VOLUMETRIC SURVEY OF LAKE NOCONA

Prepared for:
North Montague County Water Supply District

In cooperation with the
United States Army Corps of Engineers

Prepared by
Texas Water Development Board

July 17, 2002

Texas Water Development Board

J. Kevin Ward, Executive Administrator

This report was prepared by staff of the Surface Water Section:

Barney Austin, Ph.D.
Duane Thomas
Randall Burns
Marc Sansom

Published and Distributed
by the
Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711-3231

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LAKE NOCONA
VOLUMETRIC SURVEY REPORT

INTRODUCTION

Staff of the Surface Water Section of the Texas Water Development Board (TWDB) conducted a volumetric survey of Lake Nocona on July 24 and 25, 2001. The primary purpose of this survey was to determine the current volume of the lake at conservation pool elevation. Results from this survey will serve as a basis for comparison to future surveys to allow the location and rates of sediment deposition to be determined. Survey results are presented in the following pages in both graphical and tabular form.

The vertical datum used during this survey is that used by the United States Geological Survey (USGS) for the reservoir elevation gauge at Lake Nocona (07315600 LAKE NOCONA NEAR NOCONA, TX.). The datum for this gauge is reported as mean sea level (msl) (USGS, 2000). Thus, elevations are reported here, according to the same datum, in feet (ft) above mean sea level (msl). Volume and area calculations in this report are referenced to water levels provided by the USGS gauge.

According to the original design (based on USGS topographic maps 1929), the surface area of Lake Nocona was 1,470 acres at conservation pool elevation 827.0 ft and the total storage volume was estimated to be 25,400 acre-feet (ac-ft) of water (USGS 2000). In 1997 spillway modifications included pouring concrete to cap the crest of the earth-cut channel. A survey level-loop was performed at that time and a new elevation of 827.5 ft was assigned to the concrete crest and also being the conservation pool elevation. This report will establish a new elevation-area-volume table to elevation 827.50 ft from the results of the data collected during the 2001 survey. In Table 1, comparisons between the original design information and the current survey are made at elevation 827.0 ft.

LAKE HISTORY AND GENERAL INFORMATION

Historical information on Lake Nocona was obtained from the Texas Water Development Board (TWDB 1974), and United States Geological Survey (USGS 2000). The Lake Nocona project was originally designed to provide water for municipal industrial and mining purposes.

Lake Nocona (also known as Farmers Creek Reservoir) and Farmers Creek Dam is located in Montague County, eight miles northeast of Nocona, Texas (Figure 1). North Montague County Water Supply District (hereinafter referred to as the District) owns the water rights to Lake Nocona. The District also owns and maintains the dam and appurtenant structures. All releases from the reservoir and other water-related operations are under the control of the District.

Permit No. 1922 (Application No. 2104) dated March 10, 1959 issued by the State Board of Water Engineers authorized the construction of a dam to create a reservoir to impound 25,389 ac-ft of water. Certificate of Adjudication No. 02-4879 issued by the Texas Natural Resource Conservation Commission on June 7, 1987 authorized the District to maintain an existing dam and reservoir on Farmers Creek (Lake Nocona) and impound therein not to exceed 25,389 ac-ft of water. The owner was authorized to divert and use not to exceed 644.96 ac-ft of water per annum for municipal purposes. The District is currently authorized under an amended Certificate of Adjudication No. 02-4879A issued November 23, 1987. The District is allowed to impound not to exceed 25,389 ac-ft of water and divert not to exceed 1,080 ac-ft of water for municipal purposes, 100 ac-ft of water for irrigation purposes and 80 ac-ft of water for recreational purposes.

Copies of the Permit and Certificate of Adjudication (original and amended) may be obtained from the Texas Natural Resource Conservation Commission's Central Records in Austin, Texas.

Lake Nocona is located on Farmers Creek a tributary of the Red River (Red River Basin). Records indicate the drainage area is approximately 94 square miles (USGS 2000). At conservation pool elevation (827.5 ft), the reservoir has approximately 24 miles of shoreline.

Construction for the Lake Nocona project started in September 1959 and was completed in October 1960. Deliberate impoundment of water began in the spring of 1961 and the first diversion was in September 1961 (TWDB 1967). Freese and Nichols Consulting Engineers Inc. was the design engineer. The estimated cost of the dam was $1,100,000.

Engineering designs (TWDB, 1974) show Lake Nocona Dam and appurtenant structures to consist of a earthfill embankment, approximately 3,720 ft in length with a maximum height of 77 ft and a crest elevation of 847.0 ft.

The spillway is designed as a primary/secondary structure located near the left (west) end of the dam. The uncontrolled spillway consists of a two-tier three-section earth-cut channel. The outside sections are both 440 ft wide with a crest elevation of 835.0 ft. The center section or primary spillway is 100 ft wide. In 1997–98 modifications were made to the primary spillway channel that included a protective concrete cover over the crest. The final grade of the concrete cap is at elevation 827.5 ft.

The outlet for low-flow releases consist of an 18-inch diameter steel pipe that is encased in concrete and extends through and near the center of the embankment. The invert elevation for the low-flow outlet is 795.0 ft.

The pump station that supplies municipal water to the city of Nocona is located upstream of the dam and on the west shoreline of the lake. The structure consists of a vertical concrete shaft that supports a pump platform at elevation 842.0 ft. Water enters the pump station through a 24-inch diameter pipe that extends to a vertical concrete intake structure. This structure, which stands vertically above the conservation pool elevation, houses the inlets for water to gain access to the pump station. Water enters the intake structure through a 24-inch diameter pipe with an invert elevation at 800.0 ft. There is also an opening in the wall of the intake tower that water can gain access at an invert elevation of 830.0 ft. Slide gates that are operated by lift chains on top of the tower control these openings.

SURVEYING EQUIPMENT

The equipment used to perform the volumetric survey consists of a 20-foot aluminum shallow-draft flat bottom SeaArk craft with cabin and equipped with one 115-horsepower Evinrude outboard motor was used. The portable data collection equipment on-board the boat included a Knudsen 320 B/P Echosounder (depth sounder), a Trimble Navigation, Inc. Ag132 GPS receiver, an OmniSTAR receiver, and a Pentium 500 MHz laptop PC. (Reference to brand names throughout this report does not imply endorsement by TWDB).

The GPS equipment, survey vessel, and depth sounder in combination provide an efficient hydrographic survey system. As the boat travels across the lake surface, the depth sounder takes approximately ten readings of the lake bottom each second. The depth readings are stored on the survey vessel's on-board computer along with the corrected positional data generated by the boat's GPS receiver. The data files collected are downloaded from the computer and brought to the office for editing after the survey is completed. During editing, poor-quality data is removed or corrected, multiple data points are averaged to get one data point per second, and average depths are converted to elevation readings based on the lake elevation recorded on the day the survey was performed. Accurate estimates of the lake volume can be quickly determined by building a 3-D model of the reservoir from the collected data.

PRE-SURVEY PROCEDURES

The reservoir's boundary was digitized using Environmental Systems Research Institute's (ESRI) Arcview from digital orthophoto quadrangle images (DOQ's). The DOQ's were produced by VARGIS of Texas LLC for the TEXAS Orthoimagery Program (TOP). The DOQ products produced for the Department of Information Resources and the GIS Planning Council under the Texas Orthoimagery Program reside in the public domain. More information can be obtained on the Internet at http://www.tnris.state.tx.us/DigitalData/doqs.htm. The map boundary was created from the NOCONA and PRAIRIE VALLEY SCHOOL, TEXAS DOQs and Digital Raster Graphics (DRG). DRGs are scanned digital versions of U.S. Geological Survey standard topographical maps. The lake elevation at the time the DOQs were photographed was 827.15 ft (February 4, 1995). The boundary was further modified by displaying the collected data points and overlaying the DRG images of the

U.S.G.S. 7.5 minute topographical maps NOCONA (1982) and PRAIRIE VALLEY SCHOOL(1979).

The DOQ graphic boundary file was transformed from UTM Zone 14 datum to NAD '83, using Environmental Systems Research Institute's (ESRI) Arc/Info PROJECT command with the NADCOM (standard conversion method within the United States) parameters.

The survey layout was designed by placing survey track lines at 500-foot intervals within the digitized lake boundary using Coastal Oceanographics' HYPACK software. The survey design required the use of approximately 71 survey lines along the length of the lake and perpendicular to the original creek channels.

SURVEY PROCEDURES

Equipment Calibration and Operation

On the shallow draft boat the depth sounder was calibrated using the bar check feature in the Knudsen software program. This was accomplished by positioning the transducer over a known (measured) depth. The speed of sound was then adjusted (either higher or lower) until the displayed depths matched the known depth. The depth was then checked manually with a stadia (survey) rod to ensure that the depth sounder was properly calibrated and operating correctly.

While surveying Lake Nocona, the speed of sound in the water column was 4750 ft per second. Based on the measured speed of sound for various depths and the average speed of sound calculated for the entire water column, the depth sounder is accurate to within $\pm$0.2 ft. An additional estimated error of $\pm$0.3 ft arises from variation in boat inclination. These two factors combine to give an overall accuracy of $\pm$0.5 ft for any instantaneous reading. These errors tend to be minimized over the entire survey, since some readings are positive and some are negative. Further information on these calculations is presented in Appendix E.

During the survey, the horizontal mask setting on the on-board GPS receiver was set to 10°, and the PDOP (Position Dilution of Precision) limit was set to seven to maximize the accuracy of the horizontal positioning. An internal alarm sounds if PDOP rises above seven to advise the field crew that the horizontal position has degraded to an unacceptable level. The lake's initialization file used by the HYPACK data collection program was set up to convert the collected DGPS positions to state-plane coordinates on the fly.

Field Survey

TWDB staff collected data at Lake Nocona on July 24 and 25, 2001. The lake-level elevations varied minimal from 826.63 to 826.60 ft. Weather conditions were excellent with clear days and a mild but steady breeze.

The survey crew began at the dam and started collecting data on pre-plotted range lines (transects) that were spaced 500 ft apart and designed to be perpendicular to the channel for the best cross-section results. A data point that consisted of latitude, longitude and depth was collected each second. Data were collected on 70 of the 71 pre-plotted survey range lines. The survey crew would collect irregular transects when navigational hazards such as trees and stumps or shallow depths kept the crew from driving on the pre-plotted lines. Approximately 23,773 data points were collected over the 43 miles traveled during the survey. These points, shown in Figure 2, were stored digitally on the boat's computer in 104 data files.

