VOLUMETRIC SURVEY OF MEDINA LAKE AND DIVERSION LAKE

Prepared for:

BEXAR-MEDINA-ATASCOSA COUNTIES WATER CONTROL AND IMPROVEMENT DISTRICT NUMBER ONE

Prepared by:

The Texas Water Development Board

March 10, 2003

Texas Water Development Board

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

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

HYDROGRAPHIC SURVEY REPORT

INTRODUCTION

Staff of the Hydrographic Survey Unit of the Texas Water Development Board (TWDB) conducted hydrographic surveys on Medina Lake and Diversion Lake in July, 1995. The purpose of the surveys was to determine the capacity of the lakes at the conservation pool elevation and to establish baseline information for future surveys. From this information, future surveys will be able to determine sediment deposition locations and rates over time. Survey results are presented in the following pages in both graphical and tabular form. All elevations presented in this report will be reported according to the Medina datum. The Medina datum is approximately 7.8 feet below mean sea level based on the National Geodetic Vertical Datum of 1929 (NGVD '29). Based on a survey made prior to 1912, the surface area of Medina Lake at the conservation pool elevation of 1,072.0 feet was calculated to be 5,575 acres with a corresponding capacity of 254,000 acre-feet. There was no previous information for Diversion Lake. Information presented in the following report will deal mainly with the Medina Lake survey. Information regarding the procedures and processing of data for the Diversion Lake survey will be presented in the section, "Diversion Lake Survey."

HISTORY AND GENERAL INFORMATION OF THE RESERVOIR

Medina Lake is located on the Medina River approximately 16 miles southeast of Bandera, Tx. The lake and dam facility are owned by the Bexar-Medina-Atascosa Counties Water Control and Improvement District Number One. Inflows to the lake originate over a 634 square mile drainage area. At the conservation capacity pool elevation of 1072.0 feet, the lake is approximately 18 miles long and about 3 miles wide at it's widest point.

Originally the project was built by the Medina Valley Irrigation Company. The water rights were conveyed by the State Board of Water Engineers under Certificate of Filing # 18 on February 14, 1914. The Medina Valley Irrigation Company went into receivership in 1917 and several years later became Bexar-Medina-Atascosa Counties Water Improvement District Number One. On November 1, 1979, a resolution was passed, broadening its powers as a water district and changing

its name to the presently known Bexar-Medina-Atascosa Counties Water Control and Improvement District Number One (BMA). On August 1, 1981, a Certificate of Adjudication # 2130 was issued by the Texas Water Commission to BMA authorizing the owner to maintain an existing dam and reservoir known as Medina Lake and to impound not to exceed 237,874 acre-feet of water. BMA was also authorized to maintain an existing dam and reservoir, known as Diversion Lake and impound therein not to exceed 4,500 acre-feet of water. Authorization was granted to BMA to use, not to exceed, 66,000 acre-feet of water per annum from both Medina and Diversion Lake for irrigation of a maximum 33,000 acres of land within the boundaries of the Bexar-Medina-Atascosa Counties Water Control and Improvement District Number One. It also authorized the BMA to use , not to exceed 750 acre-feet of water per annum by the residents of the district for domestic and livestock purposes. Certificate of Adjudication # 2130 was amended several times. The latest amendment, # 2130C, was filed September 3, 1993 for the purpose to clarify all use authorizations. The total amount of water for usage did not change but the purpose was changed to include irrigation, municipal and industrial purposes.

Medina Dam construction commenced in 1912 and was completed in 1913. Deliberate impoundment of water began on May 7, 1913. The project was designed by Bartlett and Ranney of San Antonio, and the total cost of Medina and Diversion Dams was $2,739,300.

Medina Dam is a gravity-type concrete dam with a length of 1,580 feet, rising 164 feet above the natural stream bed to an elevation of 1084.0 feet. The uncontrolled spillway is a cut through natural rock and is 880 feet long with a 3 foot wide cutoff wall located near the right end of the dam. The water supply outlets consist of 3 steel pipes, 5 feet in diameter, with lift type gates. The invert elevation of these outlets is elevation 966.5. The low flow outlets consist of 2 steel pipes, 2.5 feet in diameter, with lift type gates. The invert elevation of these pipes is 920.0

HYDROGRAPHIC SURVEYING TECHNOLOGY

The following sections will describe the equipment and methodology used to conduct this hydrographic survey. Some of the theory behind Global Positioning System (GPS) technology and it's

accuracy are also addressed.

GPS Information

The following is a brief and simple description of Global Positioning System (GPS) technology. GPS is a new technology that uses a network of satellites, maintained in precise orbits around the earth, to determine locations on the surface of the earth. GPS receivers continuously monitor the broadcasts from the satellites to determine the position of the receiver. With only one satellite being monitored, the point in question could be located anywhere on a sphere surrounding the satellite with a radius of the distance measured. The observation of two satellites decreases the possible location to a finite number of points on a circle where the two spheres intersect. With a third satellite observation, the unknown location is reduced to two points where all three spheres intersect. One of these points is obviously in error because its location is in space, and it is ignored. Although three satellite measurements can fairly accurately locate a point on the earth, the minimum number of satellites required to determine a three dimensional position within the required accuracy is four. The fourth measurement compensates for any time discrepancies between the clock on board the satellites and the clock within the GPS receiver.

GPS technology was developed in the 1960s by the United States Air Force and the defense establishment. After program funding in the early 1970s, the initial satellite was launched on February 22, 1978. A four year delay in the launching program occurred after the Challenger space shuttle disaster. In 1989, the launch schedule was resumed. Full operational capability will be reached when the NAVSTAR (NAVigation System with Time And Ranging) satellite constellation is composed of 24 Block II satellites. At the time of the survey, the system had achieved initial operational capability. A full constellation of 24 satellites, in a combination of Block I (prototype) and Block II satellites, was fully functional. The NAVSTAR satellites provide data based on the World Geodetic System (WGS '84) spherical datum. WGS '84 is essentially identical to NAD '83.

The United States Department of Defense (DOD) is currently responsible for implementing and maintaining the satellite constellation. In an attempt to discourage the use of these survey units as a guidance tool by hostile forces, the DOD has implemented means of false signal projection called Selective Availability (S/A). Positions determined by a single receiver when S/A is active result in

errors to the actual position of up to 100 meters. These errors can be reduced to centimeters by performing a static survey with two GPS receivers, one of which is set over a point with known coordinates. The errors induced by S/A are time-constant. By monitoring the movements of the satellites over time (one to three hours), the errors can be minimized during post processing of the collected data and the unknown position computed accurately.

Differential GPS (DGPS) can determine positions of moving objects in real-time or "on-the-fly." One GPS receiver was set up over a benchmark with known coordinates established by the hydrographic survey crew. This receiver remained stationary during the survey and monitored the movements of the satellites overhead. Position corrections were determined and transmitted via a radio link once per second to a second GPS receiver located on the moving boat. The boat receiver used these corrections, or differences, in combination with the satellite information it received to determine its differential location. The large positional errors experienced by a single receiver when S/A is active are greatly reduced by utilizing DGPS. The reference receiver calculates satellite corrections based on its known fixed position, which results in positional accuracies within three meters for the moving receiver. DGPS was used to determine horizontal position only. Vertical information was supplied by the depth sounder.

Equipment and Methodology

The equipment used in the performance of the hydrographic survey consisted of a 23-foot aluminum tri-hull SeaArk craft with cabin, equipped with twin 90-Horsepower Johnson outboard motors. Installed within the enclosed cabin are an Innerspace Helmsman Display (for navigation), an Innerspace Technology Model 449 Depth Sounder and Model 443 Velocity Profiler, a Trimble Navigation, Inc. 4000SE GPS receiver, a Motorola Radius radio with an Advanced Electronic Applications, Inc. packet modem, and an on-board computer. The computer was supported by a dot matrix printer and a B-size plotter. Power was provided by a water-cooled generator through an in-line uninterruptible power supply. Reference to brand names does not imply endorsement by the TWDB.

The shore station included a second Trimble 4000SE GPS receiver, Motorola Radius radio

and Advanced Electronic Applications, Inc. packet modem, and an omni-directional antenna mounted on a modular aluminum tower to a total height of 40 feet. The combination of this equipment provided a data link with a reported range of 25 miles over level to rolling terrain that does not require that line-of-sight be maintained with the survey vessel in most conditions, thereby reducing the time required to conduct the survey.

The GPS equipment, survey vessel, and depth sounder combine together to provide an efficient hydrographic survey system. As the boat travels across the lake surface, the depth sounder gathers 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 daily data files collected are downloaded from the computer and brought to the office for editing after the survey is completed. During editing, bad data is removed or corrected, multiple data points are averaged together to get one data point per second, and average depths are converted to elevation readings based on the daily recorded lake elevation 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. The level of accuracy is equivalent to or better than previous methods used to determine lake volumes, some of which are discussed below.

Previous Survey Procedures

Originally, reservoir surveys were conducted with a rope stretched across the reservoir along pre-determined range lines. A small boat would manually pole the depth at selected intervals along the rope. Over time, aircraft cable replaced the rope and electronic depth sounders replaced the pole. The boat was hooked to the cable, and depths were again recorded at selected intervals. This method, used mainly by the Soil Conservation Service, worked well for small reservoirs.

Larger bodies of water required more involved means to accomplish the survey, mainly due to increased size. Cables could not be stretched across the body of water, so surveying instruments were utilized to determine the path of the boat. Monumentation was set for the end points of each line so the same lines could be used on subsequent surveys. Prior to a survey, each end point had to be located (and sometimes reestablished) in the field and vegetation cleared so that line of sight could

be maintained. One surveyor monitored the path of the boat and issued commands via radio to insure that it remained on line while a second surveyor determined depth measurement locations by turning angles. Since it took a major effort to determine each of the points along the line, the depth readings were spaced quite a distance apart. Another major cost was the land surveying required prior to the reservoir survey to locate the range line monuments and clear vegetation.

Electronic positioning systems were the next improvement. If triangulation could determine the boat location by electronic means, then the boat could take continuous depth soundings. A set of microwave transmitters positioned around the lake at known coordinates would allow the boat to receive data and calculate its position. Line of site was required, and the configuration of the transmitters had to be such that the boat remained within the angles of 30 and 150 degrees in respect to the shore stations. The maximum range of most of these systems was about 20 miles. Each shore station had to be accurately located by survey, and the location monumented for future use. Any errors in the land surveying resulted in significant errors that were difficult to detect. Large reservoirs required multiple shore stations and a crew to move the shore stations to the next location as the survey progressed. Land surveying was still a major cost.

Another method used mainly prior to construction utilized aerial photography to generate elevation contours which could then be used to calculate the volume of the reservoir. Fairly accurate results could be obtained, although the vertical accuracy of the aerial topography was generally one-half of the contour interval or $\pm$ five feet for a ten-foot contour interval. This method could be quite costly and was only applicable in areas that were not inundated.

PRE-SURVEY PROCEDURES

The reservoir's surface area was determined prior to the survey by digitizing with AutoCad software contour 1064.0 (the equivalent conservation pool capacity elevation in NGVD datum used by the USGS) upstream from the dam on two USGS quad sheets. The names of the quad sheets are as follows: MEDINA LAKE, TX 1964 (Photorevised 1982) and PIPE CREEK, TX 1970 (Photorevised 1982). The graphic boundary file created was then transformed into the proper datum, from NAD '27

datum to NAD '83, using Environmental Systems Research Institutes's (ESRI) Arc/Info project command with the NADCOM parameters. The area of the lake boundary was checked to verify that the area was the same in both datums.

The survey layout was designed by placing survey track lines at 500 foot intervals across the lake. The survey design for this lake required approximately 258 survey lines to be placed along the length of the lake. Survey setup files were created using Coastal Oceangraphics, Inc. Hypack software for each group of track lines that represented a specific section of the lake. The setup files were copied onto diskettes for use during the field survey.

SURVEY CONTROL SETUP

The first task of the Hydrographic Survey field staff after arriving at Medina Lake was to establish a horizontal reference control point. Figure 3 shows the location of the control point established. This location was chosen due to the close proximity to the reservoir and the security of the area.

Prior to the field survey, TWDB staff had researched locations of known first-order benchmarks and requested BMA staff to physically locate the associated monuments. Of the monuments found, the one chosen to provide horizontal control for the survey was a U. S. Geological Survey first-order monument named SCHMIDT located approximately 10 miles east of Hondo, Tx.. The coordinates for the monument are published as Latitude 29° 22' 14.23872"N and Longitude 99° 00' 14.54646"W.

On July 5, 1995, TWDB staff performed a static survey to determine the WGS'84 coordinates of the lake survey control point. The control point used for the shore station was a nail set in concrete at the west end of the dam's crest. The GPS receivers were set up over each point and satellite data were gathered for approximately one hour, with up to six satellites visible at the same time to the receivers.

Once data collection ended, the data were retrieved and processed from both receivers, using

Trimble Trimvec software, to determine the coordinates for the control point. The WGS' 84 coordinates were determined to be North latitude 29° 32' 27.28214" and West longitude 98° 56' 12.47555".

Using the newly determined coordinates, a shore station was set up over the control point to provide horizontal control during the survey. The coordinates from the static survey were entered into the GPS receiver located over the control point to fix its location. Data received during the survey could then be corrected and broadcast to the GPS receiver on the moving boat during the survey.

SURVEY PROCEDURES

The following procedures were followed during the hydrographic survey of Medina Lake performed by the TWDB. Information regarding equipment calibration and operation, the field survey, and data processing is presented.

Equipment Calibration and Operation

During the survey, the GPS receivers were operated in the following DGPS modes. The reference station receiver was set to a horizontal mask of 0°, to acquire information on the rising satellites. A horizontal mask of 10° was used on the roving receiver for the purpose of calculating better horizontal positions. A PDOP (Position Dilution of Precision) limit of 7 was set for both receivers. The DGPS positions are known to be within acceptable limits of horizontal accuracy when the PDOP is seven (7) or less. An internal alarm sounds if the PDOP rises above seven to advise the field crew that the horizontal position has degraded to an unacceptable level.

