# VOLUMETRIC SURVEY
# OF
# LAKE ARLINGTON

**Prepared for:**

**CITY OF ARLINGTON**

**Prepared by:**

**The Texas Water Development Board**

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## INTRODUCTION

Staff of the Hydrographic Survey Program of the Texas Water Development Board (TWDB) conducted a hydrographic survey on Lake Arlington in August, 1994. The purpose of the survey was to determine the capacity of the lake at the normal 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 in feet above mean sea level based on the National Geodetic Vertical Datum of 1929 (NGVD '29) unless noted otherwise. The results will be compared to the information from the latest sedimentation survey in 1980 performed by a joint venture between SEMCO, Inc., Surveying-Mapping-Planning-Consultants, Fort Worth and Freese and Nichols, Inc., Registered Professional Engineers of Fort Worth. At the normal pool elevation of 550.00 feet, they reported a surface area of 2,170 acres and a capacity of 39,930 acre-feet.

## HISTORY AND GENERAL INFORMATION OF THE RESERVOIR

Lake Arlington, is owned and operated by the City of Arlington. The facility is located on Village Creek, in Tarrant County, approximately seven miles west of downtown Arlington. Dam construction commenced May 15, 1956 and was completed July 19, 1957. Deliberate impoundment of water began March 31, 1957. Freese and Nichols Inc. were the consulting engineers and Key Construction Company was the general contractor. Estimated cost of the facility was $3,833,710.

Arlington Dam is an earthfill structure 6,482 feet in length with a maximum height of 83 feet cresting at elevation 572.0 feet. The structure is 490 feet wide at the base and has a top width of 24 feet. The service spillway is an uncontrolled concrete drop inlet located near the east end of the dam. This morning glory type structure flares to a diameter of 32 feet at a crest elevation of 550.0 feet. Once water rises to the crest or normal pool elevation it then enters a 10 foot diameter concrete conduit, passing through the earthen dam and exits 200 feet downstream at an invert elevation of 490.0 feet. The emergency spillway is an earth cut channel located 500 feet upstream of the dam on the east bank. The uncontrolled crest of this channel is at elevation 559.7 feet and is 882.0 feet in length.

The reservoir is approximately one mile wide near the dam and less than one-quarter mile wide in the upper reaches near Interstate Highway 20. Lake Arlington is an on-channel reservoir of Village Creek that stretches approximately four miles in length with very few tributaries. Records indicate the drainage basin above the dam is approximately 143 square miles.

On July 22, 1954 Permit Number 1716 was granted by the Board of Water Engineers to the City of Arlington to construct a dam on Village Creek, impounding 25,600 acre-feet of water and use not to exceed 9,000 acre-feet of water per annum for municipal purposes and use not to exceed 4,000 acre-feet of water per annum for industrial purposes. The Permit was later amended (Permit Number 1797) on December 5, 1955 authorizing the City of Arlington to relocate the proposed dam downstream and allowing the permittee to increase the impoundment to 45,710 acre-feet and increasing the amount of water for industrial purposes not to exceed 14,000 acre-feet of water per annum. On June 29, 1955 the City of Arlington sold to the Texas Electric Service Company (presently Texas Utilities Electric Company) 21,147 acre-feet of the 45,710 acre-feet storage capacity and 10,120 acre-feet of the 14,000 acre-feet of water per year authorized to be appropriated for industrial purposes. Permit Number 1716 was amended again on May 3, 1983. It granted the City of Arlington an additional 4,000 acre-feet of water per annum to be used for municipal purposes. Certificate of Adjudication Number 08-3391 was issued April 5 1985 to the City of Arlington and the Texas Utilities Electric Company. They were authorized to maintain an existing dam and reservoir on Village Creek known as Lake Arlington and impound therein not to exceed 45,710 acre-feet of water. It stated that the City of Arlington was authorized to use not to exceed 13,000 acre-feet of water per annum for municipal purposes. It also stated that Texas Utilities Electric Company was authorized to use not to exceed 10,120 acre-feet of water per annum from Lake Arlington for industrial purposes. Both the City of Arlington and Texas Utilities Electric Company are under contract to purchase water from Tarrant County Water Control and Improvement District No. 1. This water supply is piped into Lake Arlington from Cedar Creek and Richland Chambers Reservoirs for municipal and industrial purposes.