The topography surrounding Lake Nocona within a one-mile radius was generally flat with moderate relief. There was an approximate 100-foot drop in elevation from the flat prairie plateau to the basin of Lake Nocona. The topographic relief around the reservoir is pristine and somewhat unexpected compared to the local prairie land of north Montague County.

The catchment basin of Lake Nocona is located on Farmers Creek. Flow of Farmers Creek is generally south to north with Farmers Creek Dam located at the north end of the reservoir.

Contributing creeks that flow into the lake from the east are Polecat Creek and Barefoot Branch.

Residential and weekend retreats were noted mostly along the west shoreline. A residential development was noted east of the lake between Polecat Creek and Farmers Branch. There was a public park near the spillway and dam and a public boat ramp on the west side of the lake that was well maintained. The remainder of the land surrounding the lake was left undisturbed.

As data were collected along the pre-plotted transects, the survey crew noticed that the lake bottom was generally flat. At times there was evidence of the original creek channel (thalweg) when the survey crew crossed over Farmers Creek.

The majority of the lake was clear of navigational hazards such as trees, rocks and debris. It was only in the upper reaches of the lake and in the channels of the creek that the crew encountered such hazards.

Data Processing

The collected data was downloaded from diskettes onto TWDB's computer network. Tape backups were made for future reference. To process the data, the EDIT routine in the HYPACK Program was run on each raw data file. Data points such as depth spikes or data with missing depth or positional information were deleted from each file. A correction for the lake elevation at the time of data collection was also applied to each file during the EDIT routine. During the July 24 and 25, 2001 survey, the water surface varied from elevation 826.63 to 826.60 ft msl according to elevation data provided by USGS elevation gauge (007315600 LAKE NOCONA NEAR NOCONA, TX.). After all corrections were applied to the raw data file, the edited file was saved with a different extension. The edited files were combined into a single (x,y,z) data file which was used with the GIS software to develop a model of the lake's bottom surface.

The resulting data file was downloaded to a Dell Precision 410 workstation running the Microsoft's Windows NT 4.0 with service pack 6.0, Environmental System Research Institute's (ESRI)

ArcGIS software was used to convert the data to a MASS points file. The MASS points and the boundary file were then used to create a Digital Terrain Model (DTM) of the lake's bottom surface using Arc/Info's TIN software module. The module generates a triangulated irregular network (TIN) from the data points and the boundary file using a method known as Delauney's criteria for triangulation. A triangle is formed between three non-uniformly spaced points, including all points along the boundary. If there is another point within the triangle, additional triangles are created until all points lie on the vertex of a triangle. All of the data points are used in this method. The generated network of three-dimensional triangular planes represents the actual bottom surface. With this representation of the bottom, the software then calculates elevations along the triangle surface plane by determining the elevation along each leg of the triangle. The lake area and volume can be determined from the triangulated irregular network created using this method of interpolation. Volumes and area were calculated from the TIN for the entire reservoir at one-tenth of a foot interval from minimum elevation to conservation pool level. From elevation 783.3 ft to 827.5 ft, the surface areas and volumes of the lake were computed using the Arc/Info software. The computed reservoir volume table is presented in Appendix A and the area table is presented in Appendix B. Graphs for the volume and area tables can be found in Appendix C and D respectively.

Other products developed from the model include a shaded elevation range map (Figure 3) and a shaded depth range map (Figure 4). To develop these maps, the TIN was converted to a lattice using the TINLATTICE command and then to a polygon coverage using the LATTICEPOLY command. Linear filtration algorithms were applied to the DTM to produce smooth cartographic contours. The resulting elevation contour map of the bottom surface at 2-foot intervals is presented in Figure 5.

RESULTS

Results from the 2001 TWDB survey indicate Lake Nocona encompasses 1362 surface acres and contains a total volume of 21749 ac-ft at the conservation pool elevation of 827.5 ft msl. Dead pool storage, (the volume of water below the lowest outlet level from which water cannot be released by gravity flow) below elevation 795.0 feet msl, is 304 ac-ft feet. Thus, the conservation storage (total volume - dead storage) for Lake Nocona is 21,445 acre-feet. The shoreline at conservation pool elevation was calculated to be approximately 24 miles. The deepest point that was measured during the survey was at elevation 783.3 feet msl and corresponding to a depth of 44.2 feet, was located approximately 620 feet upstream from Farmers Creek Dam.

SUMMARY AND COMPARISONS

Lake Nocona and Farmers Creek Dam was completed in October 1960 and deliberate impoundment began in the spring of 1961. Original design information (TWDB, 1974) reported the volume at conservation pool elevation 827.0 feet msl to be 25,400 ac-ft with a surface area of 1,470 acres.

In 1997 spillway modifications included capping (concrete) the crest of the earth-cut channel. A survey level-loop was performed at that time and a new elevation of 827.5 ft was assigned to the concrete crest and also being the new conservation pool elevation.

During July 24 and 25,2001, TWDB staff completed a volumetric survey of Lake Nocona. The 2001 survey utilized a differential global positioning system, depth sounder and geographical information system technology to create a digital model of the lake's bathymetry.

At the new conservation pool elevation (827.50 ft), the current survey measured 1,362 surface acres with a volume of 21,749 ac-ft. The dead pool below elevation 795.0 ft was found to be 304 ac-ft, and thus the conservation storage found in this survey is 21,445 acre-feet.

Comparisons between the original design information and the 2001 data collection set is difficult and some apparent changes might simply be due to methodological differences. As shown in Table 1, are the comparisons between the original design information (1960) and the results of the 2001 survey at the original conservation pool elevation of 827.0 ft. It is recommended that the similar survey be performed in five to ten years or after major flood events to monitor changes to the lake's storage volume.

Table 1. Area and volume comparisons at elevation 827.0 feet msl.
(NOTE: New conservation pool elevation is 827.50 ft. msl)

Year	1960 (Original Design)	2001 (TWDB Survey)
Area (acres)	1,470	1,362
Volume (acre-feet)	25,400	21,749

REFERENCES

1. Texas Water Development Board. 1966. Dams and Lakes in Texas, Historical and Descriptive Information. Report 48.

2. Texas Water Development Board. 1974. Engineering Data on Dams and Lakes in Texas. Part I. Report 126.

3. United States Geological Survey. 2000. "Water Resources Data – Texas. Water Year 2000". Volume 1. Arkansas River Basin, Red River Basin, Sabine River Basin, Neches River Basin and Intervening Coastal Basins. Water-Data Report TX-00-1.

Appendix A

Lake Nocona

RESERVOIR VOLUME TABLE

TEXAS WATER DEVELOPMENT BOARD

July 2001 SURVEY

VOLUME IN ACRE-FEET

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
783				0	0	0	0	0	0	0
784	0	0	0	0	0	0	0	0	0	0
785	0	0	0	0	1	1	1	1	1	1
786	2	2	2	3	3	3	4	4	5	5
787	6	6	7	7	8	9	10	11	12	13
788	14	15	16	17	18	19	21	22	23	25
789	26	28	30	31	33	35	37	39	41	43
790	45	47	50	52	55	57	60	63	65	68
791	71	74	78	81	84	88	91	95	99	103
792	107	111	115	120	124	129	134	139	144	150
793	155	161	167	173	179	186	193	199	206	213
794	221	228	236	244	252	260	269	277	286	295
795	304	314	323	333	343	353	363	374	385	396
796	407	418	430	442	454	466	478	491	504	517
797	530	544	558	573	587	602	617	633	649	665
798	682	698	715	733	750	768	786	805	824	842
799	862	881	901	921	941	962	983	1004	1025	1047
800	1069	1092	1114	1137	1161	1185	1209	1233	1258	1283
801	1308	1334	1360	1386	1413	1440	1467	1494	1522	1550
802	1579	1608	1637	1666	1696	1725	1756	1786	1817	1848
803	1879	1911	1942	1975	2007	2040	2073	2106	2140	2174
804	2208	2242	2277	2312	2348	2384	2420	2457	2494	2531
805	2569	2608	2647	2686	2726	2766	2806	2847	2888	2930
806	2972	3015	3057	3101	3144	3188	3233	3277	3322	3368
807	3414	3460	3506	3553	3601	3648	3697	3745	3794	3843
808	3893	3943	3993	4044	4095	4146	4198	4250	4302	4355
809	4408	4462	4515	4570	4624	4679	4735	4790	4846	4903
810	4960	5017	5075	5133	5191	5250	5309	5368	5428	5489
811	5549	5610	5671	5733	5795	5857	5920	5983	6047	6111
812	6175	6239	6304	6369	6435	6501	6568	6635	6702	6770
813	6838	6907	6976	7046	7116	7187	7258	7330	7402	7475
814	7548	7622	7696	7771	7847	7922	7999	8076	8153	8231
815	8310	8389	8468	8548	8629	8710	8791	8873	8955	9038
816	9122	9205	9289	9374	9459	9545	9630	9717	9803	9891
817	9978	10066	10154	10243	10332	10422	10512	10603	10694	10785
818	10877	10970	11063	11156	11250	11344	11439	11535	11630	11727
819	11823	11921	12018	12117	12215	12315	12414	12515	12615	12716
820	12818	12920	13023	13126	13229	13333	13438	13543	13648	13754
821	13860	13967	14075	14182	14291	14399	14508	14618	14728	14839
822	14950	15062	15175	15287	15401	15515	15629	15744	15859	15975
823	16091	16208	16325	16443	16561	16679	16798	16918	17038	17158
824	17279	17400	17521	17644	17766	17889	18012	18136	18260	18385
825	18509	18635	18760	18886	19012	19139	19266	19394	19521	19649
826	19778	19907	20036	20166	20296	20426	20556	20688	20819	20951
827	21083	21215	21348	21481	21615	21749				