Prior to the survey, TWDB staff verified the horizontal accuracy of the DGPS used during the Medina Lake survey to be within the specified accuracy of three meters by the following procedure. The shore station was set up over a known United States Geological Service (USGS) first order monument and placed in differential mode. The second receiver, directly connected to the boat with its interface computer, was placed over another known USGS first order monument and data was

collected for 60 minutes in the same manner as during a survey. Based on the differentially-corrected coordinates obtained and the published coordinates for both monuments, the resulting positions fell within a three-meter radius of the actual known monument position.

At the beginning of each surveying day, the depth sounder was calibrated with the Innerspace Velocity Profiler. The Velocity Profiler calculates an average speed of sound through the water column of interest for a designated draft value of the boat (draft is the vertical distance that the boat penetrates the water surface). The draft of the boat was previously determined to average 1.2 ft. The velocity profiler probe is placed in the water to moisten and acclimate the probe. The probe is then raised to the water surface where the depth is zeroed. The probe is lowered on a cable to just below the maximum depth set for the water column, and then raised to the surface. The unit displays an average speed of sound for a given water depth and draft, which is entered into the depth sounder. The depth value on the depth sounder was then checked manually with a measuring tape to ensure that the depth sounder was properly calibrated and operating correctly. During the survey of Medina Lake, the speed of sound in the water column varied daily between 4,936 and 4,942 feet 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 feet, plus an estimated error of $\pm$0.3 feet due to the plane of the boat for a total accuracy of $\pm$0.5 feet for any instantaneous reading. These errors tend to be minimized over the entire survey, since some are plus readings and some are minus readings. Further information on these calculations is presented in Appendix A.

Field Survey

Data was collected on Medina Lake during the period of July 18-20, 1995. Approximately 57,570 data points were collected over the 92.47 miles traveled along the pre-planned survey lines and the random data-collection lines. These points were stored digitally on the boat's computer in 234 data files. Data were not collected in areas of shallow water (depths less than 3.0 ft.) or with significant obstructions unless these areas represented a large amount of water. Random data points were collected, when determined necessary by the field crew, by manually measuring the depth with a surveying rod and entering the depth value into the data file. As each point was entered, the DGPS horizontal position was stored automatically with each return keystroke on the computer. The boat

was moving slowly during this period so positions stored were within the stated accuracy of $\pm$ 3 meters to the point poled. Figure 2 shows the actual location of the data collection points.

The collected data were stored in individual data files for each pre-plotted range line or random data collection events. These files were downloaded to diskettes at the end of each day for future processing.

Data Processing

The collected data were down-loaded from diskettes onto the TWDB's computer network. The diskettes were then stored in a secured, safe location for future reference as needed. 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 the file. The depth information collected every 0.1 seconds was averaged to get one reading for each second of data collection. A correction for the lake elevation at the time of data collection was also applied to each file during the EDIT routine. During the survey, the water surface elevation ranged daily from 1,056.37 to 1,056.40 feet. After all changes had been made to the raw data file, the edited file was saved with a different extension. After all the files were edited, the edited files were combined into a single data file, representative of the lake, to be used with the GIS software to develop a model of the lake's bottom surface.

An aerial survey was flown by Tobin Surveys, Inc. of the lake in 1984 and 1985. Information from this survey was used to supplement the TWDB survey for the area from elevation 994.88 to elevation 1080.0. 39,947 data points inside the lake below elevation 1080.0 feet were determined from the aerial photos using photo-metric processes.

The resulting DOS data file was imported into the UNIX operating system used to run Environmental System Research Institutes's (ESRI) Arc/Info GIS software. The latitude and longitude coordinates of each point were then converted to decimal degrees by a UNIX awk command. The awk command manipulates the data file format into a MASS points format for use by the GIS software. The graphic boundary file previously digitized was also imported.

To develop a model of the lake using both the TWDB and Tobin data, a new boundary was digitized from the maps used to create the survey lines file in the Pre-survey Procedures. Contour elevation 1080.0 was digitized upstream from the dam. The file was then converted from NAD ‘27 to NAD ‘83. The NAD ‘83 file was then converted to the Medina datum by adding 7.8 feet to the contour elevation or elevation 1087.8. This file was then down-sized to elevation 1080 based on the location of any of the Tobin data that was at elevation 1080 or less. The Board does not represent any of the contour lines developed in this report to be actual land versus water boundaries. Instead, it is a graphical approximation of the actual boundary used solely to compute the volume and area of the lake.

The edited MASS points and modified boundary file were used to create a Digital Terrain Model (DTM) of the reservoir's bottom surface using Arc/Info's TIN module. The module builds an irregular triangulated network from the data points and the boundary file. This software uses 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 preserved for use in determining the solution of the model by using this method. The generated network of three-dimensional triangular planes represents the actual bottom surface. Once the triangulated irregular network (TIN) is formed, the software then calculates elevations along the triangle surface plane by solving the equations for elevation along each leg of the triangle. Information for the entire reservoir area can be determined from the triangulated irregular network created using this method of interpolation.

There were some areas where values could not be calculated by interpolation because of a lack of information along the boundary of the reservoir. "Flat triangles" were drawn at these locations. Arc/Info does not use flat triangle areas in the volume or contouring features of the model. These areas were determined to insignificant on Medina Lake. Therefore no additional points were required for interpolation and contouring of the entire lake surface. The TIN product then calculated the surface area and volume of the entire reservoir at one-tenth of a foot intervals from the three-dimensional triangular plane surface representation. The computed reservoir volume table is

presented in Appendix B and the area table in Appendix C. An elevation-area-volume graph is presented in Appendix D.

Other presentations developed from the model include a shaded relief map and a shaded depth range map. To develop the shaded relief map, the three-dimensional triangular surface was modified by a GRIDSHADE command. Colors were assigned to different elevation values of the grid. Using the command COLORRAMP, a set of colors that varied from navy to yellow was created. The lower elevation was assigned the color of navy, and the lake upper pool elevation was assigned the color of yellow. Different color shades were assigned to the different depths in between. Figure 4 presents the resulting depth shaded representation of the lake. Figure 5 presents a similar version of the same map, using bands of color for selected depth intervals. The color increases in intensity from the shallow contour bands to the deep water bands.

The DTM was then smoothed and linear smoothing algorithms were applied to the smoothed model to produce smoother contours. The resulting contour map of the bottom surface at ten-foot intervals is presented in Figure 6.

MEDINA LAKE SURVEY RESULTS

Medina Lake is located on the Medina River in Bandera and Medina Counties. The major tributaries that flow into the main body of the lake are Mescal and Elm Creeks. This pristine lake with it's clear waters lies west of San Antonio in the limestone outcrop of the Texas Hill Country. Over one dozen coves and hollows with steep canyon walls are located along the shoreline from the dam upstream to Turks Head on the west bank and Goat Hill on the east bank. The elevation relief becomes more gentle in the upper reaches of the lake's head waters. While collecting data the field crew rarely encountered any navigational hazards such as stumps. The crew did locate a few sand bars in the flats and upper reaches. Lake grasses were also encountered in the shallow areas at the upper end of the lake.

Results from the 1995 survey indicate Medina Lake now encompasses around 6,066 surface

acres and contains a volume of 254,843 acre-feet at the conservation pool elevation of 1072.0 feet. The volume at elevation 1080.0 was 305,784 acre-feet and the surface area was 6,742 acres. The shoreline at conservation pool was calculated to be 71.09 miles. The shoreline for elevation 1080.0 was calculated to be 87.76 miles. The lowest elevation encountered was around elevation 933.2 feet, or 138.8 feet of depth when the lake is at the top of the conservation pool. This point was found 1,800 feet north of the dam.

The storage volume calculated by the 1995 survey is approximately 2.5 percent less than the previous record information for the lake. The lowest gated outlet invert elevation is at elevation 920.0 feet. There is no dead storage volume at this elevation so the conservation storage capacity for the lake is 254,843 acre-feet.

DIVERSION LAKE SURVEY RESULTS

The field survey on the Diversion Lake was performed on July 12, 1995. The method used to performed the field survey was a modified range line survey. Cross-sections were located and an electronic distance measuring device was used to determined the lengths of the cross-sections. A 14 foot boat with a recording fathometer was then driven at a constant speed across the lake to create a bottom profile. The survey of Diversion Lake consisted of a total of 13 cross-sectional lines. After the survey, the data was processed and coverages were created in ArcInfo. A TIN model similar to the model created for Medina Lake was created. Additional data points were interpolated in between the cross-sections for contouring purposes. An area-elevation-capacity table was created from the resultant model. Figure 7 shows the cross-section locations and the contour lines that were created. The volume of the Diversion Lake was calculated from this survey to be 2,555 acre-feet at elevation 926.5 and the surface area was 169 acres.

SUMMARY

Medina Lake and Dam were completed in 1913 and deliberate impoundment of water began on May 7, 1913. Initial storage calculations estimated the volume of the lake at the conservation pool elevation of 1072.0 to be 254,000 acre-feet with a surface area of 5,575 acres. There was no prior

information on the capacity of the Diversion Lake.

During the period July 18-20, 1995, a hydrographic survey of Medina Lake was performed by the Texas Water Development Board's Hydrographic Survey Program. The water elevation of the lake during this period ranged from 1056.37 - 1056.40 ft., or about 16 ft below the conservation pool elevation. Additional data from an aerial survey performed by Tobin Surveys, Inc. in 1984 and 1985 provided additional information from elevation 994.88 to 1080.0. The Tobin data was merged with the TWDB data at the request of BMA from which the TWDB developed a model of the entire depth range of the lake up to elevation 1080.0. Results from the survey indicate that the lake's capacity at the conservation pool elevation of 1072.0 feet was 254,843 acre-feet and the lake's capacity at elevation 1080.0 was 305,784 acre-feet. The previous storage capacity for Medina Lake, based on a survey made prior to 1912, was estimated at 254,000 acre-feet for elevation 1072.0 and 300,000 acre-feet at elevation 1080.0. The storage information generated by the TWDB and Tobin Surveys, Inc. shows no loss of storage during the last 84 years in Medina Lake.

In addition to the survey on Medina Lake, TWDB staff performed a modified range line survey of Diversion Lake on July 12, 1995. From this survey, the capacity of Diversion Lake at elevation 926.5 was determined to be 2,555 acre-feet.

It is difficult to compare the original design information and the information generated from the TWDB and Tobin Surveys, Inc. because little is know about the original survey procedures and data. However, the TWDB considers the 1995 survey to be a significant improvement over previous survey procedures and recommends that the same methodology be used in five to ten years or after major flood events to monitor changes to the lake's storage capacity. The second survey will remove any noticeable errors between the previous survey and the 1995 survey and will facilitate accurate calculations of sedimentation rates and storage losses presently occurring in Medina Lake.

CALCULATION OF DEPTH SOUNDER ACCURACY

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

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

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' (-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' (+0.2')

TEXAS WATER DEVELOPMENT BOARD

Apr 9 1996

RESERVOIR VOLUME TABLE

MEDINA LAKE JULY 1995 SURVEY

VOLUME IN ACRE-FEET

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
951					1	1	2	3	4	5
952	6	8	9	11	13	15	17	19	22	24
953	27	30	33	36	40	43	46	50	54	57
954	61	65	69	73	78	82	86	91	95	100
955	106	111	117	122	128	134	141	147	154	160
956	167	174	181	189	196	203	211	219	227	235
957	243	251	259	268	276	285	293	302	311	320
958	329	338	347	356	366	375	385	395	404	414
959	424	435	445	455	466	476	487	498	509	520
960	531	542	554	565	577	589	601	613	625	637
961	649	662	674	687	700	713	726	740	753	767
962	780	794	808	822	836	850	865	879	894	909
963	924	939	954	969	985	1000	1016	1032	1048	1064
964	1081	1097	1114	1130	1147	1164	1181	1199	1216	1234
965	1252	1269	1288	1306	1324	1343	1362	1381	1400	1419
966	1439	1459	1479	1499	1519	1539	1560	1581	1602	1623
967	1645	1666	1688	1711	1733	1756	1779	1802	1825	1849
968	1873	1898	1922	1947	1972	1997	2023	2048	2074	2101
969	2127	2154	2181	2209	2236	2264	2293	2321	2350	2379
970	2409	2438	2468	2499	2529	2560	2591	2623	2655	2687
971	2719	2751	2784	2817	2850	2884	2917	2951	2985	3020
972	3054	3089	3124	3160	3196	3232	3268	3304	3341	3378
973	3415	3453	3491	3529	3567	3606	3645	3684	3723	3763
974	3803	3843	3883	3924	3965	4006	4047	4089	4131	4173
975	4215	4258	4301	4344	4388	4432	4476	4521	4566	4611
976	4657	4703	4749	4796	4843	4891	4939	4987	5036	5085
977	5134	5184	5234	5285	5336	5388	5440	5493	5546	5600
978	5654	5708	5763	5818	5874	5929	5985	6042	6099	6156
979	6213	6270	6328	6386	6445	6503	6562	6621	6681	6741
980	6801	6861	6922	6983	7044	7105	7167	7229	7292	7354
981	7417	7481	7544	7608	7672	7736	7801	7866	7931	7996
982	8062	8128	8194	8260	8327	8394	8461	8529	8596	8664
983	8732	8801	8869	8938	9007	9077	9146	9216	9286	9356
984	9427	9498	9569	9640	9712	9783	9856	9928	10000	10073
985	10146	10220	10293	10367	10441	10516	10591	10666	10741	10816
986	10892	10968	11045	11121	11198	11276	11353	11431	11509	11587
987	11666	11744	11823	11902	11982	12061	12141	12221	12302	12382
988	12463	12544	12626	12707	12789	12871	12953	13036	13119	13202
989	13286	13369	13453	13537	13622	13707	13792	13877	13963	14049
990	14135	14222	14308	14396	14483	14571	14659	14747	14836	14925
991	15014	15103	15193	15284	15374	15465	15556	15648	15740	15832
992	15925	16018	16111	16205	16299	16393	16488	16583	16678	16773
993	16869	16965	17061	17158	17254	17352	17449	17547	17644	17743
994	17841	17940	18039	18138	18238	18337	18437	18538	18638	18739
995	18840	18941	19043	19145	19247	19349	19452	19555	19658	19762
996	19865	19969	20073	20178	20283	20388	20493	20599	20705	20811
997	20917	21024	21131	21238	21346	21454	21562	21670	21779	21888
998	21997	22106	22216	22326	22436	22547	22658	22769	22880	22992
999	23104	23216	23329	23442	23555	23668	23782	23896	24010	24124