## 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 its 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 1960's by the United States Air Force and the defense establishment. After program funding in the early 1970's, 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 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" and was used during the survey. One GPS receiver is set up over a benchmark with known coordinates established by the hydrographic survey crew. This receiver remains stationary during the survey and monitors the movements of the satellites overhead. Position corrections are determined and transmitted via a radio link once per second to a second GPS receiver located on the moving boat. The boat receiver uses 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

The equipment used to perform 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; 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.

As the boat traveled across the lake surface, the depth sounder gathered approximately ten readings of the lake bottom each second. The depth readings were averaged over the one-second interval and stored with the positional data to an on-board computer. After the survey, the average depths were corrected to elevation using the daily lake elevation. The set of data points logged during the survey were used to calculate the lake volume. Accurate estimates of the lake volume can be quickly determined using these methods, to produce an affordable survey. 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 strung 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 strung across the body of water, so surveying instruments were utilized to determine the path of the boat. Monumentation was set for each end point 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 it's 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 hard to detect after the fact. 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 again 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 ± five feet for a ten foot contour interval. This method could be quite costly, and was only applicable in areas that were not inundated.

## Survey Methods

The first task of the Hydrographic Survey field staff after arriving at Lake Arlington was to establish a horizontal position reference control point. Figure 3 shows the location of the control point established for the survey. The location for the point, TWDB #014 was chosen due to the close proximity to the reservoir, the unobstructed view of the reservoir, and the security of the area.

A static survey using two Trimble 4000SE GPS receivers was performed to obtain coordinates for TWDB #014 on August 15, 1994. Prior to the field survey, staff researched locations of known first-order benchmarks and requested City of Arlington employees to physically locate the associated monuments prior to arrival. The monument chosen to provide horizontal control was a U. S. Department of Commerce Coast and Geodetic Survey (USGS) first-order monument named SEMINARY (1935). The monument is located on the gabled portion of the roof of the Hall of Music Building on the campus of the Southwest Baptist Theological Seminary in Fort Worth, Texas. The coordinates for this monument are published as Latitude 32° 40' 58.06813"N and Longitude 097° 20' 50.36455"W. Staff positioned a GPS receiver over this monument and positioned a second receiver over the TWDB #014 control point. Satellite data, with up to six satellites visible to the receiver, were gathered for approximately one hour at both locations in order to determine the coordinates of TWDB #014.

The data was retrieved and processed from both receivers, using Trimble Trimvec software, to determine coordinates for the shore station benchmark. The NAVSTAR satellites use the World Geodetic System (WGS '84) spherical datum. WGS '84 is essentially identical to NAD '83. The WGS' 84 coordinates for TWDB #014 were determined to be North latitude 32° 43' 00.14474", West longitude 097° 11' 31.33617". These coordinates were entered into the shore station receiver located over TWDB #014 to fix its location and allow calculation and broadcasting of corrections through the radio and modem to the roving receiver located on the boat during the survey.

The reservoir's surface area was determined prior to the survey by digitizing the lake boundary from one USGS quad sheet named KENNEDALE, 1959 (photorevised 1981). AutoCad software was used to digitize an estimate of the 550 contour based on the North American Datum of 1927 (NAD '27) used for this map. The graphic boundary was then transformed from NAD '27 to NAD '83 using Environmental Systems Research Institutes's (ESRI) ARC/INFO project command with the NADCOM parameters, to get the boundary into a more recent datum compatible with the positions received from the satellites. The area of the boundary shape was the same in both datum. All of the collected data and the calculations performed after the survey were done in the NAD '83 datum, a flat projected representation of the curved earth surface. NAD '27 is also a flat projection, but the two datum have a slightly different point of origin, and distinctly different state plane false northing and false easting coordinates to be able to distinguish coordinate points between the two datum.