Appendix B

Lake Nocona

RESERVOIR AREA TABLE

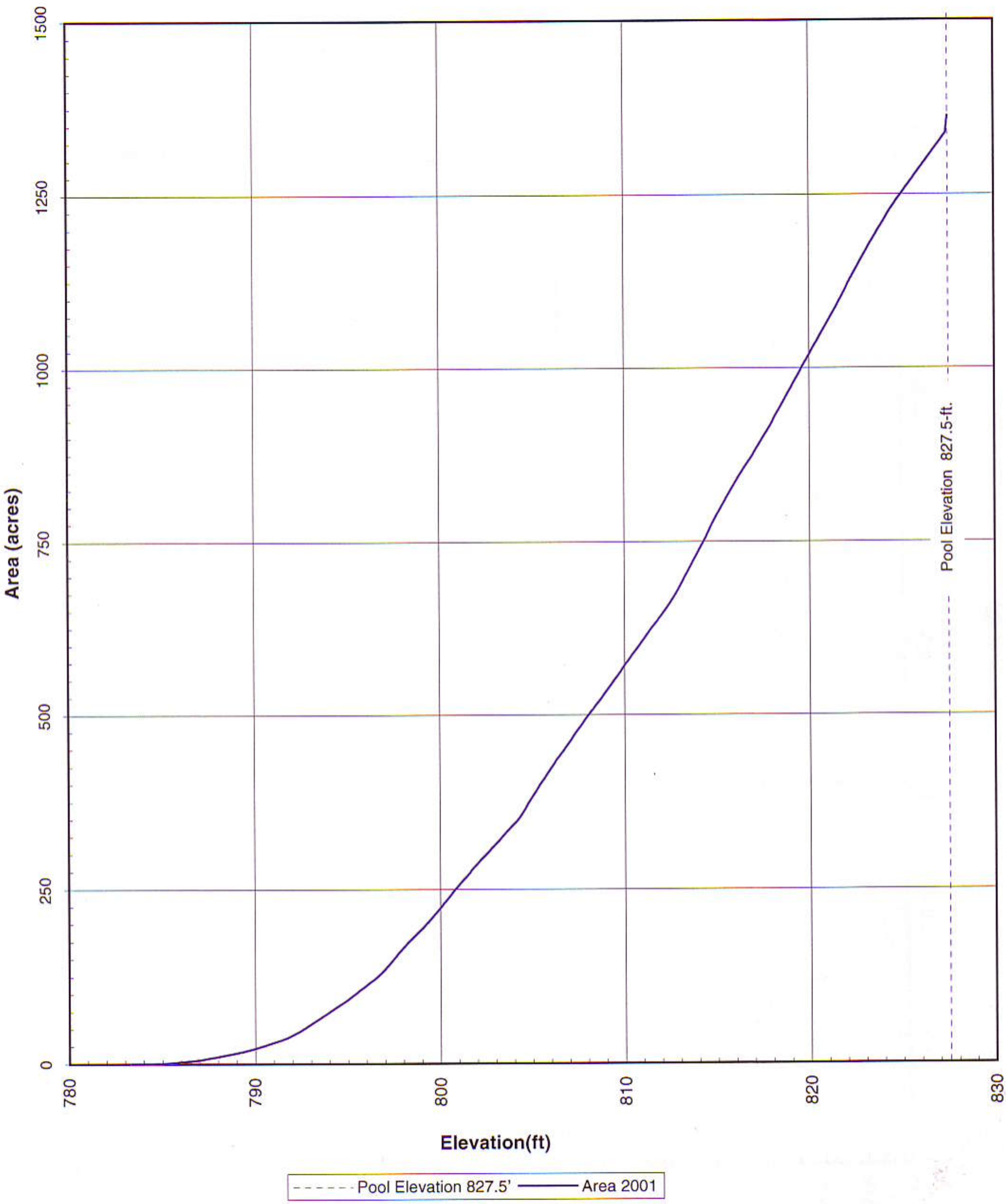
TEXAS WATER DEVELOPMENT BOARD

July 2001 SURVEY

AREA IN ACRES

ELEVATION INCREMENT IS ONE TENTH FOOT

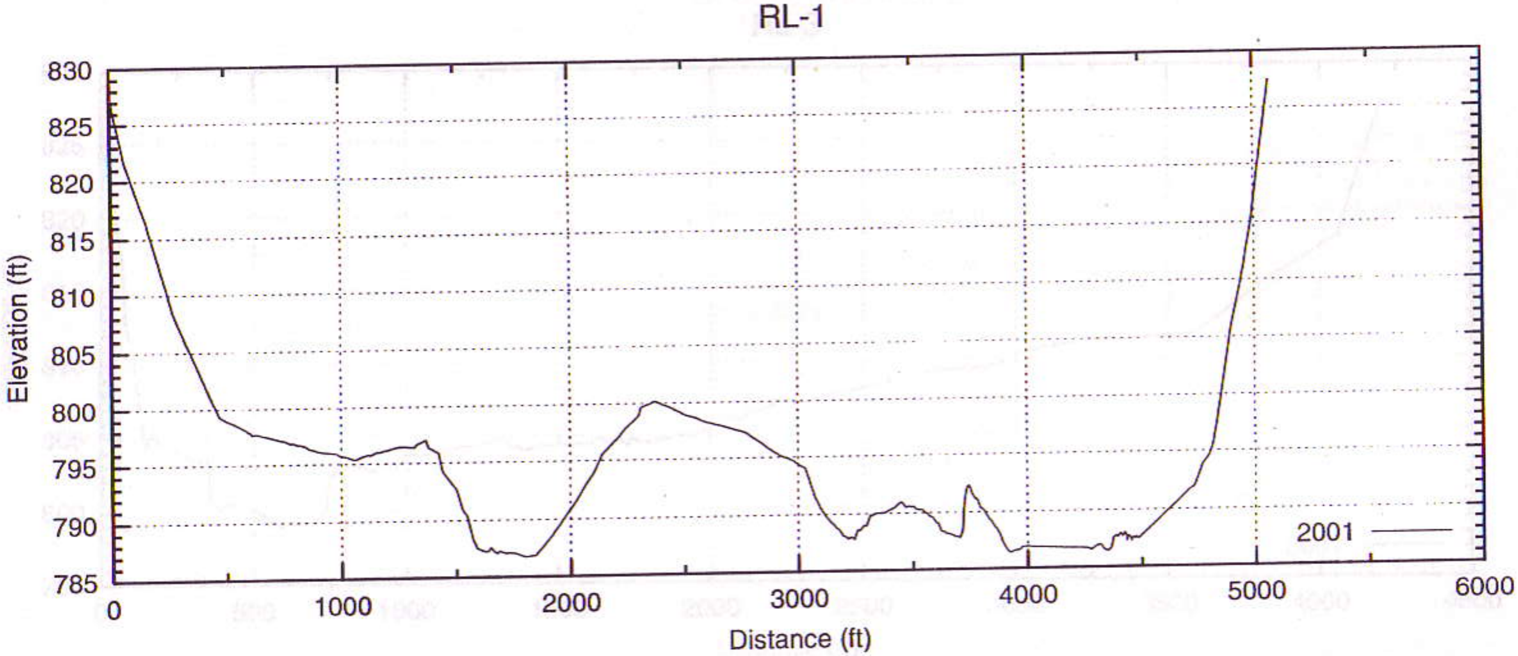
ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
783				0	0	0	0	0	0	0
784	0	0	0	0	0	0	0	0	0	0
785	0	1	1	1	1	1	2	2	2	2
786	3	3	3	3	4	4	4	5	5	5
787	6	6	6	7	7	8	8	9	9	10
788	10	11	11	12	12	13	13	14	14	15
789	16	16	17	17	18	19	19	20	20	21
790	22	23	24	25	25	26	27	28	29	30
791	31	31	32	33	34	35	36	37	38	40
792	41	42	44	45	47	48	50	52	53	55
793	57	59	60	62	64	66	67	69	71	73
794	74	76	78	80	82	83	85	87	89	91
795	92	94	96	98	101	103	105	107	109	111
796	113	115	117	119	121	123	125	128	130	133
797	136	139	142	145	148	151	154	157	160	164
798	167	169	172	175	178	180	183	185	188	190
799	193	196	199	201	204	207	210	213	216	220
800	223	226	229	233	236	239	242	246	249	252
801	255	258	261	264	267	270	273	277	280	283
802	286	289	292	295	297	300	303	306	309	311
803	314	317	320	323	326	329	332	335	338	341
804	343	346	349	352	356	360	365	370	374	378
805	382	386	390	395	399	403	407	411	415	418
806	423	427	431	435	438	442	445	449	452	456
807	460	464	468	472	476	479	483	486	490	494
808	498	501	505	508	512	515	519	522	526	530
809	533	537	541	544	548	552	555	559	563	567
810	571	575	578	582	586	589	593	596	600	604
811	607	611	615	619	622	626	629	633	636	640
812	643	647	651	655	659	663	667	671	676	680
813	685	690	695	701	705	710	715	721	726	731
814	735	740	745	751	756	761	767	773	778	783
815	788	793	797	802	807	812	817	821	826	831
816	835	840	844	849	853	857	861	865	869	873
817	877	882	886	891	895	899	904	908	912	917
818	922	927	932	937	942	946	951	956	961	965
819	970	975	980	985	990	995	1000	1004	1009	1014
820	1019	1024	1028	1033	1038	1042	1047	1052	1056	1061
821	1066	1071	1075	1080	1085	1090	1095	1100	1105	1110
822	1116	1121	1126	1131	1136	1141	1146	1151	1155	1160
823	1165	1169	1174	1179	1183	1188	1192	1197	1201	1205
824	1210	1214	1218	1223	1227	1231	1235	1239	1243	1246
825	1250	1254	1258	1261	1265	1269	1272	1276	1279	1283
826	1287	1290	1294	1298	1301	1305	1308	1312	1316	1319
827	1323	1326	1330	1334	1337	1362				