MEDINA LAKE JULY 1995 SURVEY

VOLUME IN ACRE-FEET ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1,000	24239	24354	24470	24585	24701	24818	24934	25051	25168	25286
1,001	25404	25522	25640	25759	25878	25997	26117	26237	26357	26478
1,002	26599	26720	26842	26963	27086	27208	27331	27454	27577	27701
1,003	27825	27949	28074	28199	28324	28450	28576	28702	28828	28955
1,004	29083	29210	29338	29466	29594	29723	29852	29981	30111	30241
1,005	30372	30502	30633	30764	30896	31028	31160	31293	31426	31559
1,006	31693	31826	31961	32095	32230	32365	32500	32636	32772	32909
1,007	33045	33182	33320	33457	33596	33734	33872	34012	34151	34291
1,008	34431	34571	34712	34853	34994	35136	35278	35421	35564	35707
1,009	35851	35995	36140	36285	36430	36576	36722	36868	37015	37163
1,010	37311	37459	37608	37757	37907	38057	38207	38358	38510	38662
1,011	38814	38967	39120	39274	39428	39583	39738	39894	40049	40206
1,012	40363	40520	40678	40836	40995	41154	41314	41474	41635	41796
1,013	41957	42119	42282	42445	42608	42772	42936	43101	43266	43432
1,014	43598	43764	43931	44099	44267	44435	44604	44773	44943	45113
1,015	45284	45455	45627	45799	45972	46145	46319	46493	46668	46843
1,016	47018	47194	47371	47548	47726	47904	48082	48262	48441	48621
1,017	48802	48983	49164	49346	49529	49712	49895	50079	50264	50449
1,018	50634	50820	51007	51194	51381	51569	51758	51947	52137	52327
1,019	52517	52709	52901	53093	53286	53480	53674	53869	54065	54261
1,020	54458	54655	54854	55052	55252	55452	55652	55853	56055	56257
1,021	56460	56663	56866	57070	57275	57480	57686	57892	58099	58306
1,022	58514	58722	58931	59141	59351	59561	59772	59983	60195	60408
1,023	60620	60834	61048	61263	61478	61693	61909	62126	62343	62561
1,024	62779	62997	63216	63436	63656	63877	64098	64319	64542	64764
1,025	64987	65211	65435	65660	65886	66111	66338	66565	66792	67020
1,026	67249	67478	67707	67938	68168	68400	68632	68864	69097	69331
1,027	69566	69801	70037	70274	70511	70749	70988	71227	71468	71708
1,028	71950	72192	72435	72679	72924	73169	73414	73661	73908	74156
1,029	74405	74654	74904	75155	75406	75658	75911	76165	76419	76674
1,030	76929	77185	77442	77699	77957	78216	78475	78734	78995	79256
1,031	79517	79779	80042	80305	80569	80833	81098	81364	81630	81896
1,032	82164	82431	82699	82968	83238	83508	83778	84049	84321	84593
1,033	84866	85139	85412	85687	85961	86237	86512	86789	87066	87343
1,034	87621	87899	88178	88458	88737	89018	89299	89580	89862	90145
1,035	90428	90712	90996	91281	91566	91852	92138	92424	92712	93000
1,036	93288	93577	93866	94157	94447	94738	95030	95322	95615	95908
1,037	96202	96496	96791	97087	97384	97680	97978	98276	98575	98874
1,038	99174	99474	99775	100077	100379	100682	100985	101289	101594	101900
1,039	102205	102512	102819	103127	103436	103745	104055	104365	104677	104988
1,040	105301	105614	105928	106243	106558	106875	107191	107509	107828	108146
1,041	108466	108787	109108	109430	109753	110077	110401	110726	111053	111379
1,042	111707	112035	112365	112695	113026	113358	113690	114024	114359	114694
1,043	115030	115366	115704	116043	116382	116722	117063	117405	117748	118092
1,044	118436	118782	119128	119475	119823	120172	120522	120873	121225	121578
1,045	121931	122286	122641	122998	123355	123713	124072	124432	124794	125156
1,046	125519	125883	126249	126616	126983	127352	127722	128093	128465	128839
1,047	129213	129589	129966	130344	130723	131103	131485	131868	132252	132637
1,048	133024	133411	133801	134192	134585	134985	135386	135789	136194	136600
1,049	137007	137415	137824	138235	138646	139059	139472	139887	140304	140721

MEDINA LAKE JULY 1995 SURVEY

VOLUME IN ACRE-FEET ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1,050	141139	141558	141978	142399	142822	143245	143669	144095	144522	144949
1,051	145378	145807	146238	146670	147103	147537	147972	148408	148846	149284
1,052	149723	150163	150604	151048	151491	151936	152382	152829	153277	153726
1,053	154176	154628	155080	155534	155988	156443	156898	157355	157813	158271
1,054	158730	159192	159655	160119	160583	161048	161514	161981	162449	162918
1,055	163388	163859	164331	164804	165277	165751	166226	166701	167178	167655
1,056	168132	168611	169089	169570	170050	170531	171013	171495	171979	172463
1,057	172947	173433	173919	174407	174895	175384	175873	176363	176854	177346
1,058	177838	178331	178824	179319	179814	180310	180806	181304	181802	182301
1,059	182800	183301	183801	184304	184806	185309	185813	186318	186824	187330
1,060	187837	188347	188857	189369	189881	190394	190908	191423	191939	192455
1,061	192972	193490	194008	194529	195049	195570	196092	196615	197139	197663
1,062	198188	198714	199241	199769	200297	200827	201357	201888	202420	202952
1,063	203485	204019	204554	205090	205626	206162	206700	207238	207777	208317
1,064	208857	209398	209940	210484	211027	211572	212117	212662	213209	213756
1,065	214304	214853	215403	215955	216507	217060	217614	218168	218724	219281
1,066	219839	220397	220956	221517	222078	222640	223202	223765	224330	224895
1,067	225460	226026	226594	227162	227731	228301	228872	229444	230017	230592
1,068	231166	231742	232319	232897	233475	234054	234634	235214	235797	236379
1,069	236961	237545	238129	238715	239301	239888	240476	241065	241655	242245
1,070	242837	243429	244022	244616	245211	245806	246402	246999	247597	248195
1,071	248794	249393	249994	250595	251197	251800	252403	253006	253612	254217
1,072	254823	255430	256038	256647	257256	257865	258476	259087	259700	260312
1,073	260926	261540	262155	262771	263388	264005	264623	265242	265862	266482
1,074	267104	267725	268348	268972	269597	270222	270848	271474	272102	272730
1,075	273359	273989	274620	275252	275884	276517	277150	277784	278420	279056
1,076	279693	280330	280969	281608	282248	282888	283529	284171	284815	285458
1,077	286102	286747	287393	288040	288687	289335	289983	290633	291284	291935
1,078	292586	293239	293892	294547	295201	295857	296513	297170	297828	298486
1,079	299146	299806	300466	301129	301791	302454	303118	303783	304449	305116
1,080	305784	306459	307135	307814	308493	309173	309854	310535	311219	311902
1,081	312586	313271	313957	314645	315333	316022	316711	317401	318093	318785
1,082	319478	320172	320866	321562	322258	322955	323653	324351	325051	325752
1,083	326452	327154	327857	328561	329265	329970	330676	331383	332091	332799
1,084	333508									

TEXAS WATER DEVELOPMENT BOARD

Apr 9 1996

RESERVOIR AREA TABLE

MEDINA LAKE JULY 1995 SURVEY

AREA IN ACRES

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
951			1	3	5	6	8	10	11	12
952	13	14	16	17	19	21	23	24	26	27
953	28	30	31	32	33	34	35	36	37	38
954	39	40	41	42	43	43	44	46	48	51
955	53	55	57	58	60	62	63	65	66	68
956	69	71	72	73	74	76	77	78	79	80
957	81	82	83	84	85	86	87	88	89	90
958	90	91	93	94	95	96	97	98	99	100
959	101	102	103	104	105	106	107	109	110	111
960	113	114	115	116	117	118	119	120	122	123
961	124	126	127	128	130	131	132	134	135	136
962	137	139	140	141	142	144	145	146	147	148
963	150	151	152	154	155	157	158	160	161	163
964	164	165	167	168	170	171	172	174	175	177
965	179	181	182	184	186	187	189	191	193	194
966	196	198	200	202	203	205	207	209	211	214
967	216	219	221	224	226	229	231	234	236	239
968	242	244	246	249	251	254	257	259	262	264
969	267	270	273	275	278	281	284	287	290	293
970	296	299	302	305	308	310	313	316	318	321
971	323	326	328	331	333	335	338	340	343	346
972	348	351	353	356	358	361	364	366	369	372
973	374	377	379	382	385	387	390	392	395	398
974	400	403	405	408	410	413	415	418	420	423
975	426	428	431	435	438	441	444	448	451	455
976	459	463	466	470	474	477	481	485	489	493
977	497	501	505	509	514	519	525	530	535	539
978	542	546	549	553	556	559	562	565	568	571
979	574	577	580	582	585	588	590	593	596	599
980	602	605	608	611	614	617	620	623	625	628
981	631	634	637	639	642	645	647	650	653	655
982	658	660	663	665	668	670	673	675	678	680
983	683	685	687	690	692	695	697	700	702	704
984	707	709	712	714	717	719	722	725	727	730
985	732	735	738	740	743	745	748	751	754	757
986	760	763	766	769	771	774	776	779	781	783
987	786	788	790	793	795	798	800	802	805	807
988	810	812	815	817	820	822	825	828	830	833
989	836	838	841	844	847	849	852	855	858	861
990	864	867	870	873	876	879	882	885	888	891
991	894	897	901	904	908	911	915	918	922	925
992	928	932	935	938	941	944	947	950	953	956
993	959	961	964	967	970	972	975	978	980	983
994	986	988	991	994	996	999	1002	1004	1007	1010
995	1012	1015	1017	1020	1023	1025	1028	1030	1033	1036
996	1038	1041	1043	1046	1049	1052	1055	1058	1061	1063
997	1066	1069	1072	1074	1077	1080	1082	1085	1088	1091
998	1093	1096	1099	1102	1104	1107	1110	1113	1115	1118
999	1121	1124	1127	1129	1132	1135	1138	1141	1144	1147