After the survey, the resulting shape was modified slightly to insure that all data points gathered were within the boundary. Areas that did not contain water in the upper reachs of the lake were also deleted. The resulting acreage at the normal pool elevation was thereby estimated to be 1,939 acres, or within 10.6 percent of the recorded 2,170 acres. An aerial topo of the upper five feet of the lake or an aerial photo taken when the lake is at the normal pool elevation would more closely define the present boundary. However, the minimal increase in accuracy does not appear to offset the cost of those services at this time.

The survey layout was pre-planned, using approximately 50 survey lines at a spacing of 500 feet. Innerspace Technology Inc. software was utilized for navigation and to integrate and store positional data along with depths. In areas where vegetation or obstructions prevented the boat from traveling the planned line, random data were collected wherever the boat could maneuver. Additional random data were collected lengthwise in the reservoir. Data points were entered into the data set utilizing the DGPS horizontal position and manually poling the depth in shallow areas where the depth was less than the minimum recordable depth of the depth sounder, which is about 3.5 feet. Figure 2 shows the actual location of the data collection sites. Data were not collected in areas that were inaccessible due to shallow water or obstructions. The data set included approximately 23,883 data points.

TWDB staff verified the horizontal accuracy of the DGPS used in the Lake Arlington survey to be within the specified accuracy of three meters prior to the survey. 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 set to receive and process the corrections. 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.

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 better satellite geometry and thus 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 the maximum entered by the user, to advise the field crew that the horizontal position has degraded to an unacceptable level.

The depth sounder measures depth by measuring the time between the transmission of the sound pulse and the reception of its echo. The depth sounder was calibrated with the Innerspace Velocity Profiler typically once per day, unless the maximum depth varied by more than twenty feet. The velocity profiler calculates an average speed of sound through the water column of interest (typically set at a range of two feet below the surface to about ten feet above the maximum encountered depth), and the draft value or distance from the transducer to the surface. The velocity profiler probe is placed in the water to wet the transducers, then raised to the water surface where the depth is zeroed. The probe is then lowered on a cable to just below the maximum depth set for the water column, and then raised to the surface. The unit reads out an average speed of sound for the water column and the draft measurement, which are then entered into the depth sounder. The speed of sound can vary based on temperature, turbidity, density, or other factors. 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 ±0.2 feet, plus an estimated error of ±0.3 feet due to the plane of the boat for a total accuracy of ±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. Manual poling of depths within shallow areas agreed with the depth obtained by the depth sounder typically within ± 0.3 feet, and since the boat is moving much slower, the plane of the boat has much less effect.

Analog charts were printed for each survey line as the data were collected. The gate mark, which is a known distance above the actual depth that was recorded in the data file, was also printed on the chart. Each analog chart was analyzed, and where the gate mark indicated that the recorded depth was other than the bottom profile, depths in the corresponding data files were modified accordingly. The depth sounder was set to record bad depth readings as 0. During post-processing, all points with a zero depth were deleted.

Each of the resulting data points collected consisted of a latitude, longitude and depth reading. The depths were transformed to elevations with a simple Unix command based on the water surface elevation each day, rounded to the nearest tenth of a foot since the depth sounder reads in tenths of a foot. The water surface ranged from 544.23 to 544.20 feet during the field survey. The latitude, longitude data set was converted to decimal degrees and loaded into Arc/Info along with the NAD '83 boundary file using the CREATETIN command. The data points and the boundary file were used to create a Digital Terrain Model (DTM) of the reservoir's bottom surface using the ARC\INFO TIN module. 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 is formed, the software then calculates elevations along the triangle surface plane by solving the equations for elevation along each leg of the triangle. Areas that were too shallow for data collection or obstructed by vegetation were estimated by the ARC/INFO's TIN product using this method of interpolation.