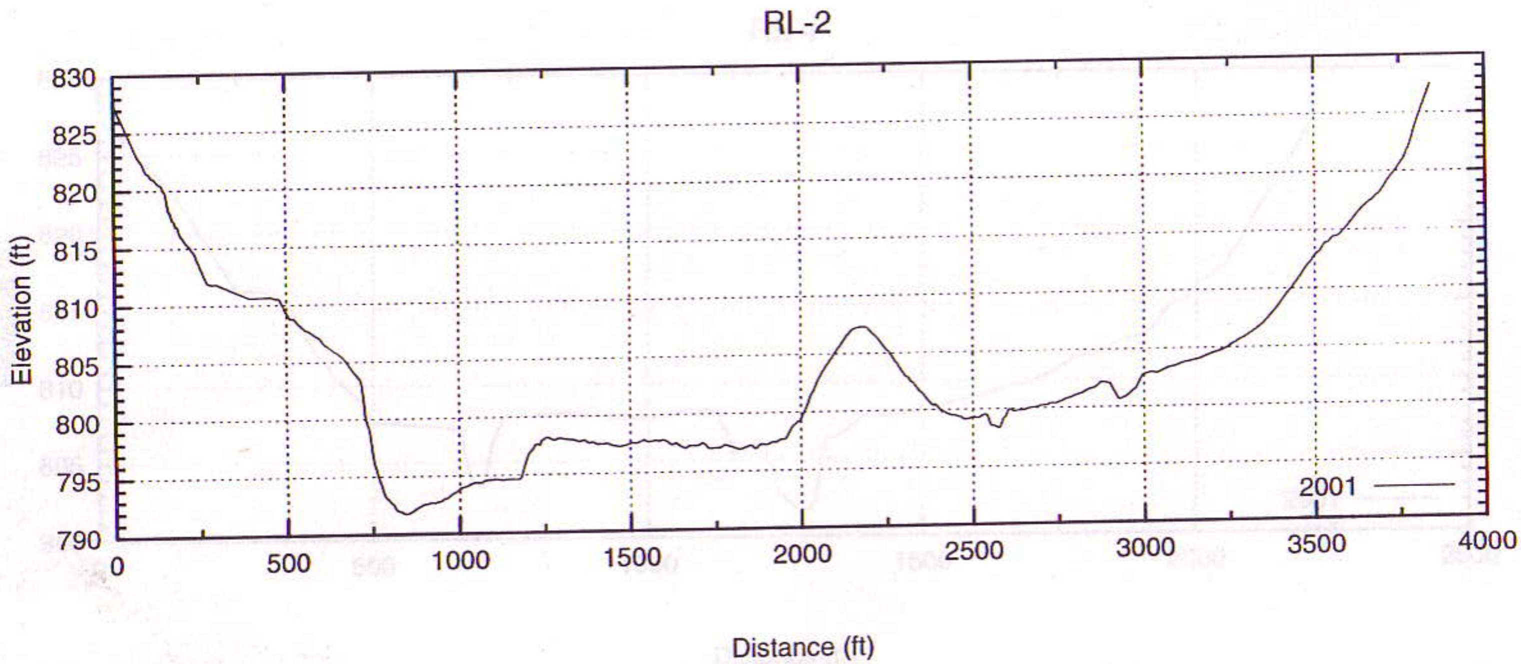


Lake Nocona
July 2001
Prepared by: TWDB

Appendix D Elevation vs. Area

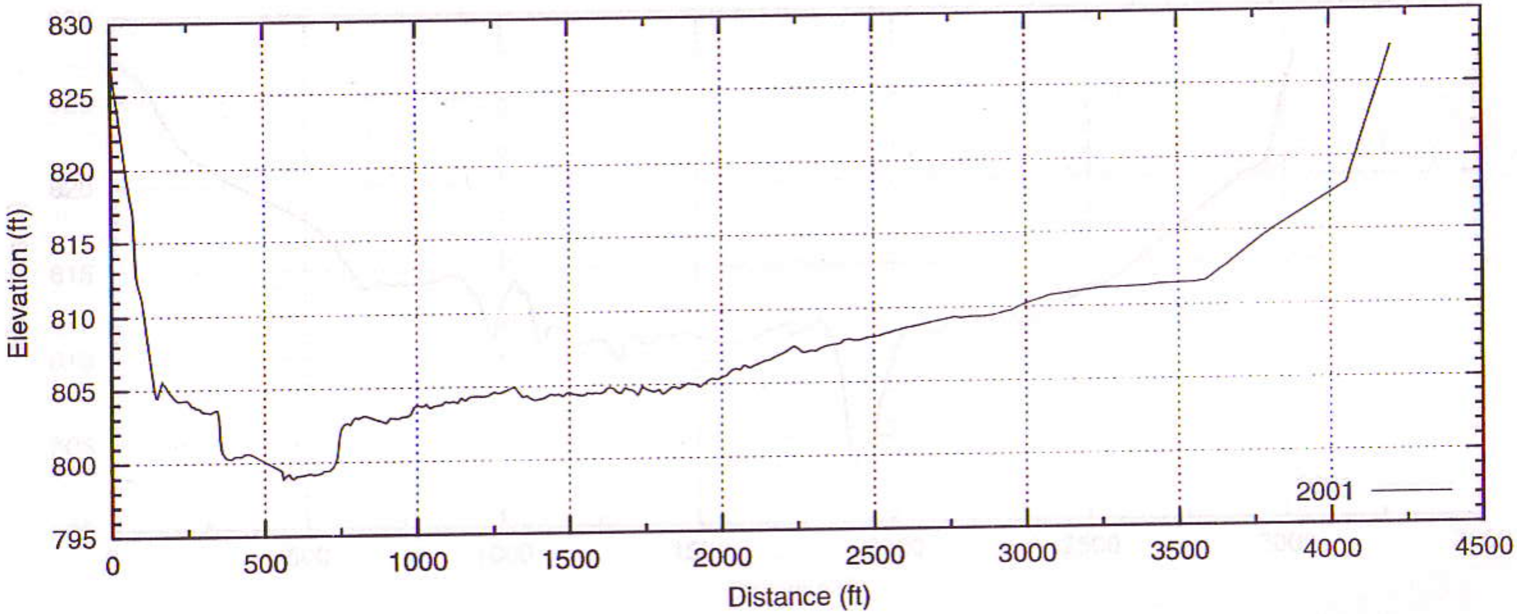
Lake Nocona


RL-1
Elevation (ft)
830
825
820
815
810
805
800
795
790
785
0
1000
2000
3000
4000
5000
6000
Distance (ft)
2001

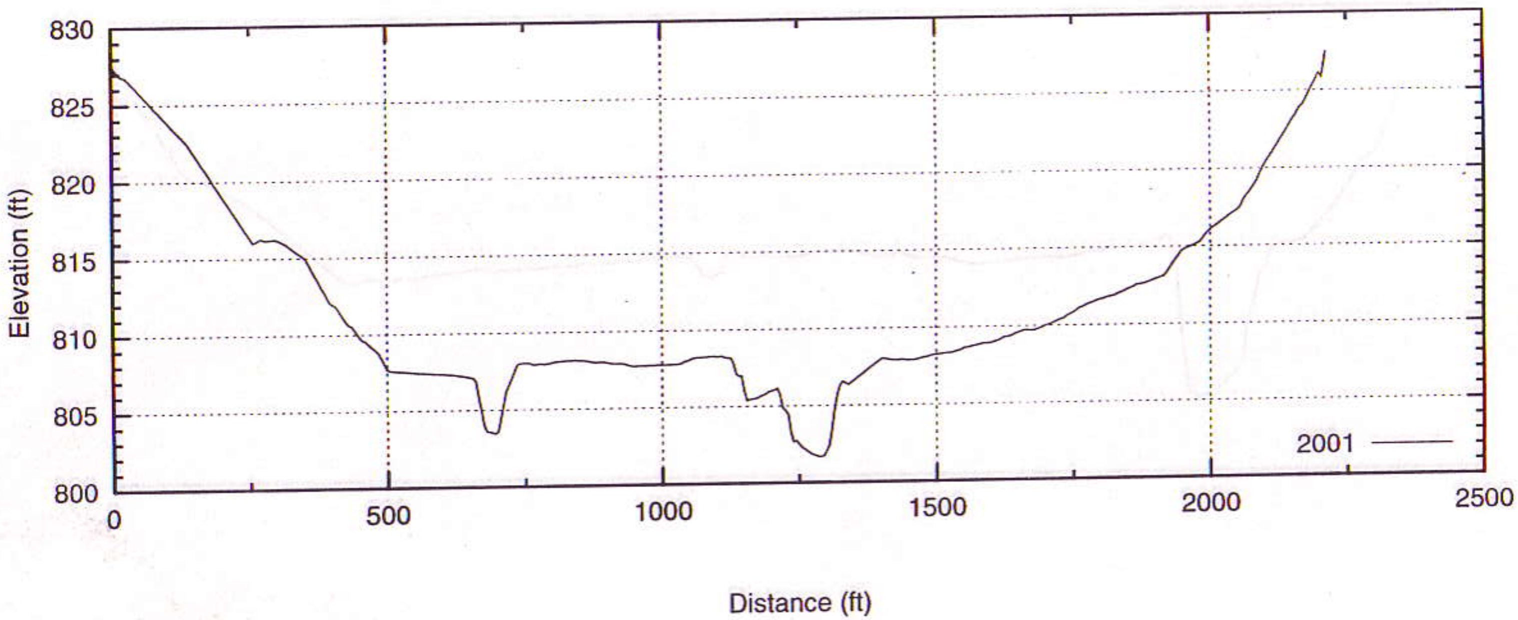

RL-2
Elevation (ft)
830
825
820
815
810
805
800
795
790
0
500
1000
1500
2000
2500
3000
3500
4000
Distance (ft)
2001