MEDINA LAKE JULY 1995 SURVEY

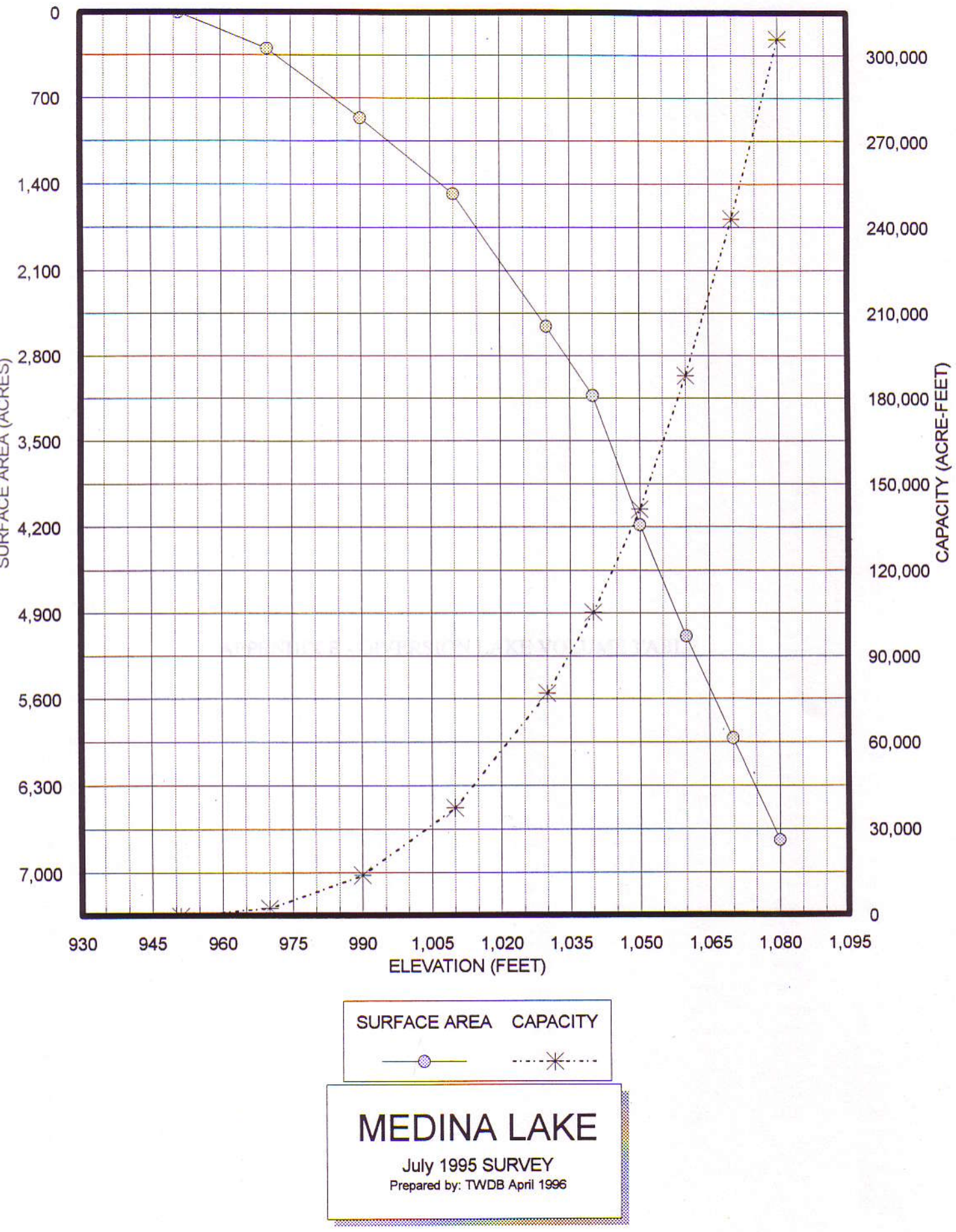
AREA IN ACRES — ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1,000	1150	1153	1155	1158	1161	1164	1167	1170	1173	1177
1,001	1180	1183	1186	1189	1192	1195	1198	1201	1205	1208
1,002	1211	1214	1217	1220	1223	1226	1229	1232	1236	1239
1,003	1242	1245	1248	1251	1254	1258	1261	1264	1267	1270
1,004	1273	1276	1279	1283	1286	1289	1292	1295	1299	1302
1,005	1305	1308	1312	1315	1318	1321	1324	1327	1331	1334
1,006	1337	1340	1343	1346	1350	1353	1356	1359	1362	1366
1,007	1369	1372	1375	1378	1382	1385	1388	1392	1395	1399
1,008	1402	1406	1409	1413	1417	1420	1424	1428	1431	1435
1,009	1439	1443	1447	1451	1455	1459	1464	1468	1472	1477
1,010	1481	1485	1490	1494	1499	1504	1508	1513	1517	1521
1,011	1526	1530	1535	1540	1544	1549	1553	1558	1562	1567
1,012	1571	1576	1580	1585	1590	1594	1599	1604	1608	1613
1,013	1618	1622	1627	1631	1636	1641	1645	1650	1654	1659
1,014	1663	1668	1672	1677	1682	1686	1691	1696	1700	1705
1,015	1710	1715	1719	1724	1729	1734	1739	1744	1749	1754
1,016	1759	1764	1769	1774	1778	1783	1788	1793	1798	1803
1,017	1808	1813	1818	1822	1827	1832	1837	1842	1847	1852
1,018	1857	1862	1868	1873	1878	1883	1888	1894	1899	1905
1,019	1910	1916	1922	1928	1934	1940	1946	1953	1959	1965
1,020	1972	1979	1985	1991	1997	2002	2008	2013	2018	2024
1,021	2029	2034	2039	2044	2049	2054	2060	2065	2070	2076
1,022	2081	2086	2091	2096	2101	2106	2111	2117	2122	2127
1,023	2132	2138	2143	2148	2153	2158	2163	2168	2173	2178
1,024	2183	2188	2193	2198	2203	2209	2214	2219	2224	2230
1,025	2235	2240	2246	2251	2256	2261	2266	2272	2277	2283
1,026	2288	2294	2299	2305	2311	2316	2322	2329	2335	2342
1,027	2349	2356	2363	2370	2377	2385	2392	2399	2405	2412
1,028	2419	2427	2434	2441	2448	2455	2462	2469	2476	2483
1,029	2490	2497	2504	2510	2517	2524	2531	2538	2545	2551
1,030	2558	2564	2570	2576	2582	2588	2594	2600	2606	2612
1,031	2618	2624	2629	2635	2641	2646	2652	2658	2663	2669
1,032	2674	2680	2685	2691	2696	2702	2708	2713	2719	2724
1,033	2729	2734	2740	2745	2750	2755	2760	2766	2771	2776
1,034	2781	2786	2791	2797	2802	2807	2812	2818	2823	2829
1,035	2834	2839	2845	2850	2855	2860	2865	2871	2876	2881
1,036	2887	2892	2897	2903	2908	2914	2919	2925	2930	2936
1,037	2942	2948	2954	2960	2966	2972	2977	2983	2989	2995
1,038	3001	3007	3014	3020	3026	3032	3038	3044	3050	3056
1,039	3063	3069	3075	3082	3088	3095	3102	3109	3116	3123
1,040	3129	3137	3144	3151	3158	3165	3172	3180	3187	3194
1,041	3201	3209	3217	3225	3233	3241	3249	3257	3265	3273
1,042	3281	3289	3298	3306	3314	3323	3331	3339	3348	3356
1,043	3364	3373	3381	3390	3398	3407	3415	3423	3432	3441
1,044	3450	3459	3468	3477	3486	3495	3504	3513	3522	3531
1,045	3540	3550	3559	3568	3578	3588	3597	3607	3617	3627
1,046	3638	3649	3660	3671	3682	3693	3705	3717	3728	3740
1,047	3752	3763	3775	3786	3798	3810	3822	3834	3846	3859
1,048	3872	3886	3902	3917	3994	4008	4021	4042	4053	4065
1,049	4076	4087	4099	4109	4121	4132	4144	4155	4165	4176

MEDINA LAKE JULY 1995 SURVEY

AREA IN ACRES — ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1,050	4186	4197	4208	4218	4229	4239	4250	4260	4271	4281
1,051	4292	4303	4313	4324	4334	4345	4355	4366	4377	4388
1,052	4399	4409	4420	4432	4443	4454	4465	4476	4486	4497
1,053	4508	4520	4528	4537	4545	4554	4562	4570	4579	4587
1,054	4617	4626	4633	4641	4648	4657	4665	4674	4681	4689
1,055	4706	4715	4723	4732	4738	4745	4752	4759	4766	4773
1,056	4780	4787	4794	4801	4808	4815	4821	4828	4835	4847
1,057	4854	4861	4868	4876	4883	4890	4897	4905	4912	4919
1,058	4926	4933	4941	4948	4955	4962	4970	4977	4985	4992
1,059	5000	5007	5014	5022	5029	5037	5044	5052	5060	5067
1,060	5089	5099	5110	5119	5128	5136	5144	5152	5159	5167
1,061	5176	5184	5192	5200	5209	5217	5224	5232	5240	5248
1,062	5257	5265	5273	5281	5290	5298	5306	5315	5322	5329
1,063	5336	5343	5350	5357	5364	5371	5379	5386	5394	5401
1,064	5410	5418	5426	5433	5440	5447	5454	5461	5468	5476
1,065	5484	5492	5512	5519	5527	5535	5543	5551	5564	5574
1,066	5582	5590	5598	5605	5614	5621	5629	5637	5645	5653
1,067	5661	5669	5677	5685	5693	5709	5717	5725	5738	5745
1,068	5757	5764	5772	5779	5787	5795	5802	5811	5818	5826
1,069	5834	5842	5849	5858	5866	5874	5885	5893	5901	5909
1,070	5921	5928	5935	5943	5950	5957	5964	5971	5979	5987
1,071	5994	6001	6008	6015	6022	6029	6036	6044	6051	6059
1,072	6066	6073	6081	6088	6095	6103	6110	6117	6125	6132
1,073	6139	6147	6154	6162	6169	6177	6186	6194	6201	6209
1,074	6217	6225	6232	6240	6248	6256	6263	6271	6279	6287
1,075	6295	6303	6310	6318	6326	6334	6341	6349	6357	6364
1,076	6372	6379	6387	6395	6402	6409	6417	6424	6432	6439
1,077	6447	6454	6461	6469	6476	6484	6491	6499	6506	6514
1,078	6522	6529	6537	6544	6552	6559	6567	6575	6582	6590
1,079	6598	6605	6613	6621	6629	6637	6645	6654	6662	6671
1,080	6742	6762	6777	6787	6796	6805	6813	6822	6831	6840
1,081	6848	6857	6866	6875	6884	6892	6900	6909	6917	6925
1,082	6934	6942	6950	6958	6966	6975	6983	6991	6999	7007
1,083	7015	7023	7031	7039	7048	7056	7064	7073	7081	7089
1,084	7098									


0
700
1,400
2,100
2,800
3,500
4,200
4,900
5,600
6,300
7,000
SURFACE AREA (ACRES)
300,000
270,000
240,000
210,000
180,000
150,000
120,000
90,000
60,000
30,000
0
CAPACITY (ACRE-FEET)
930
945
960
975
990
1,005
1,020
1,035
1,050
1,065
1,080
1,095
ELEVATION (FEET)
SURFACE AREA
CAPACITY
MEDINA LAKE
July 1995 SURVEY
Prepared by: TWDB April 1996

TEXAS WATER DEVELOPMENT BOARD Oct 25 1995

RESERVOIR VOLUME TABLE

DIVERSION LAKE JULY 1995 SURVEY

VOLUME IN ACRE-FEET ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
880										
881										
882						1	1	1	1	1
883	1	1	1	1	1	1	1	1	1	1
884	1	1	2	2	2	2	2	2	2	2
885	2	3	3	3	3	3	3	4	4	4
886	4	4	5	5	5	5	5	6	6	6
887	6	7	7	7	7	8	8	8	9	9
888	9	10	10	10	11	11	11	12	12	13
889	13	14	14	15	15	16	16	17	17	18
890	18	19	20	21	22	23	24	25	26	27
891	28	29	30	31	32	33	34	35	36	37
892	38	39	40	41	43	44	45	46	47	48
893	50	51	52	53	55	56	57	58	60	61
894	62	64	65	66	68	69	71	72	73	75
895	76	78	79	81	83	84	86	88	90	91
896	93	95	97	99	101	103	105	107	109	111
897	113	115	117	119	121	124	126	128	130	133
898	135	137	140	142	144	147	149	152	154	157
899	159	162	164	167	170	172	175	178	180	183
900	186	189	192	195	198	201	204	208	211	214
901	217	221	224	228	231	234	238	241	245	248
902	252	256	259	263	267	270	274	278	282	286
903	289	293	297	301	305	309	313	317	322	326
904	330	334	338	342	347	351	355	360	364	369
905	373	378	383	387	392	397	402	407	412	417
906	422	427	433	438	443	448	454	459	465	470
907	476	481	487	493	498	504	510	516	522	528
908	533	539	546	552	558	564	570	576	583	589
909	595	602	608	615	621	628	635	641	648	655
910	661	668	675	683	690	697	704	712	719	726
911	734	741	749	757	764	772	780	788	796	804
912	812	820	828	836	844	853	861	870	878	887
913	895	904	912	921	930	939	948	957	966	975
914	984	993	1002	1011	1021	1030	1040	1049	1059	1068
915	1078	1088	1097	1107	1117	1127	1137	1147	1157	1167
916	1177	1188	1198	1208	1219	1229	1239	1250	1261	1271
917	1282	1293	1303	1314	1325	1336	1347	1358	1369	1380
918	1392	1403	1414	1426	1437	1448	1460	1471	1483	1495
919	1506	1518	1530	1542	1554	1566	1578	1590	1602	1614
920	1626	1639	1651	1664	1676	1689	1702	1715	1727	1740
921	1753	1766	1779	1792	1805	1818	1832	1845	1858	1872
922	1885	1899	1912	1926	1939	1953	1967	1981	1995	2009
923	2023	2037	2051	2065	2079	2093	2108	2122	2136	2151
924	2166	2180	2195	2210	2224	2239	2254	2269	2284	2299
925	2314	2330	2345	2361	2376	2392	2408	2424	2440	2456
926	2472	2489	2505	2522	2538	2555				

