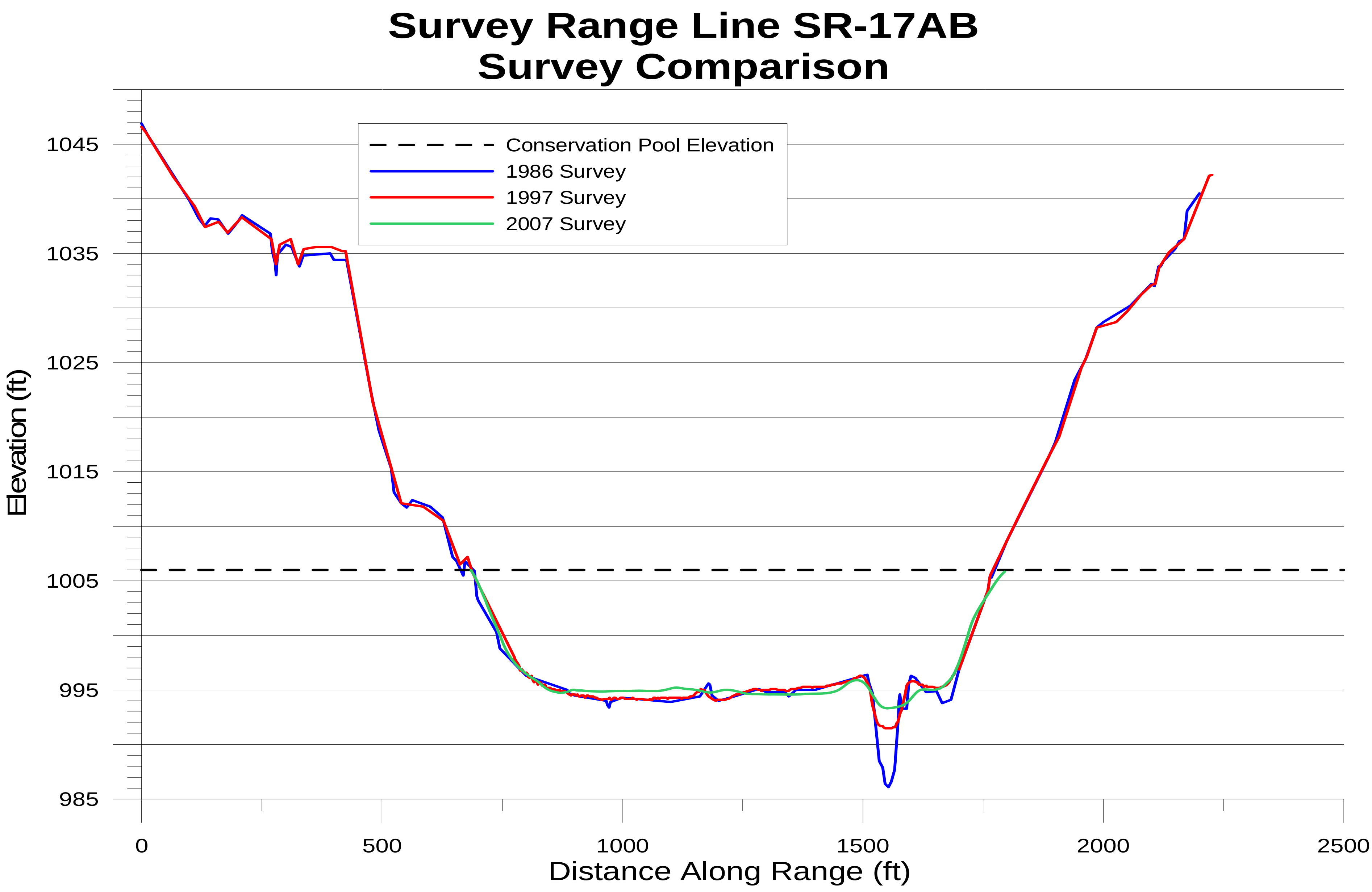


Figure E. 9: Comparison of 1986, 1997, and 2007 Surveys along Line SR-17AB.