Lake Nocona

RL-3

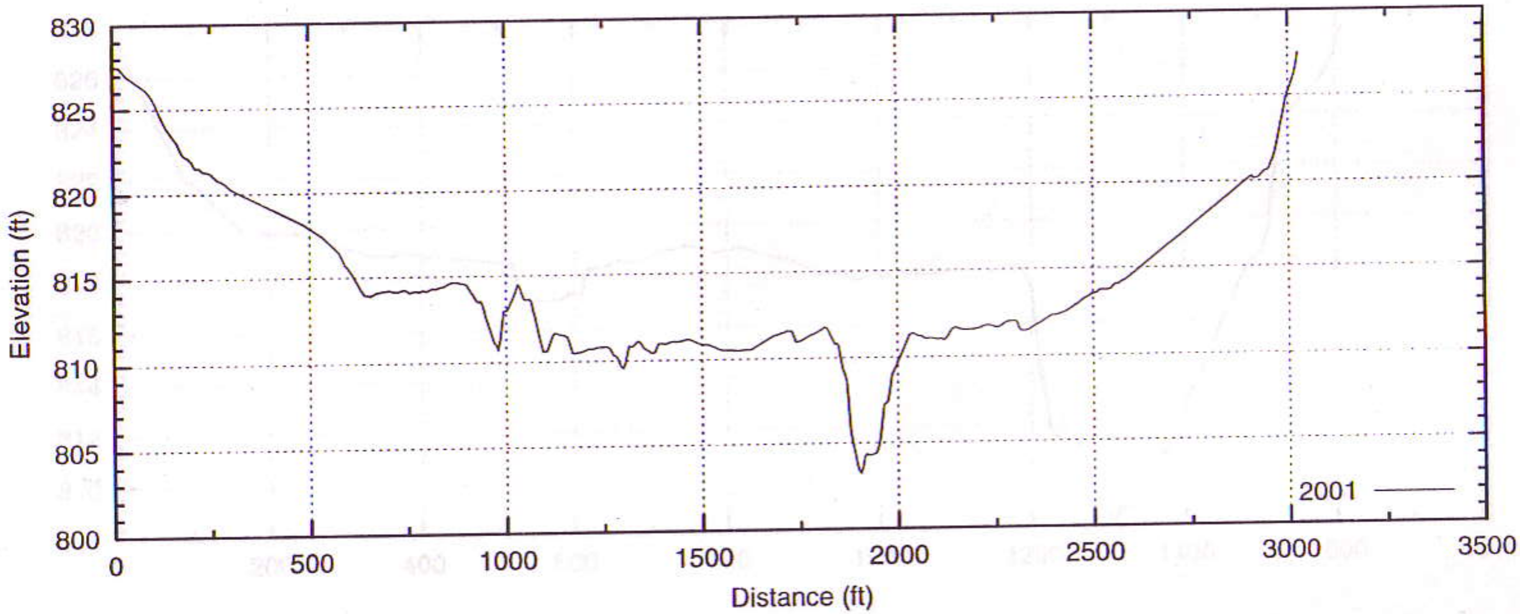


RL-4

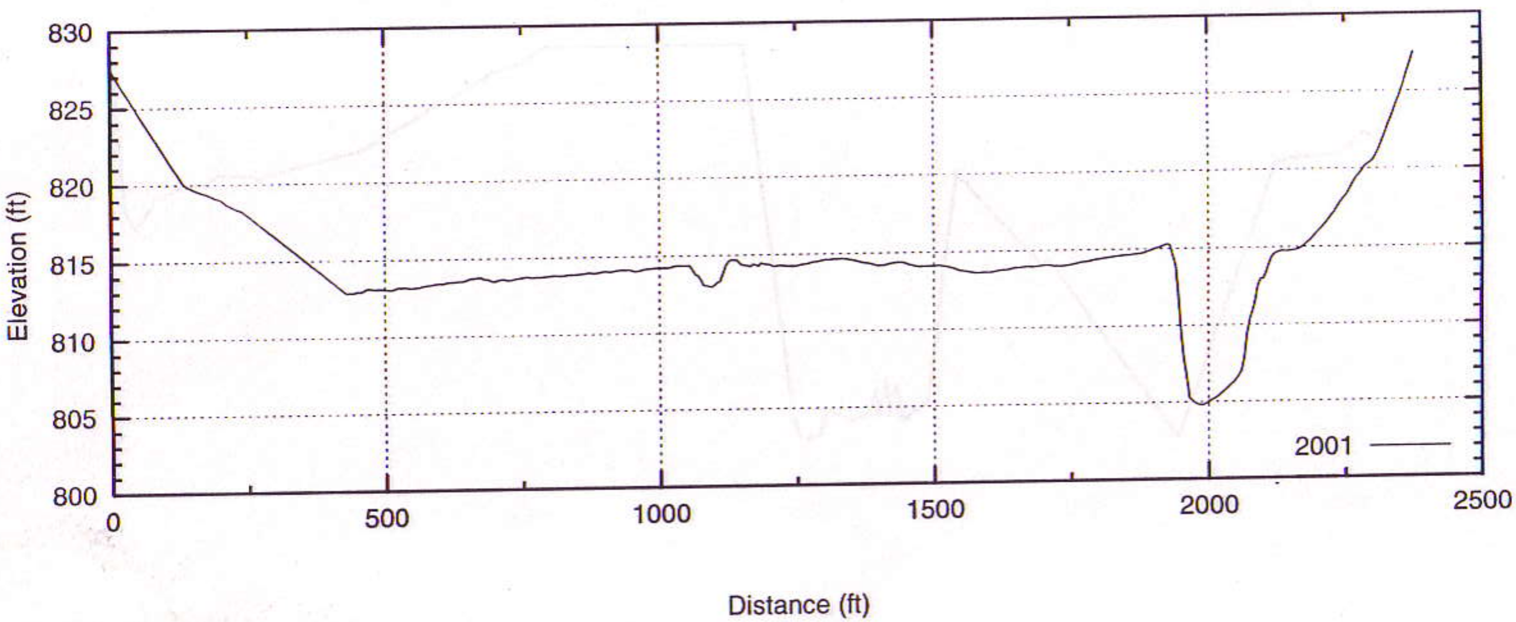


Lake Nocona

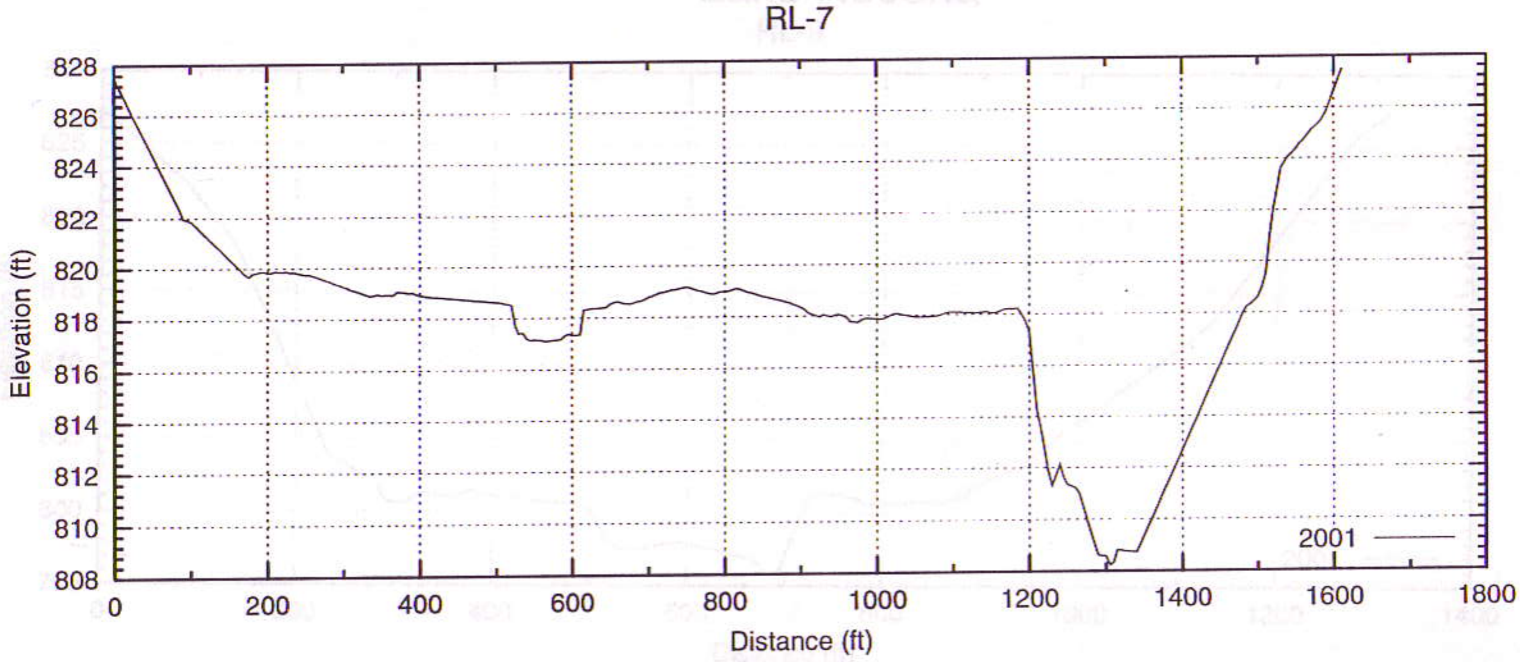
RL-5

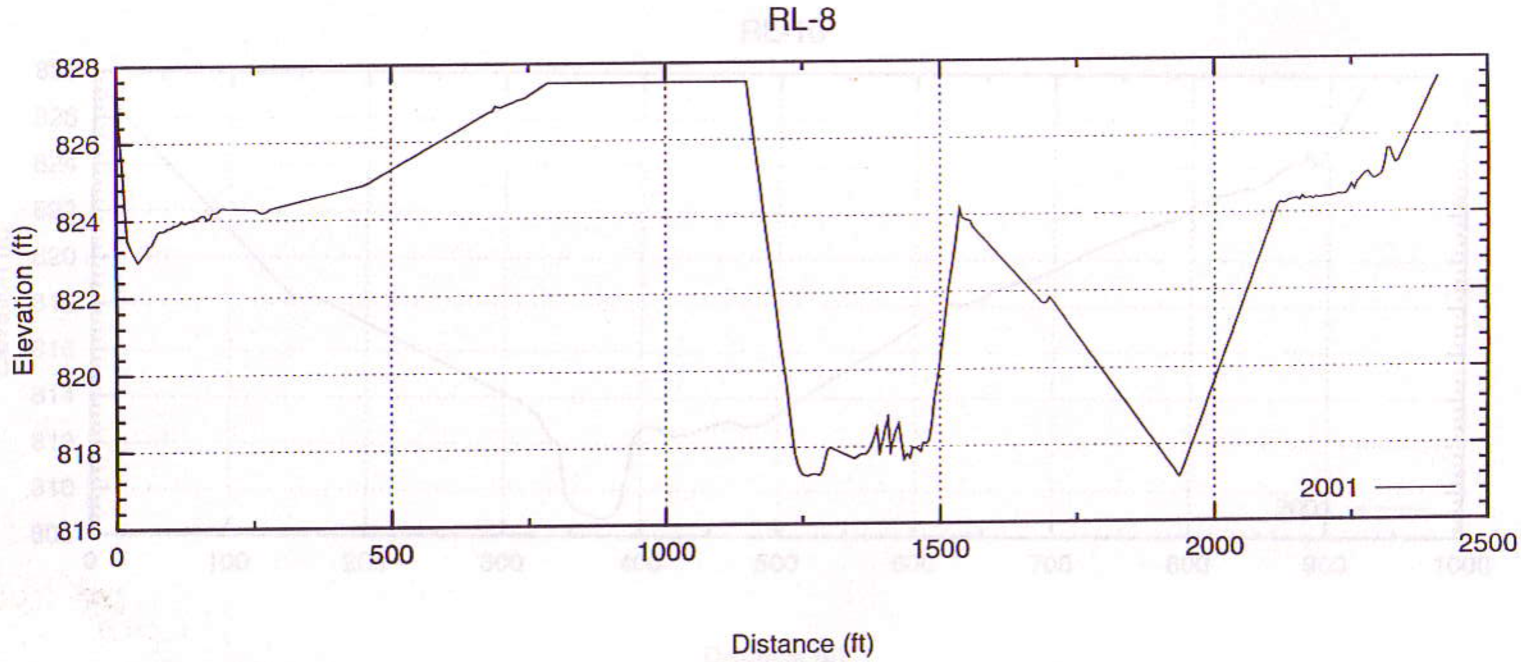


RL-6



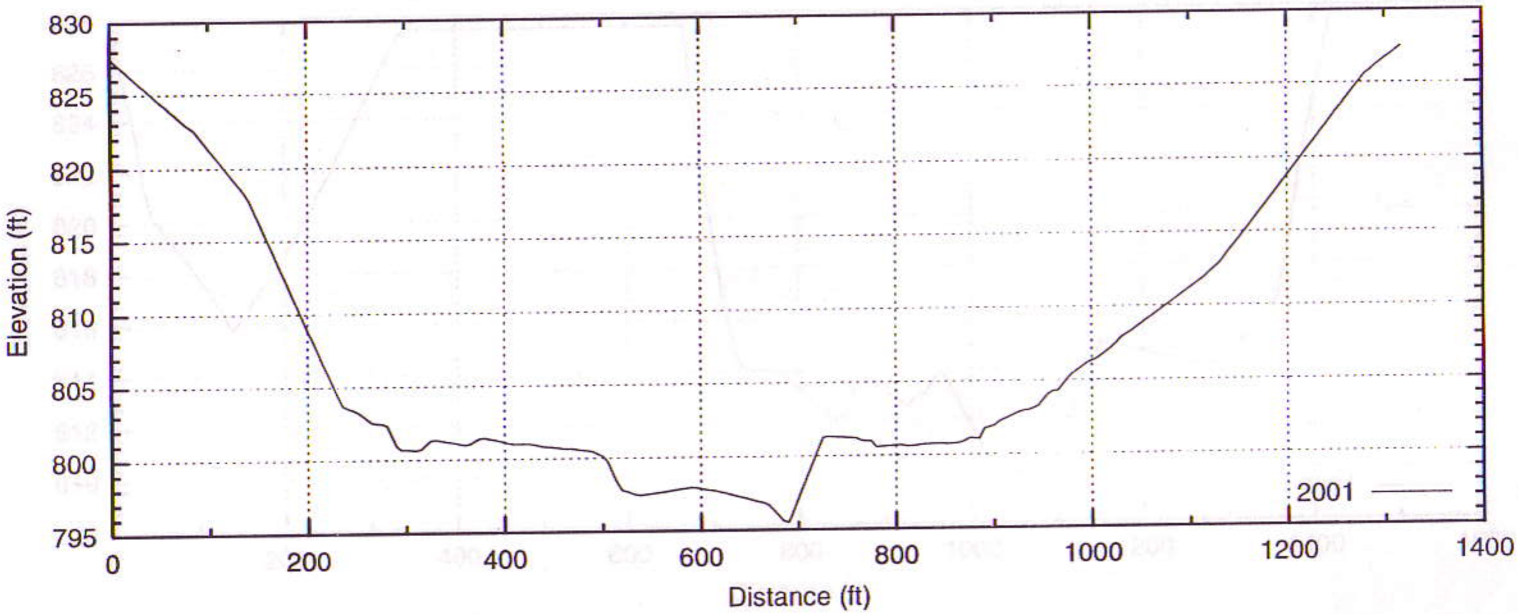