TEXAS WATER DEVELOPMENT BOARD

Oct 25 1995

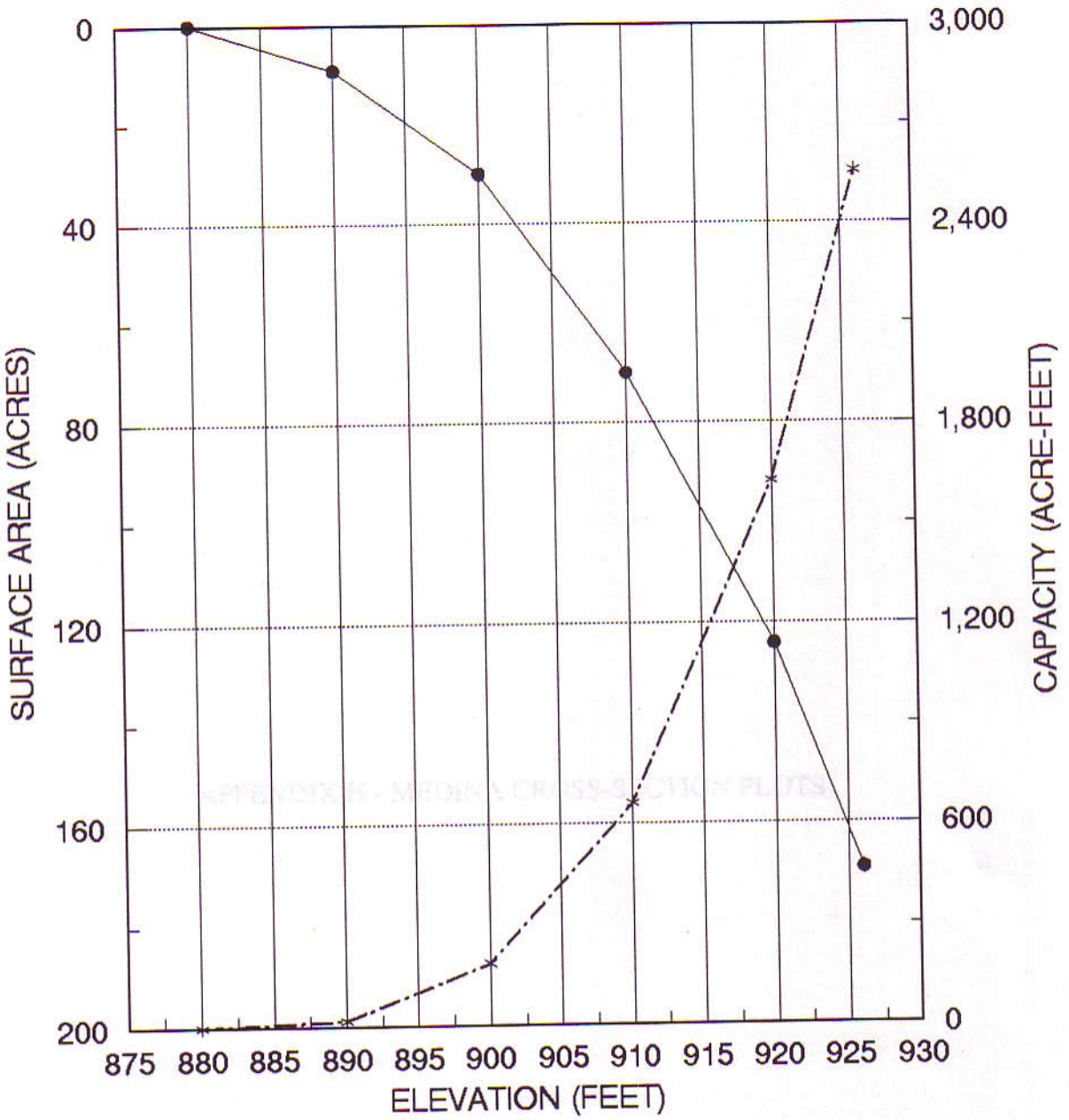
RESERVOIR AREA TABLE

DIVERSION LAKE JULY 1995 SURVEY

AREA IN ACRES

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
880										
881										
882										
883		1	1	1	1	1	1	1	1	1
884	1	1	1	1	1	1	1	1	1	1
885	1	1	2	2	2	2	2	2	2	2
886	2	2	2	2	2	2	2	2	2	2
887	2	3	3	3	3	3	3	3	3	3
888	3	4	4	4	4	4	4	4	4	4
889	5	5	5	5	5	5	5	5	6	6
890	9	9	9	9	9	9	9	10	10	10
891	10	10	10	10	10	10	11	11	11	11
892	11	11	11	11	11	12	12	12	12	12
893	12	12	12	12	13	13	13	13	13	13
894	13	13	14	14	14	14	14	14	14	14
895	16	16	16	17	17	17	17	18	18	18
896	18	19	19	19	19	20	20	20	20	21
897	21	21	21	22	22	22	22	22	23	23
898	23	23	24	24	24	24	25	25	25	25
899	26	26	26	26	26	27	27	27	27	28
900	30	30	31	31	31	32	32	32	32	33
901	33	33	34	34	34	35	35	35	35	36
902	36	36	37	37	37	37	38	38	38	39
903	39	39	39	40	40	40	41	41	41	42
904	42	42	42	43	43	43	44	44	44	45
905	47	47	48	48	49	49	50	50	50	51
906	51	52	52	53	53	53	54	54	55	55
907	56	56	56	57	57	58	58	59	59	59
908	60	60	61	61	61	62	62	63	63	64
909	64	64	65	65	66	66	66	67	67	68
910	70	70	71	71	72	72	73	74	74	75
911	75	76	76	77	77	78	78	79	80	80
912	81	81	82	82	83	83	84	84	85	85
913	86	87	87	88	88	89	89	90	90	91
914	91	92	92	93	94	94	95	95	96	96
915	97	97	98	98	99	99	100	101	101	102
916	102	103	103	104	104	105	105	106	106	107
917	107	108	108	109	109	110	110	111	111	112
918	112	113	113	114	114	115	115	116	116	117
919	117	118	118	119	119	120	121	121	122	122
920	124	124	125	126	126	127	127	128	128	129
921	129	130	130	131	131	132	133	133	134	134
922	135	135	136	136	137	137	138	139	139	140
923	140	141	141	142	142	143	144	144	145	145
924	146	146	147	148	148	149	149	150	150	151
925	154	155	156	156	157	158	159	160	161	162
926	163	164	165	166	167	169				