Lake Nocona


RL-7
Elevation (ft)
828
826
824
822
820
818
816
814
812
810
808
0
200
400
600
800
1000
1200
1400
1600
1800
Distance (ft)
2001

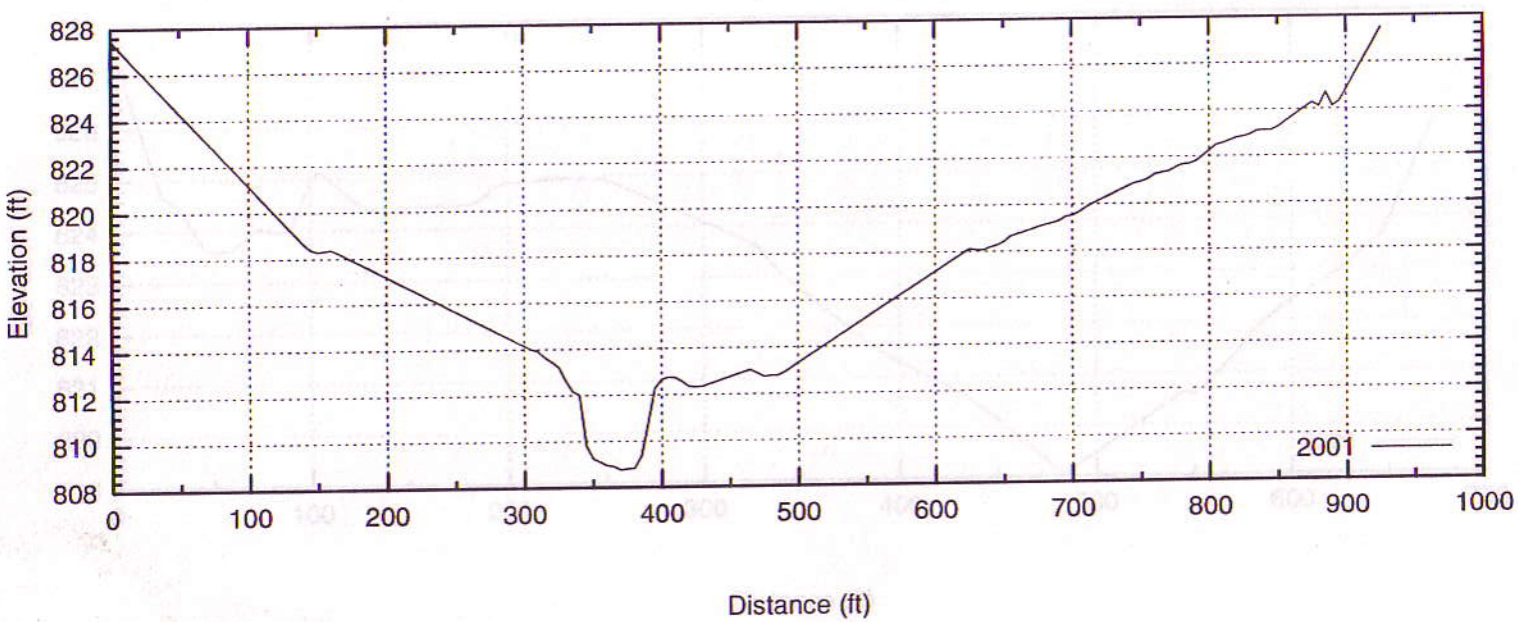

RL-8
Elevation (ft)
828
826
824
822
820
818
816
0
500
1000
1500
2000
2500
Distance (ft)
2001