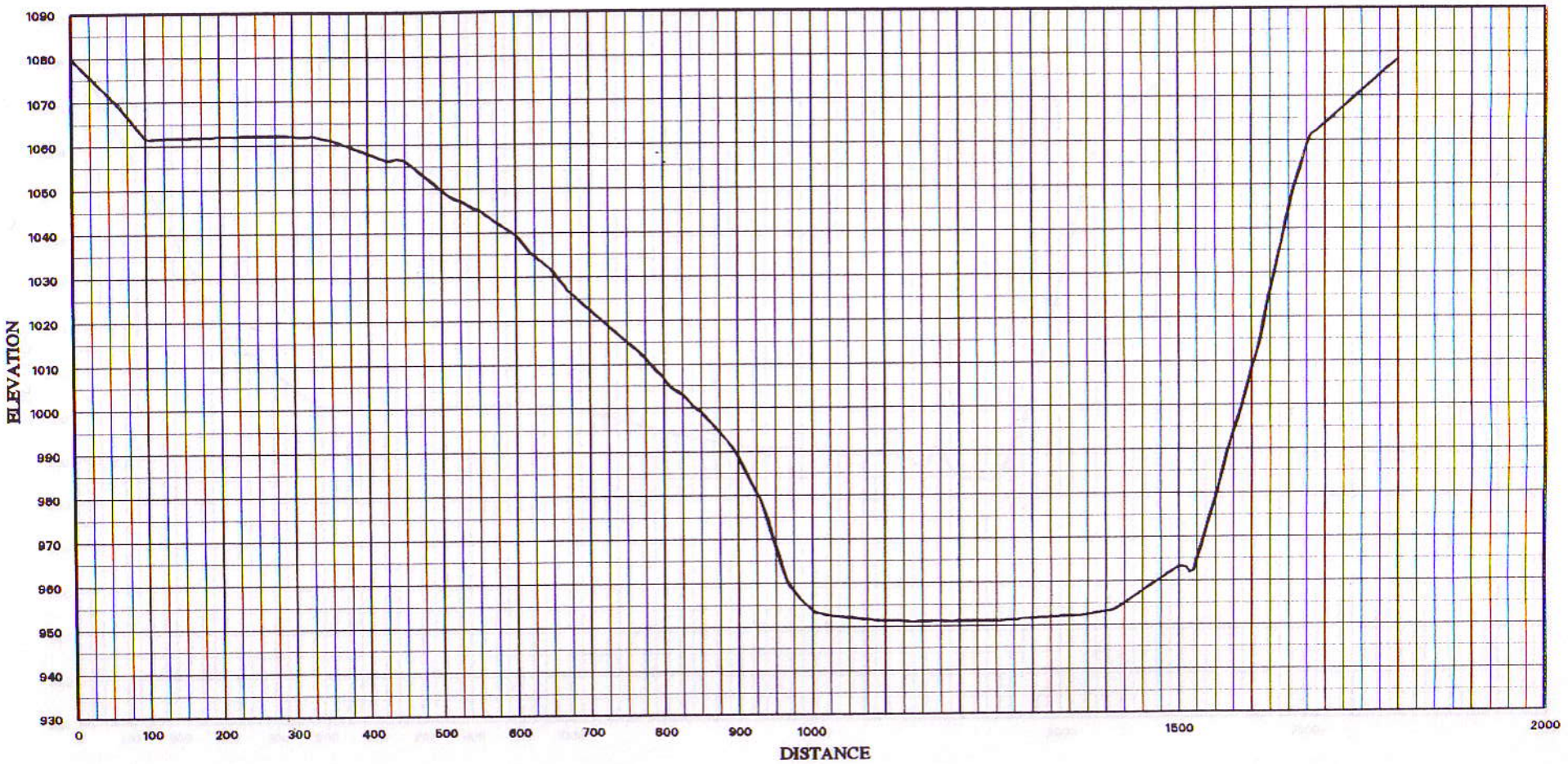


DIVERSION LAKE

July 1995 Survey

Prepared by: TWDB August 1996

A-A′

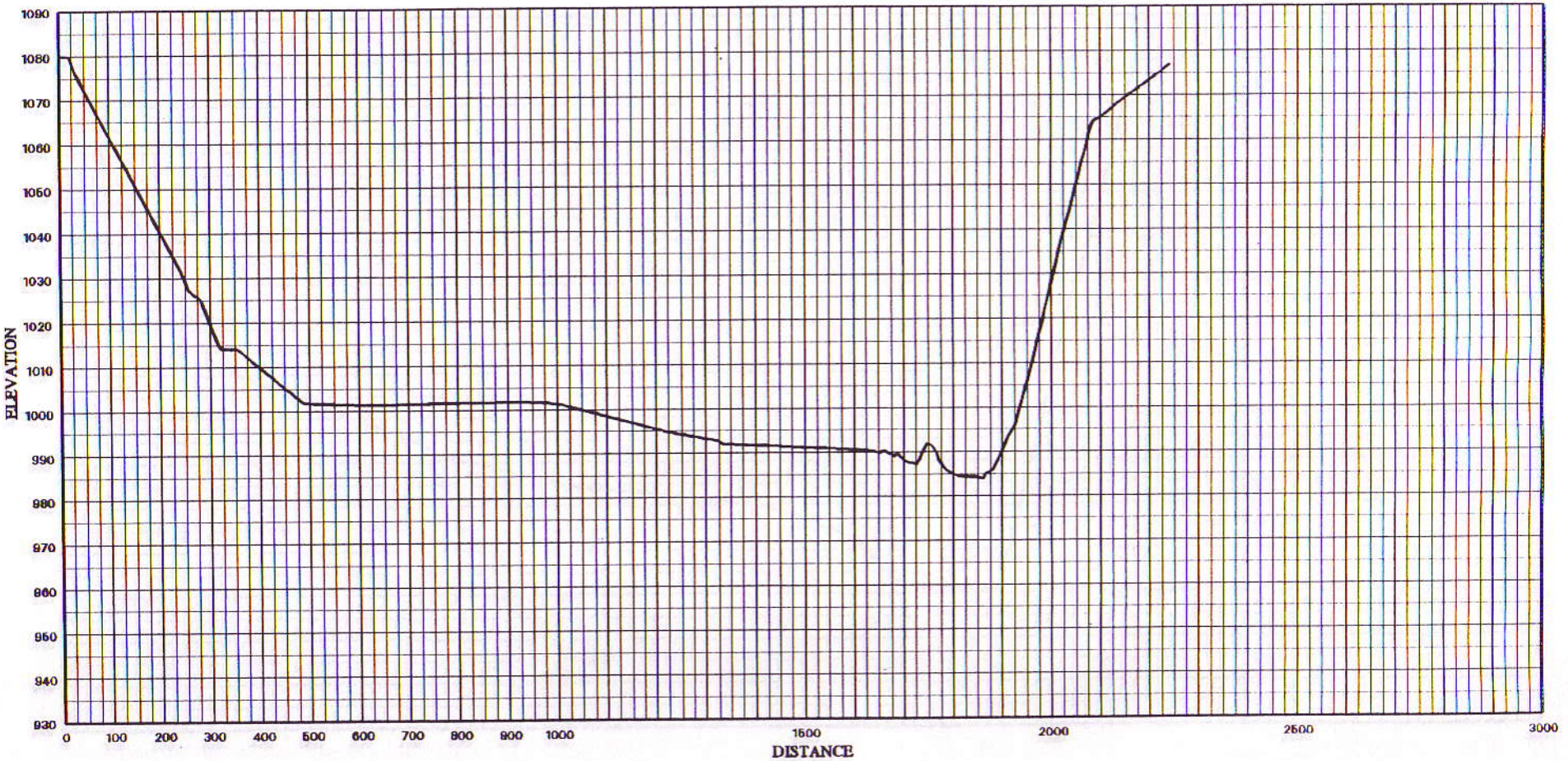


Range Line Generated Using ARC/INFO's TIN Module

1 Grid Cell = 100 Ft. with 25 Ft. Intervals (Horizontal)

1 Grid Cell = 10 Ft. with 5 Ft. Intervals (Vertical)

B-B′

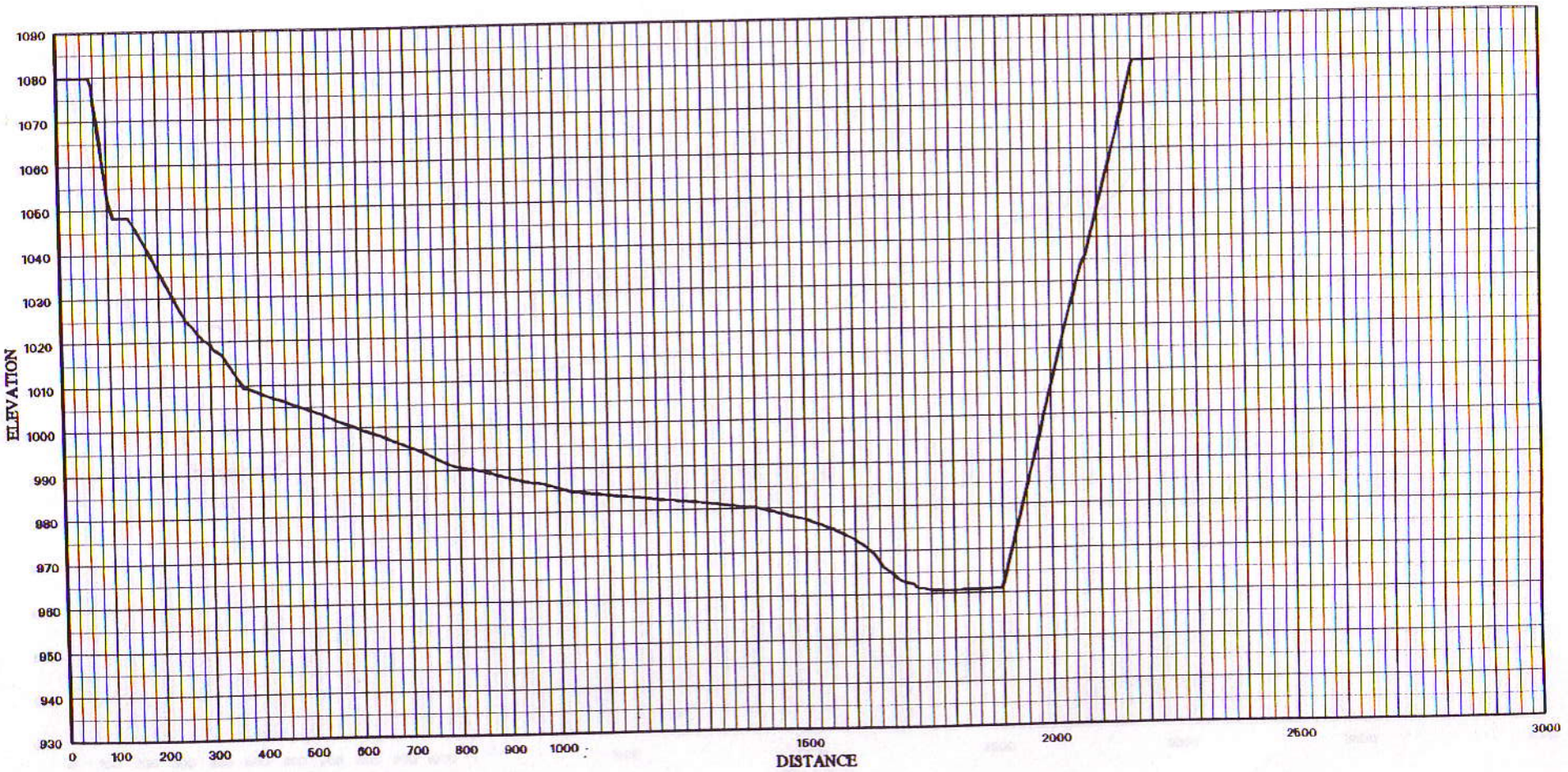


Range Line Generated Using ARC/INFO's TIN Module

1 Grid Cell = 100 Ft. with 25 Ft. Intervals (Horizontal)

1 Grid Cell = 10 Ft. with 5 Ft. Intervals (Vertical)

C-C′

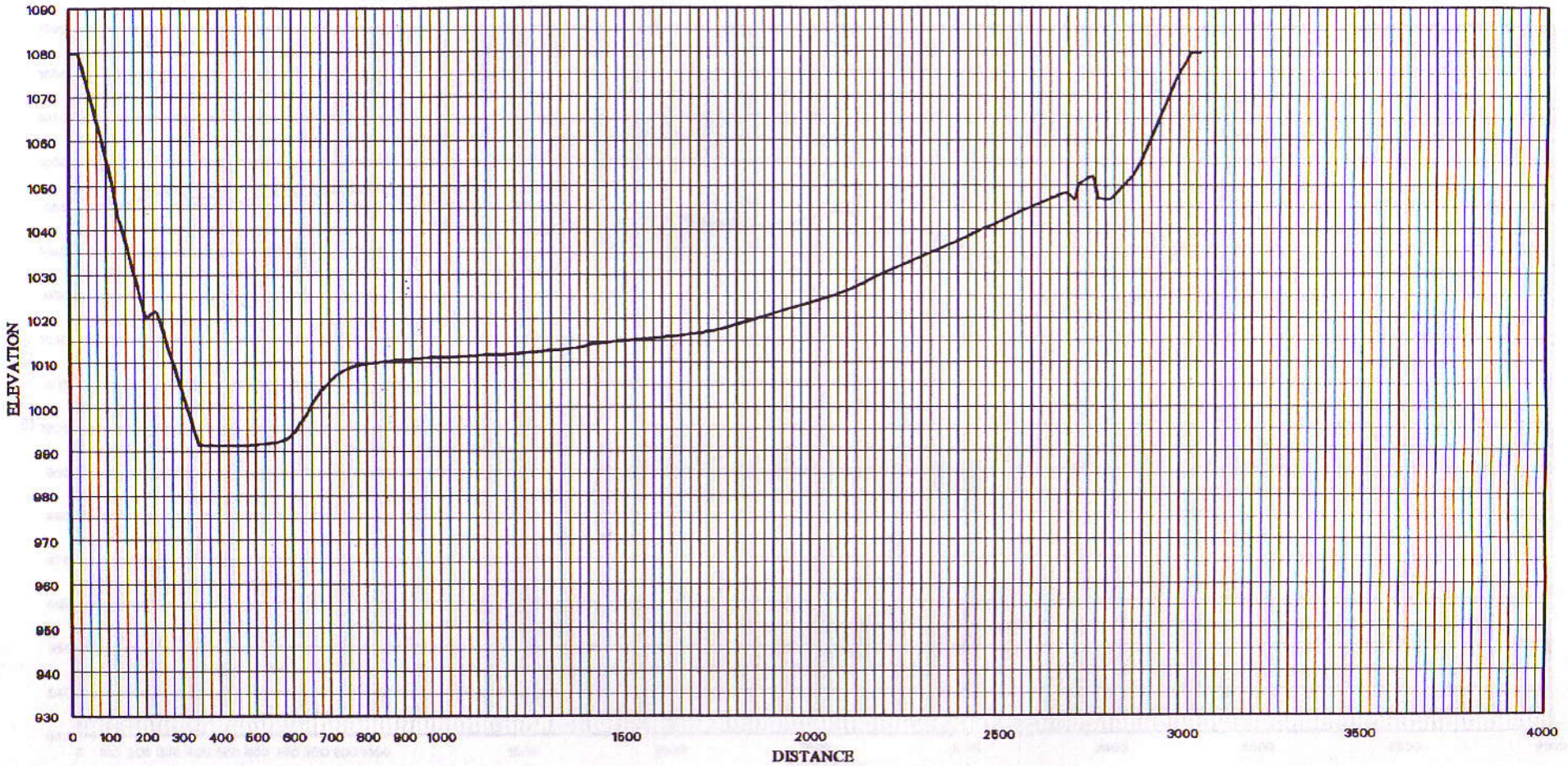


——— Range Line Generated Using ARC/INFO's TIN Module

1 Grid Cell = 100 Ft. with 25 Ft. Intervals (Horizontal)

1 Grid Cell = 10 Ft. with 5 Ft. Intervals (Vertical)

D-D′

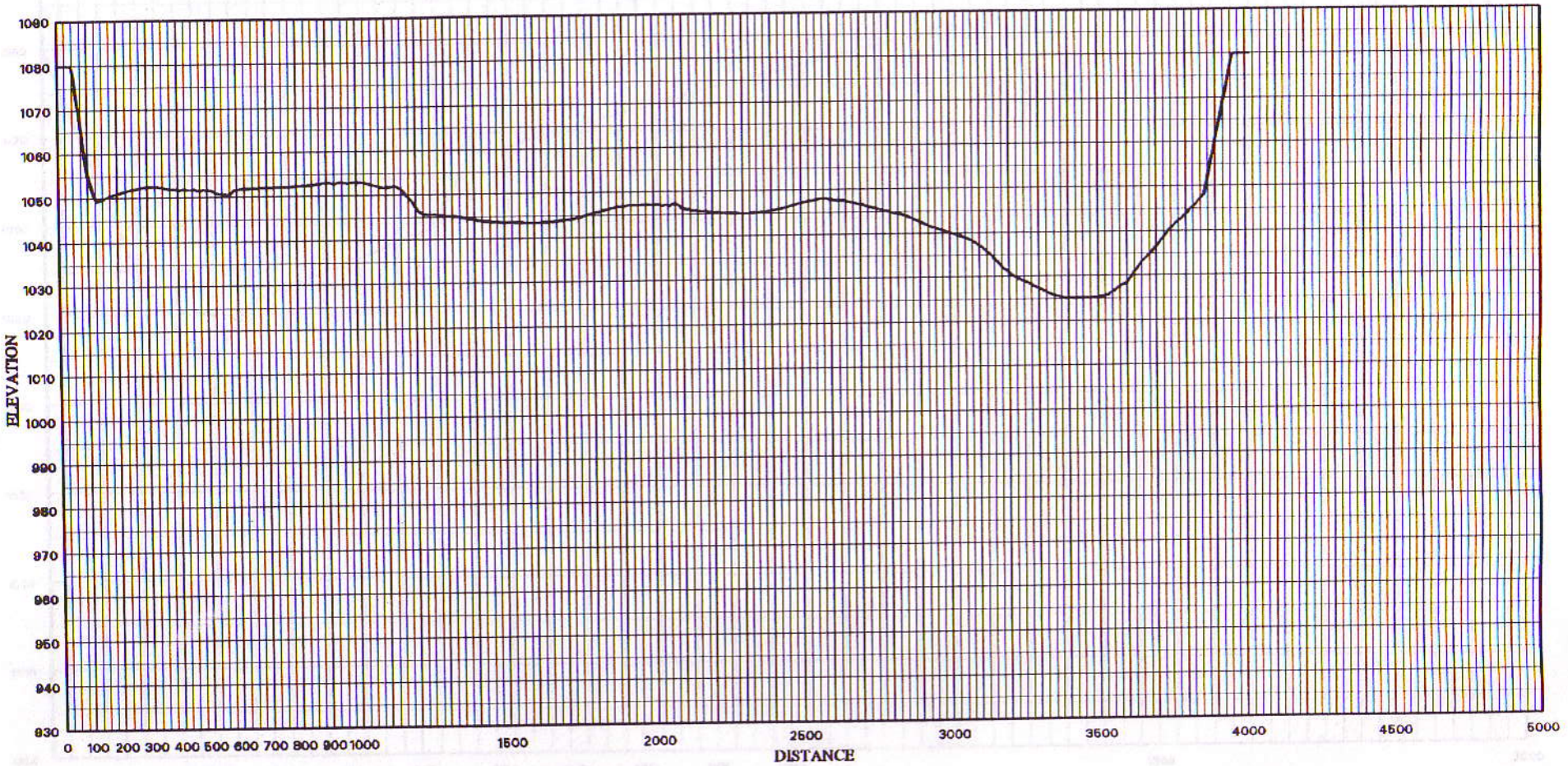


—— Range Line Generated Using ARC/INFO's TIN Module

1 Grid Cell = 100 Ft. with 25 Ft. Intervals (Horizontal)

1 Grid Cell = 10 Ft. with 5 Ft. Intervals (Vertical)

E-E'

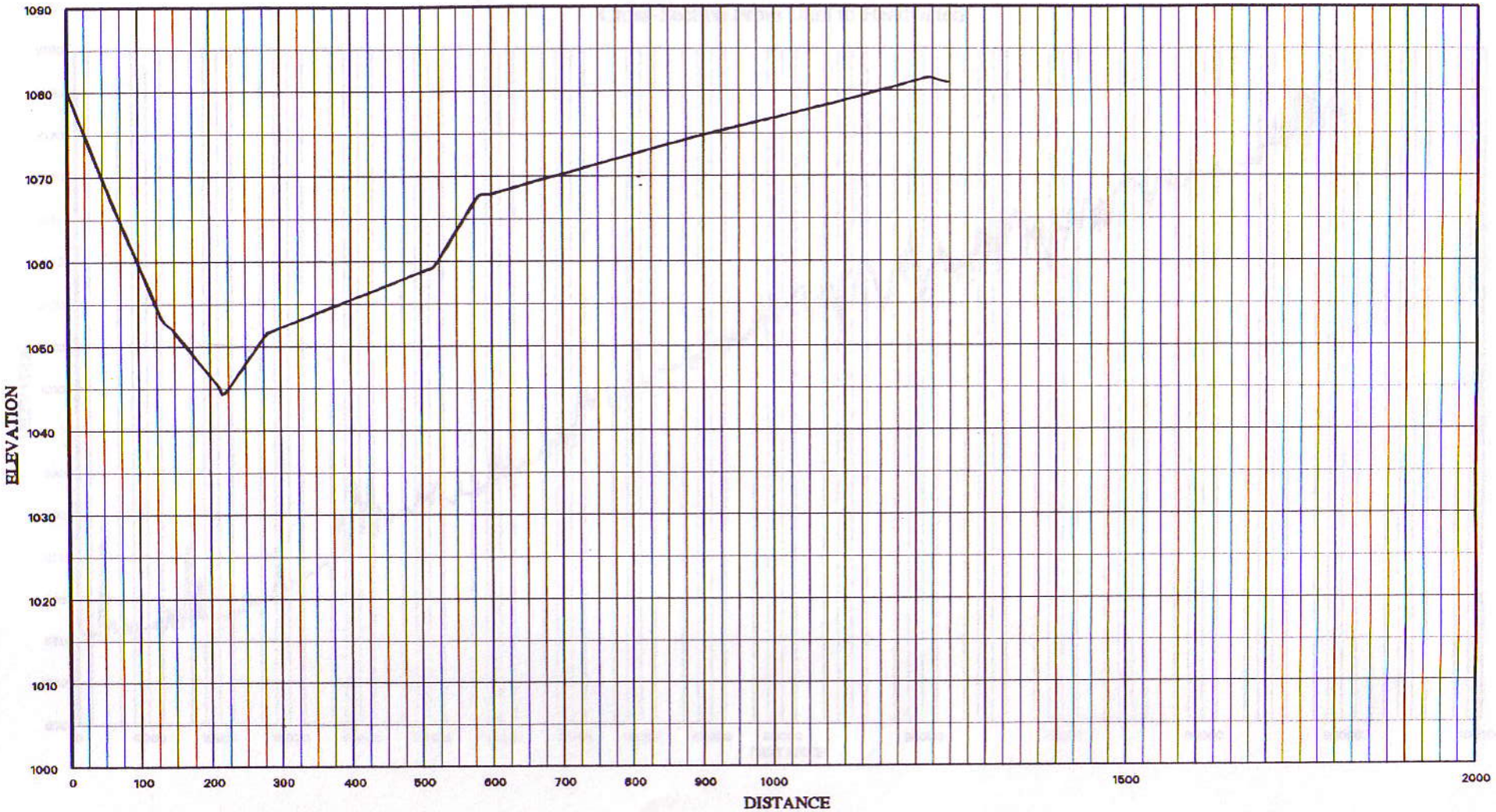


—— Range Line Generated Using ARC/INFO's TIN Module

1 Grid Cell = 100 Ft. with 25 Ft. Intervals (Horizontal)

1 Grid Cell = 10 Ft. with 5 Ft. Intervals (Vertical)

F-F′



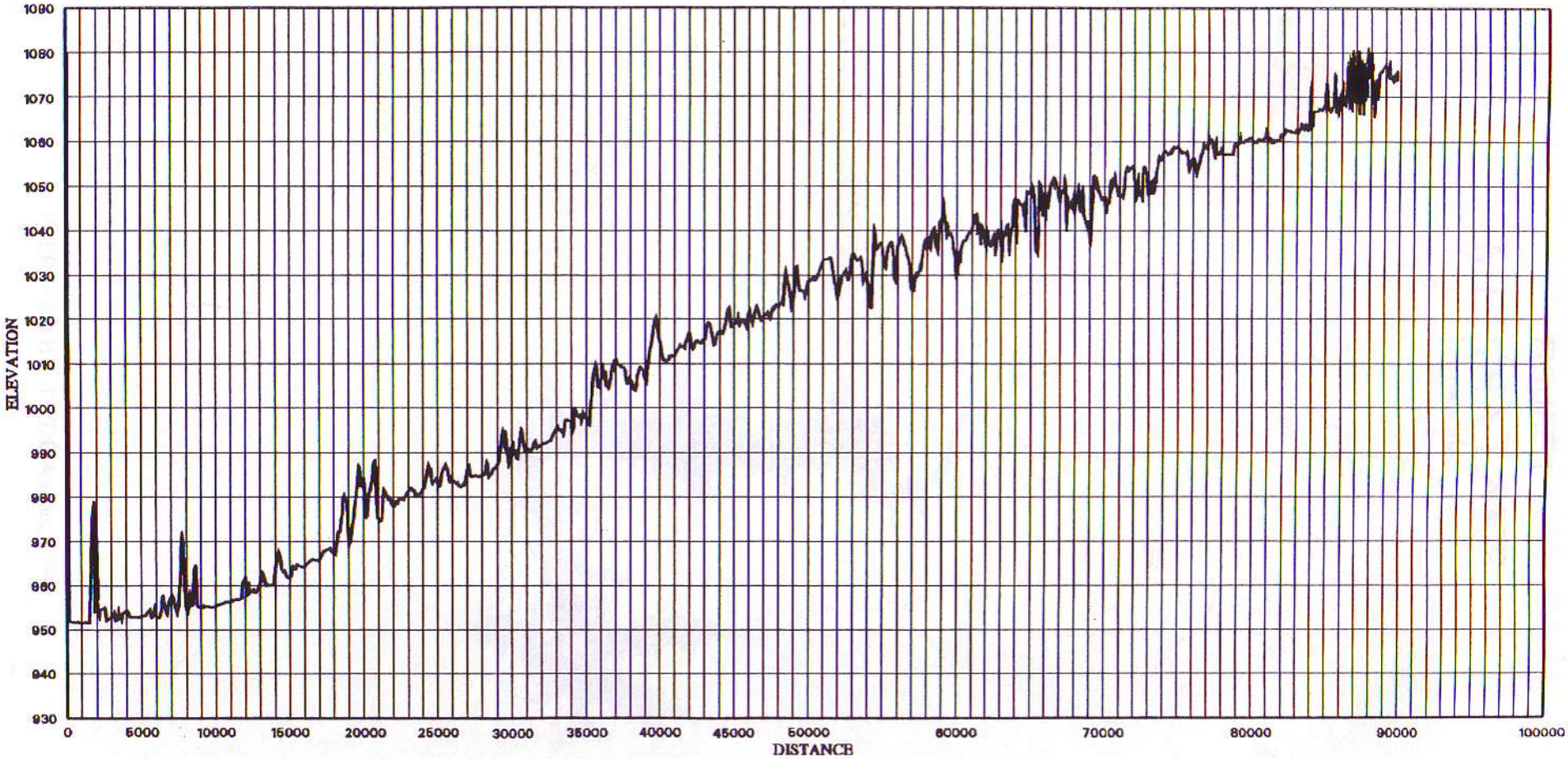
Range Line Generated Using ARC/INFO's TIN Module

1 Grid Cell = 100 Ft. with 25 Ft. Intervals (Horizontal)

1 Grid Cell = 10 Ft. with 5 Ft. Intervals (Vertical)

G-G'

Cross-Section From Dam to Headwaters



Range Line Generated Using ARC/INFO's TIN Module

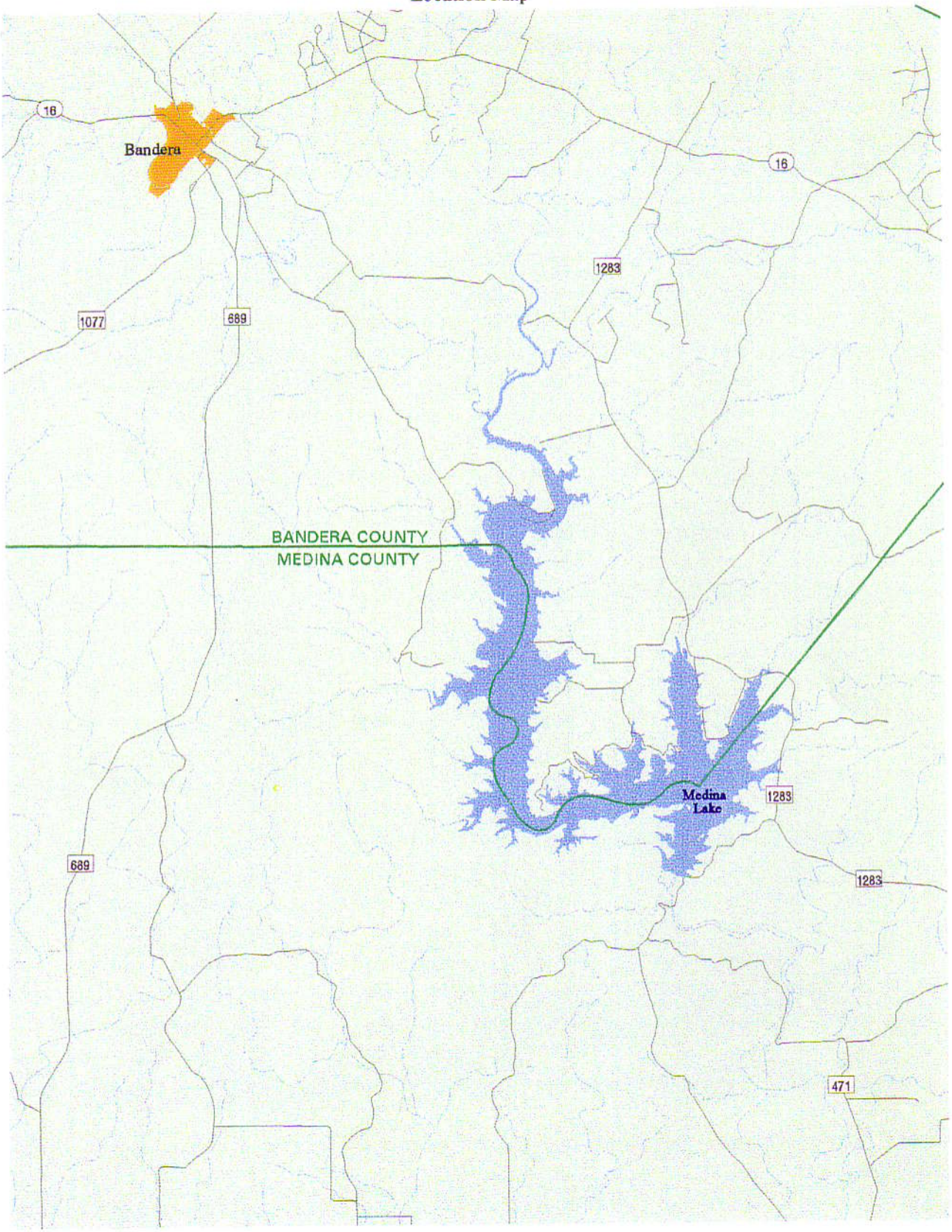
1 Grid Cell = 1000 Feet (Horizontal)