Lake Nocona

RL-9

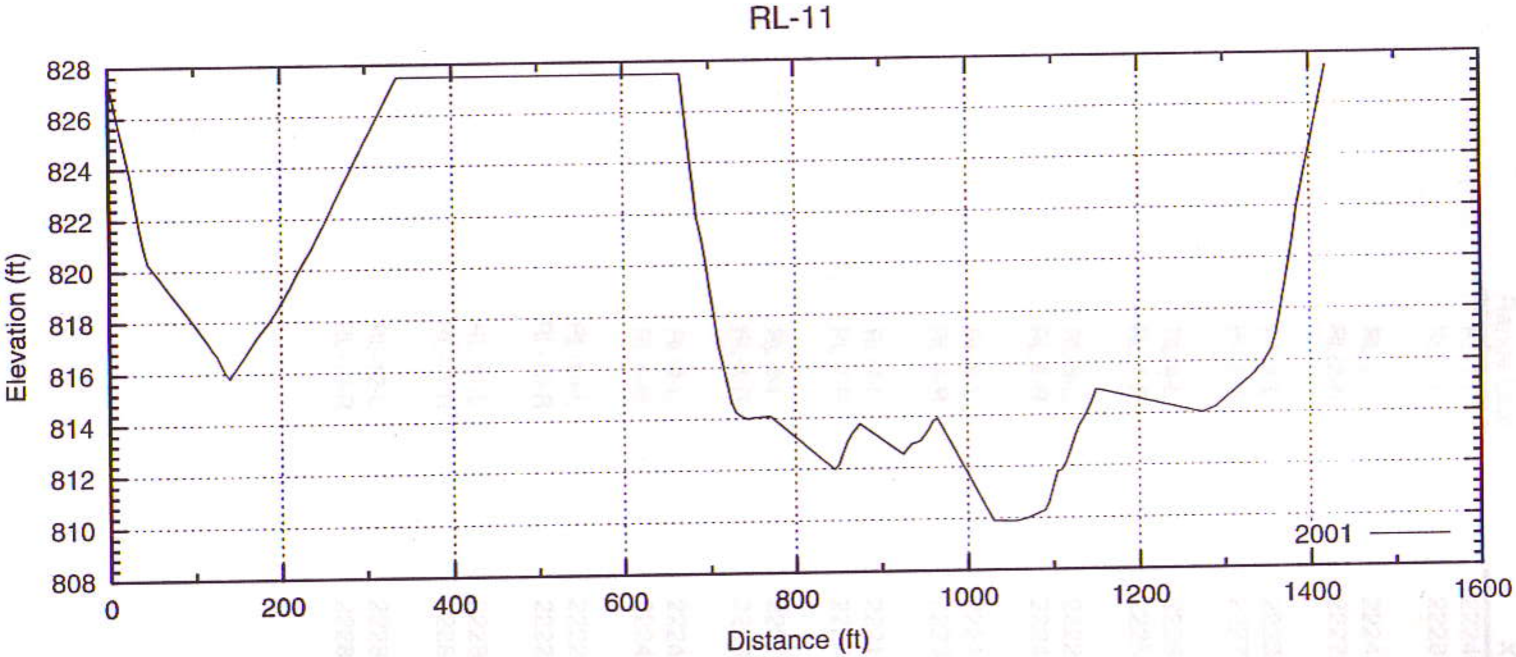


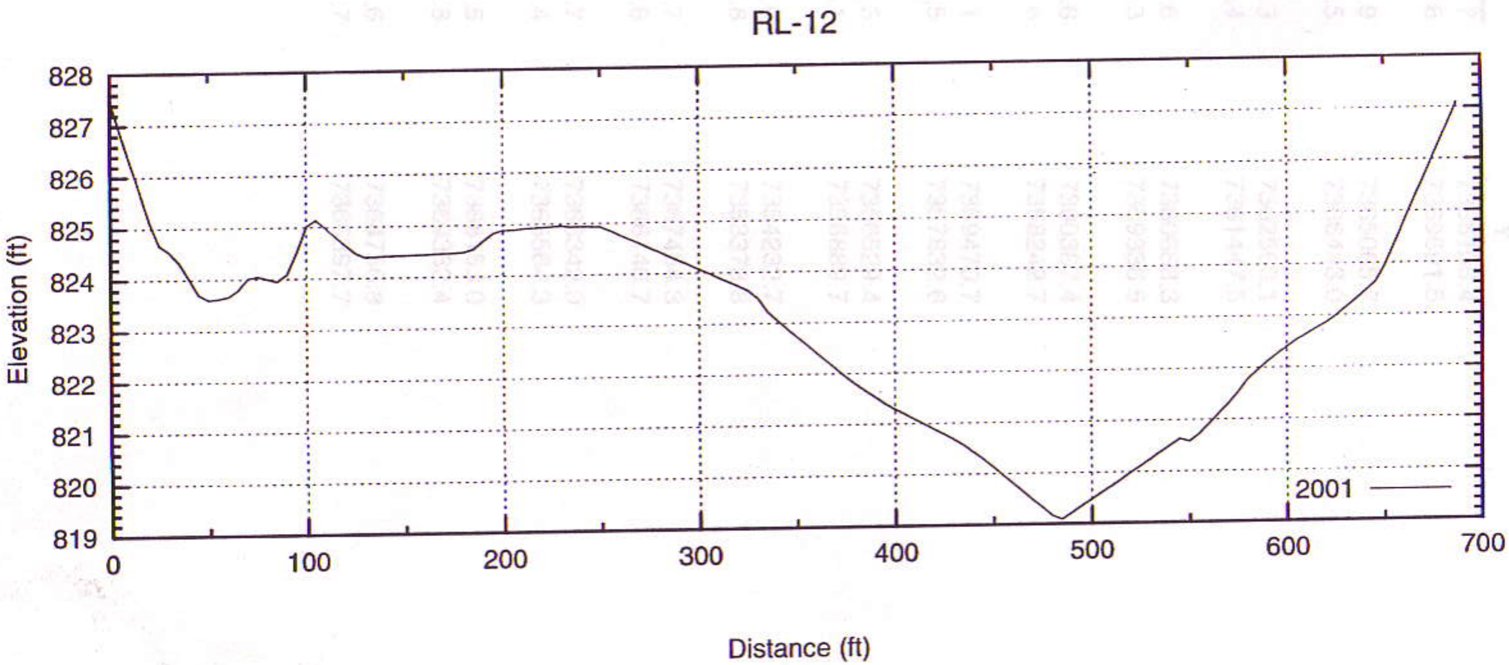
RL-10



Appendix E

Lake Nocona





Appendix E

Appendix F

Lake Nocona

TEXAS WATER DEVELOPMENT BOARD

July 2001 SURVEY

Range Line Endpoints

State Plane NAD83 Units-feet

Range Line	X	Y
RL-1-L	2224531.7	7366106.4
RL-1-R	2228116.8	7369691.5
RL-2-L	2224349.9	7365065.7
RL-2-R	2227936.5	7366443.0
RL-3-L	2223728.3	7362560.1
RL-3-R	2227779.4	7361447.5
RL-4-L	2223732.6	7360668.3
RL-4-R	2225499.3	7359336.5
RL-5-L	2222529.6	7360367.4
RL-5-R	2224684.6	7358242.7
RL-6-L	2221322.1	7359470.7
RL-6-R	2223043.5	7357832.6
RL-7-L	2221616.5	7356529.4
RL-7-R	2223186.1	7356889.7
RL-8-L	2221216.0	7354232.7
RL-8-R	2223466.8	7353373.8
RL-9-L	2224136.7	7367454.3
RL-9-R	2224230.6	7366140.7
RL-10-L	2222449.7	7366342.0
RL-10-R	2222951.4	7365564.3
RL-11-L	2228280.5	7368153.0
RL-11-R	2228990.8	7369382.4
RL-12-L	2228181.6	7364756.8
RL-12-R	2228429.7	7365397.7

APPENDIX G - DEPTH SOUNDER ACCURACY

This example was extracted from the Innerspace Technology, Inc. Operation Manual for the Model 443 Velocity Profiler.

For the following examples, $t_D = (D - d)/V$

Where: t_D = travel time of the sound pulse, in seconds (at depth = D)
D = depth, in feet
d = draft = 1.2 feet
V = speed of sound, in feet per second

To calculate the error of a measurement based on differences in the actual versus average speed of sound, the same equation is used, in this format:

$$D = [t\ (V)]+d$$

For the water column from 2 to 30 feet: V = 4832 fps
$t_{30} = (30-1.2)/4832 = 0.00596$ sec.

For the water column from 2 to 45 feet: V = 4808 fps
$t_{45} = (45-1.2)/4808 = 0.00911$ sec.
For a measurement at 20 feet (within the 2 to 30 foot column with V = 4832 fps):
$D_{20} = [((20-1.2)/4832)(4808)]+1.2$
= 19.9’ (-0.1’)
For a measurement at 30 feet (within the 2 to 30 foot column with V = 4832 fps):
$D_{30} = [((30-1.2)/4832)(4808)]+1.2$
= 29.9’ (-0.1’)

For a measurement at 50 feet (within the 2 to 60 foot column with V = 4799 fps):
$D_{50} = [((50-1.2)/4799)(4808)]+1.2$
= 50.1’ (+0.1’)

For the water column from 2 to 60 feet: V = 4799 fps Assumed V_{80} = 4785 fps

$t_{60} = (60-1.2)/4799$
$= 0.01225$ sec.
For a measurement at 10 feet (within the 2 to 30 foot column with V = 4832 fps):
$D_{10} = [((10-1.2)/4832)(4799)]+1.2$
= 9.9’ (-0.1’)
For a measurement at 30 feet (within the 2 to 30 foot column with V = 4832 fps):
$D_{30} = [((30-1.2)/4832)(4799)]+1.2$
= 29.8’ (-0.2’)
For a measurement at 45 feet (within the 2 to 45 foot column with V = 4808 fps):

$$D_{45} = [((45-1.2)/4808)(4799)]+1.2$$
$$= 44.9' \qquad (-0.1')$$

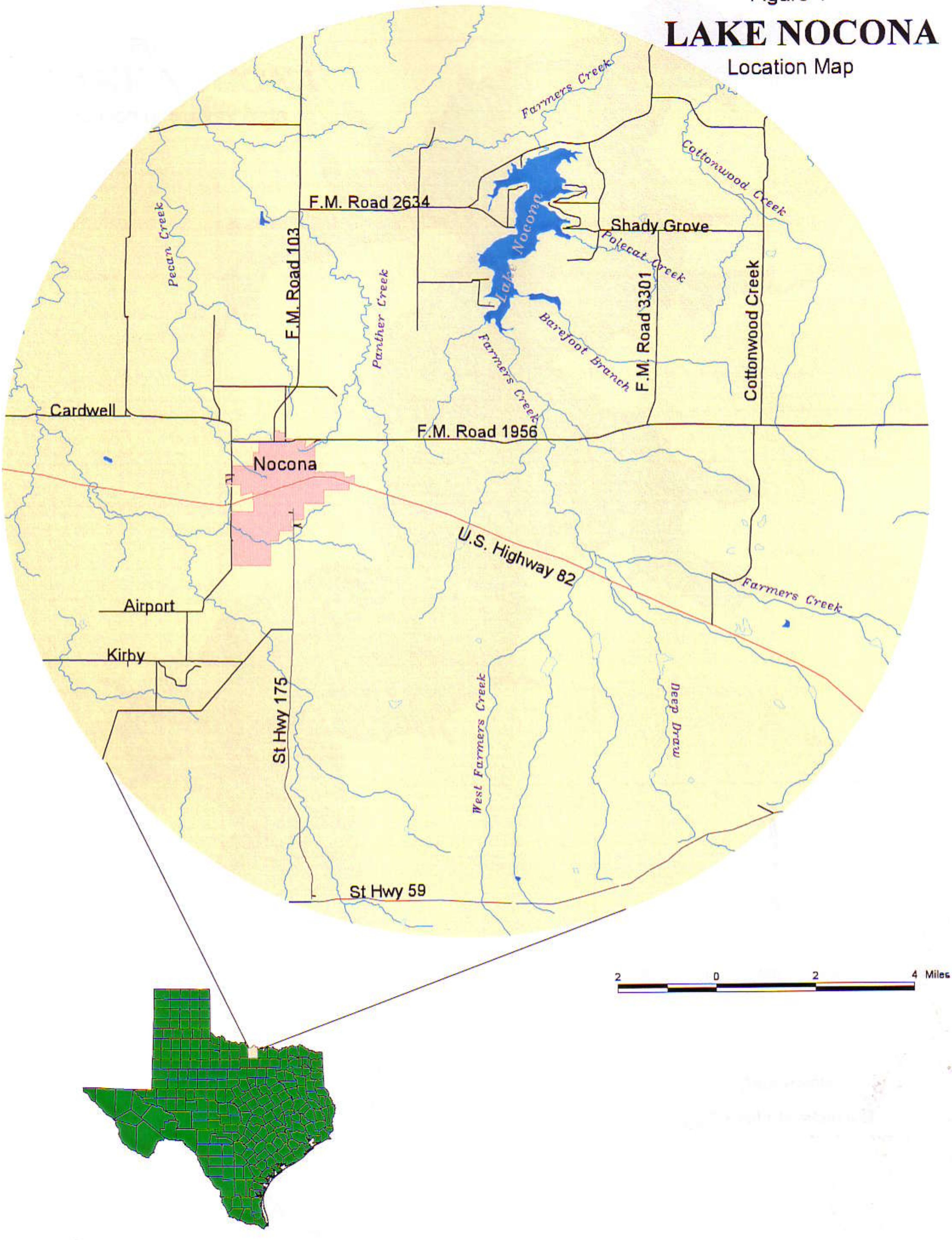
For a measurement at 80 feet (outside the 2 to 60 foot column, assumed V = 4785 fps):