1 Grid Cell = 10 Feet (Vertical)

FIGURE 1

MEDINA LAKE

Location Map

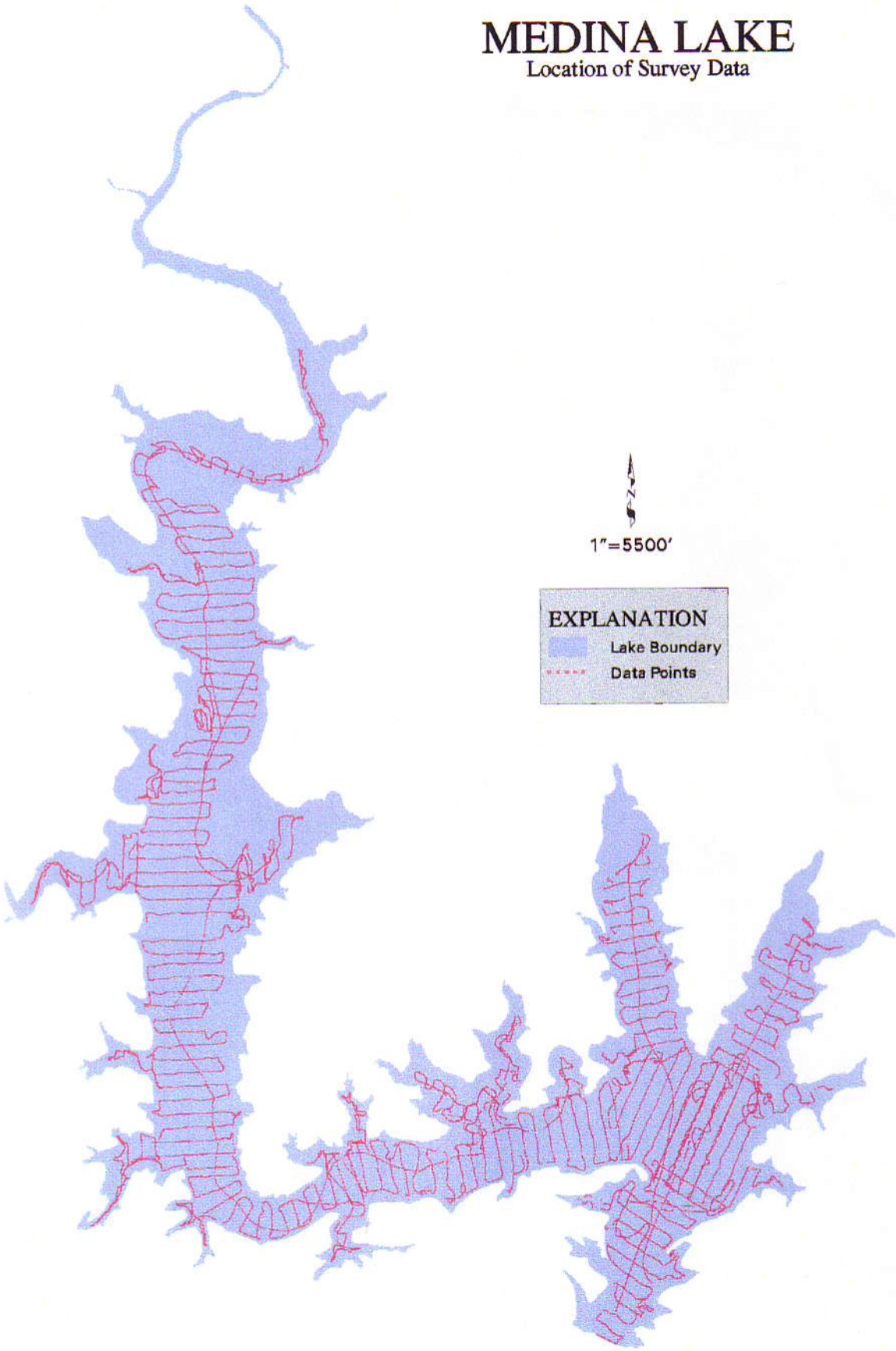


PREPARED BY: TWDB August, 1996

FIGURE 2

MEDINA LAKE

Location of Survey Data

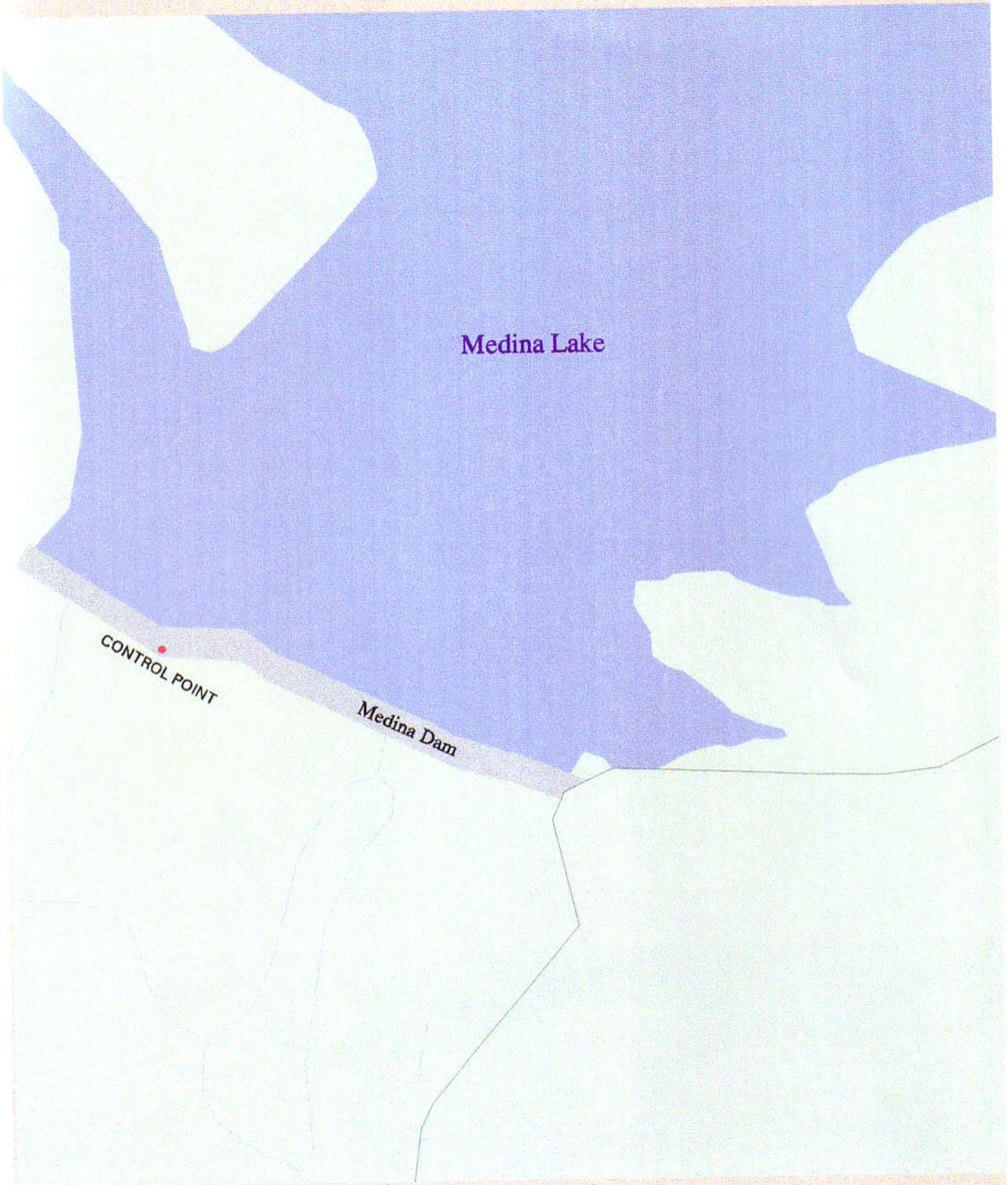


PREPARED BY: TWDB August, 1996

FIGURE 3

MEDINA LAKE

Location of Survey Control Point

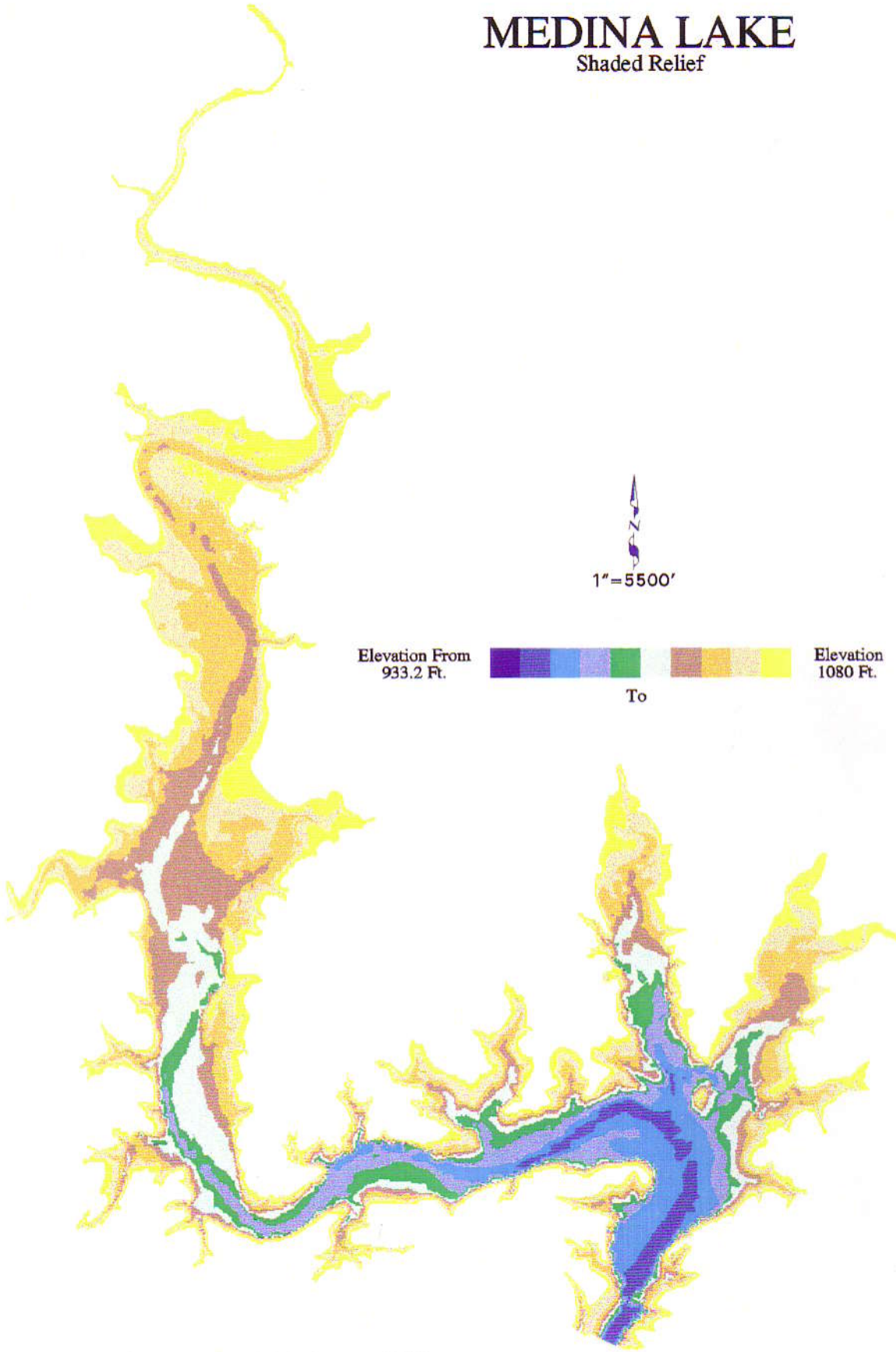


PREPARED BY: TWDB August, 1996

FIGURE 4

MEDINA LAKE

Shaded Relief

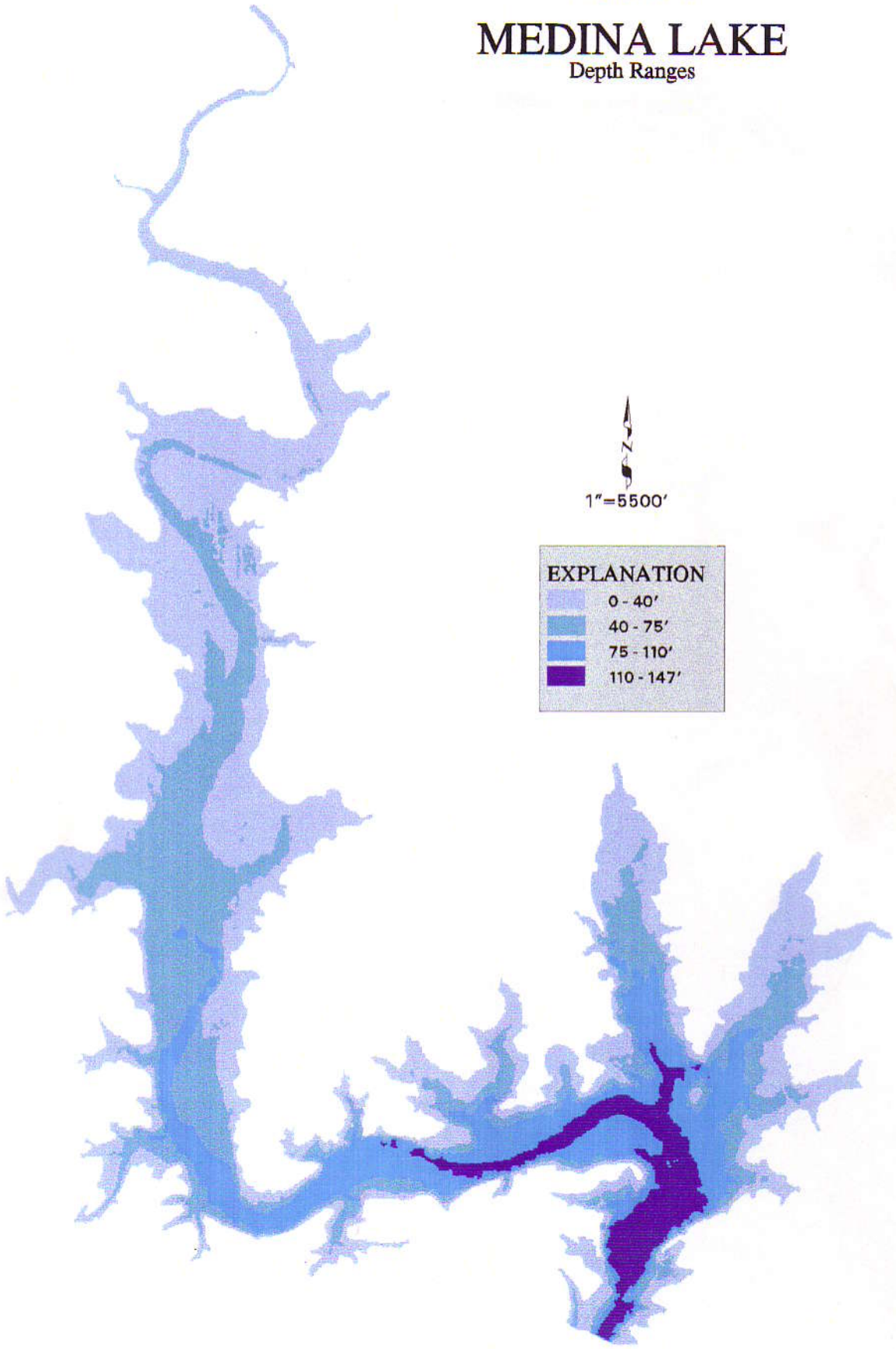


PREPARED BY: TWDB August, 1996

FIGURE 5

MEDINA LAKE

Depth Ranges

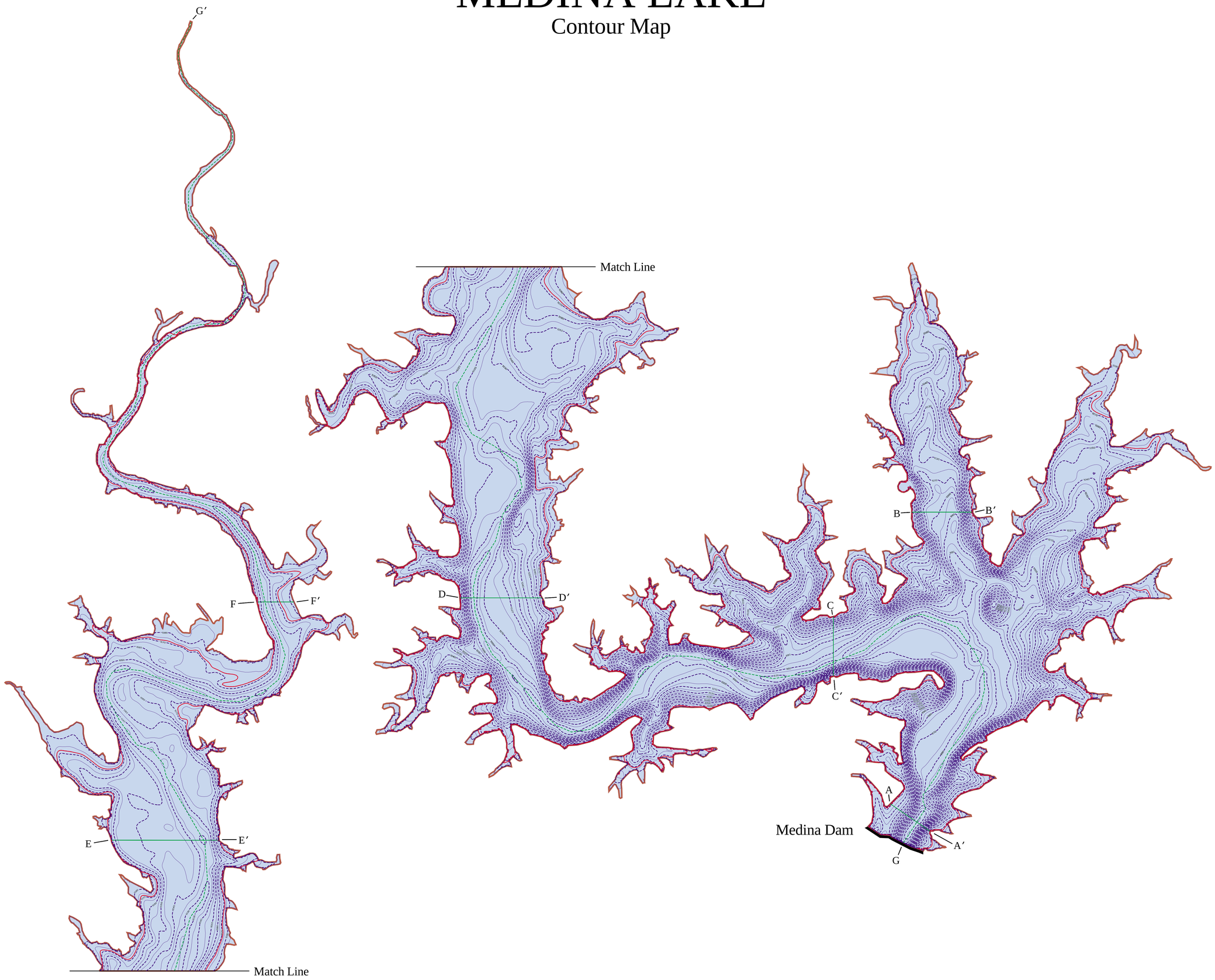


PREPARED BY: TWDB August, 1996

FIGURE 6

MEDINA LAKE

Contour Map



N

1″=1400′

BANDERA AND MEDINA COUNTIES

TEXAS WATER DEVELOPMENT BOARD

EXPLANATION

- 10 Ft. Contour Lines
- 5 Ft. Contour Lines
- Top of Dam Elevation 1080 Ft.
- Conservation Pool Elevation 1072 Ft.
- Cross Section Line
- Cross Section Line From Dam to Headwaters

This map is the product of a survey conducted by the Texas Water Development Board's Hydrographic Survey Program to determine the capacity of Medina Lake. The Texas Water Development Board makes no representations or assumes any liability if this information is used for other purposes such as boating maps.

PREPARED BY: TWDB August, 1996