$$D_{80} = [((80-1.2)/4785)(4799)]+1.2$$
$$= 80.2' \qquad (+0.2')$$

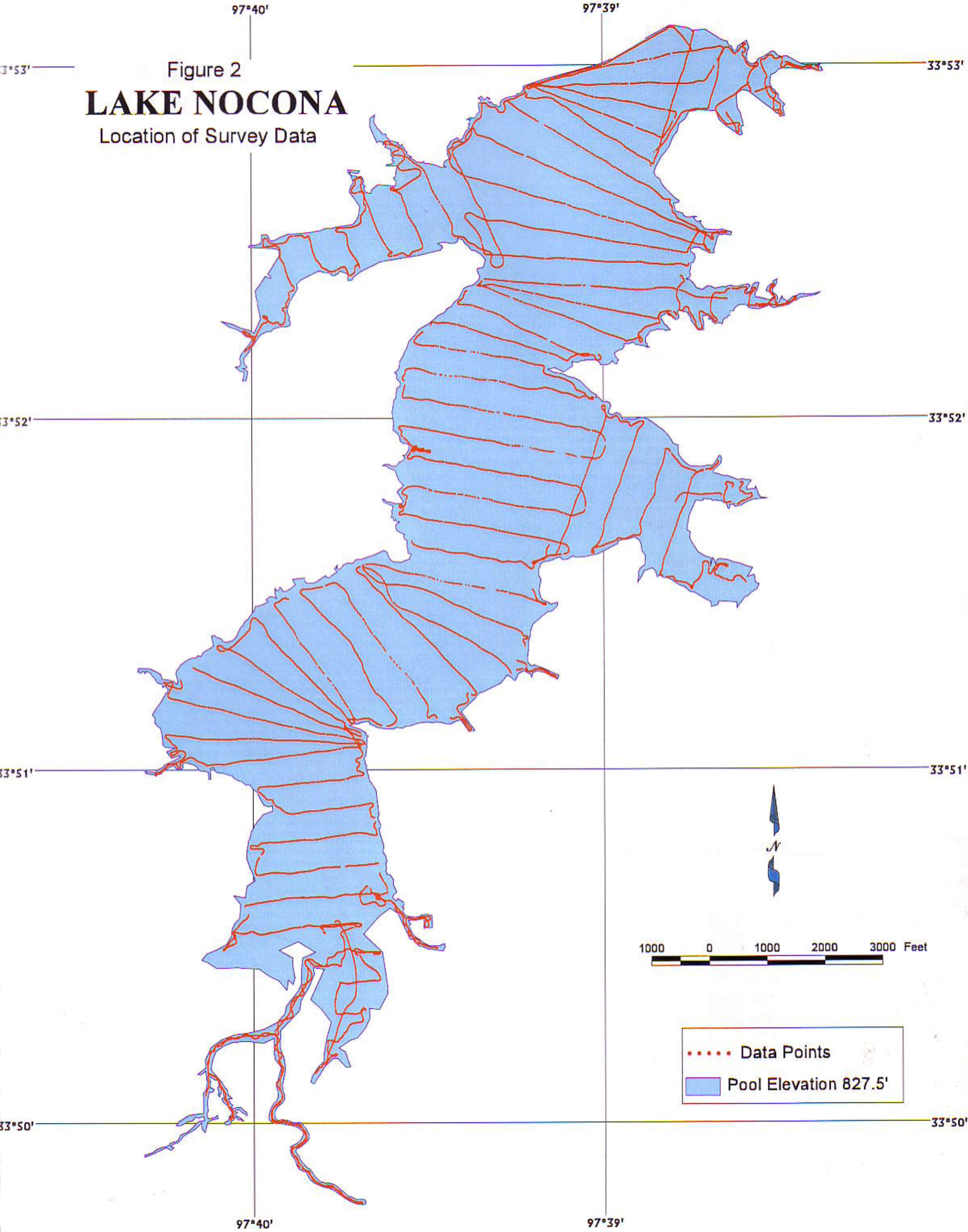
Figure 1

LAKE NOCONA

Location Map



TWDB Survey July 2001

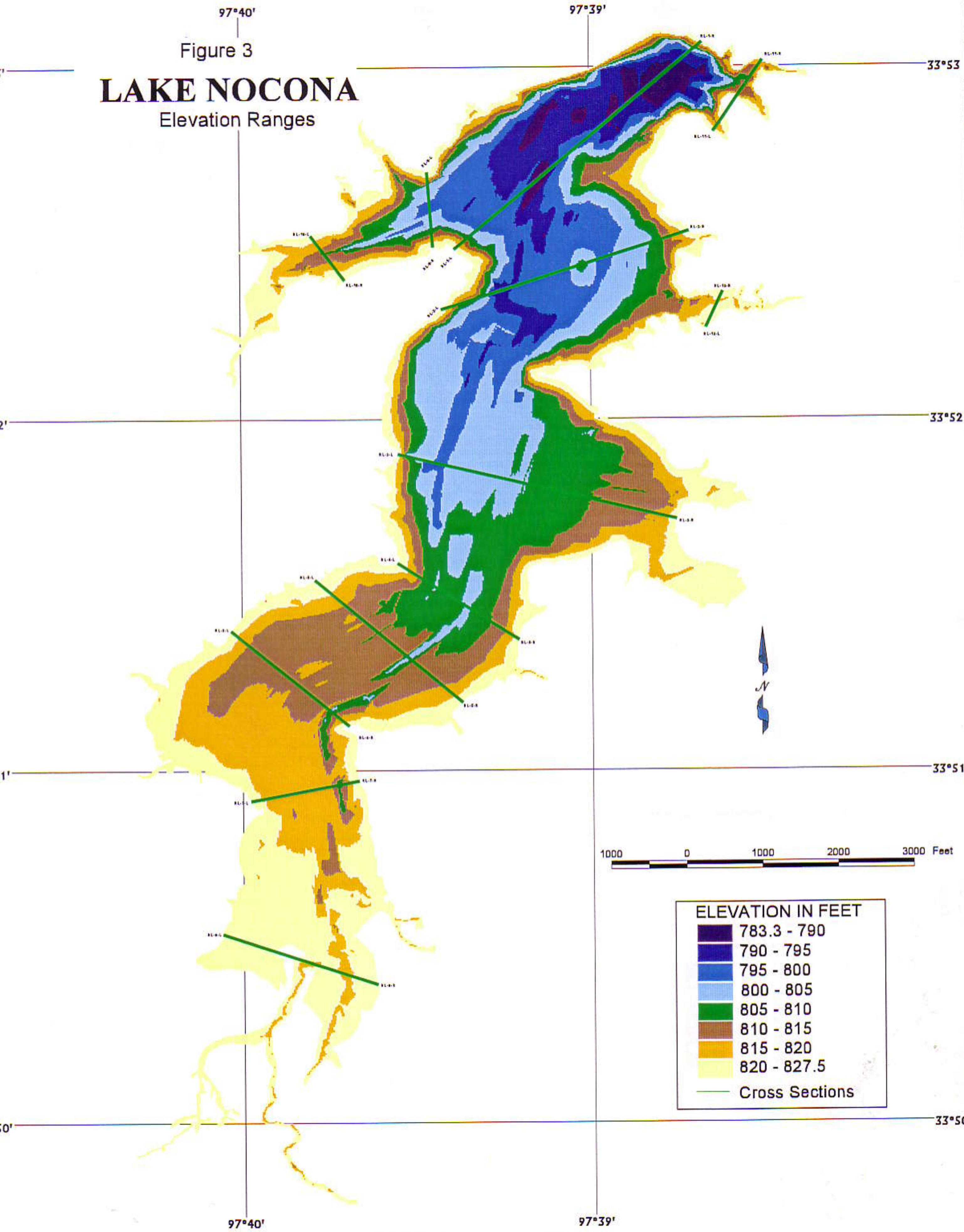


TWDB Survey July 2001

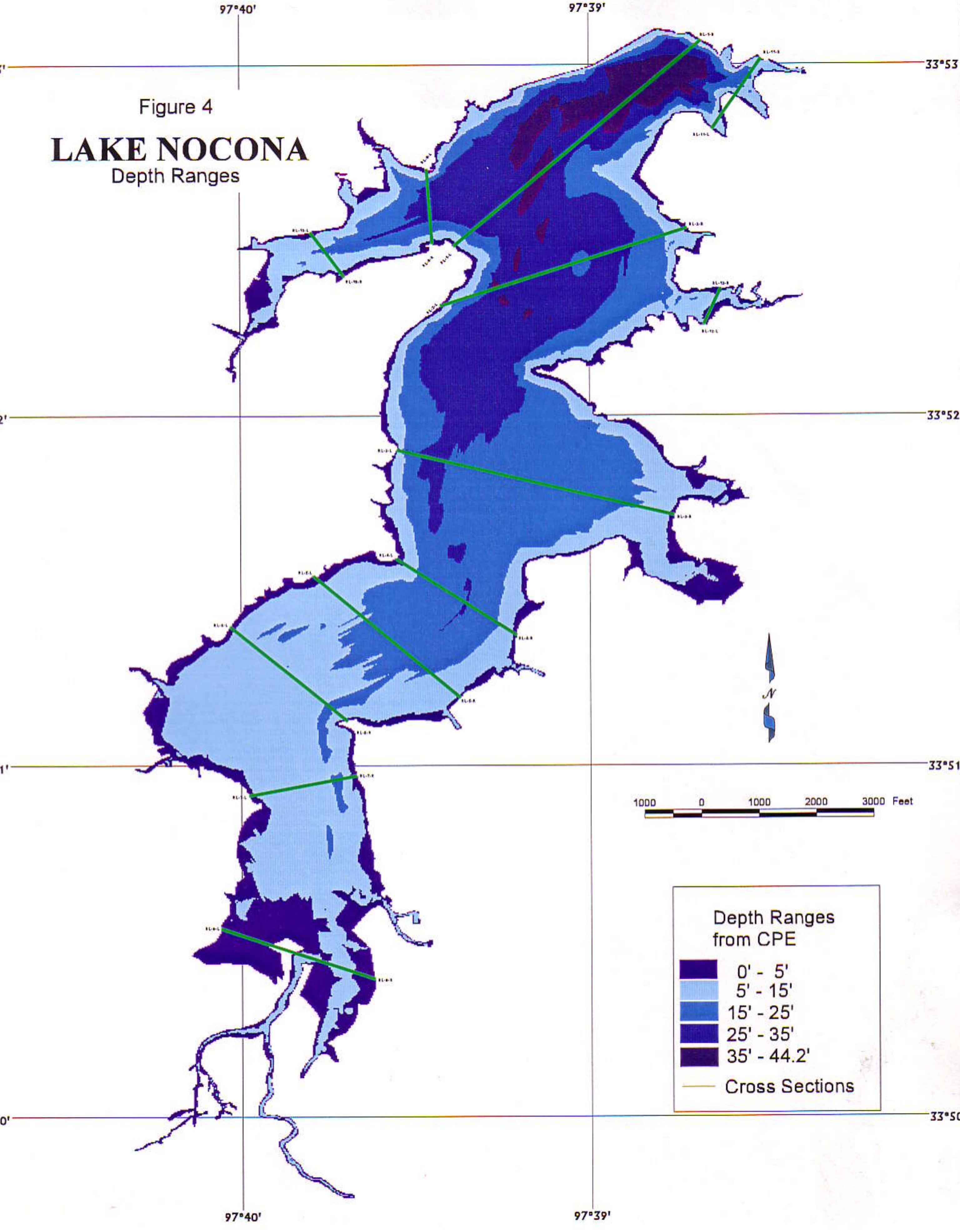
Figure 3

LAKE NOCONA

Elevation Ranges



TWDB Survey July 2001



TWDB Survey July 2001