There were some areas where interpolation could not occur because of a lack of information along the boundary of the reservoir. "Flat triangles" were drawn at these locations. ArcInfo does not use flat triangle areas in the volume or contouring features of the model. Therefore 314 additional data points were estimated and added as required for interpolation and contouring of the entire lake surface. From the resulting three-dimensional triangular plane surface representation, the TIN product calculated the surface area and volume of the entire reservoir at one-tenth of a foot intervals.

The three-dimensional triangular surface was then shaded 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 normal pool elevation was assigned the color of yellow. Different intensities of these colors were assigned to the different depths in between. Figure 4 consists of the resulting depth shaded representation of the lake. Figure 5 presents a similar version of the same map, using bands of color for selected contour 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 following smoothing options were chosen for this model: Douglas-Peucker option with a 1/1000 tolerance level to eliminate any duplicate points, and Round Corners with a maximum delta of 1/1000 of the model's maximum linear size, in an attempt to smooth some of the angularity of the contours. Contours of the bottom surface at two foot intervals are presented in Figure 6.

## DATA

Staff of the TWDB collected hydrographic data on Lake Arlington August 16 and 17, 1994. The survey crew noticed a gentle relief in the topography along the perimeter of the lake. The lake bottom appeared relatively monotonous. There were some deep depressions or large holes that were assumed to be old tank dams, gravel pits or borrow pits. The fathometer charts showed the original streambed as well as some of the roads that were inundated when the lake was built. Bordering the lake on the west bank near the dam was an electric power generating plant owned and operated by Texas Utilities. Both the intake and discharge channels of this plant were barricaded by a cyclone fence. No data was collected in these channels. The survey crew noticed a concrete barrier that separated the warm discharge waters of the power plant from the main body of the lake. This concrete wall diverted the discharge waters into a cove allowing the water tempature to cool before entering the main body of the lake. One island was encountered while driving the range lines in the main body. Large sediment deposits were found upstream of this island. The survey crew observed man-made changes in the upper end of the lake. Apparently, a channel had been excavated for lake front property owners. An earthen levee had also been built in the upper reaches of the lake. The survey crew collected random data in this area of the lake to document the changes. The survey crew was unable to collect data upstream of Interstate Highway 20 on Village Creek. Approximately 24 miles of parallel range lines were driven in the two days of collecting the field data.

Lake Arlington was estimated by this survey to encompass 1,939 acres and to contain a volume of 38,785 acre-feet at the normal pool elevation of 550 feet. The lowest elevation encountered during the field survey was elevation 499.81 feet, or 50.2 feet of depth. The reservoir volume table is presented in Appendix B and the area table in Appendix C. The one-tenth foot intervals are based on actual calculations from the model. An elevation-area-volume graph is presented in Appendix D. No data points were collected in areas where the depth was shallower than two feet because of the draft limitations of the boat. Straight-line interpolation occurs from the last data points collected to the normal pool elevation lake boundary as digitized. The field data collected corresponded well with the boundary data obtained from the USGS map except in the upper reaches of the lake. The Board does not represent the boundary, as depicted in this report, to be a detailed actual boundary. It is a graphical approximation of the actual boundary that was used solely to compute the volume and area of the lake. This boundary does not represent the true land versus water boundary of the lake.

The storage volume calculated by this survey is approximately 3.0 percent less than the previous record information for the lake. The low flow outlet is at elevation 505.0 feet, resulting in a dead storage of 45 acre-feet. Therefore, the conservation storage for the reservoir is calculated to be 38,740 acre-feet.

## SUMMARY

Lake Arlington was originally built in 1957 and had a surface area of 2,200 acres and a storage capacity of 45,710 acre-feet. A sedimentation survey performed in 1980 jointly by SEMCO, Inc., Surveying-Mapping-Planning-Consultants, Fort Worth and Freese and Nichols, Inc., Registered Professional Engineers of Fort Worth estimated that Lake Arlington had lost 5,780 acre-feet, or 12.6 percent of its capacity due to sedimentation since completion of the reservoir. This equates to an average loss of 251.3 acre-feet per year during the 23 year period.

In August 1994, a survey was performed by the Texas Water Development Board's Hydrographic Survey Program. The purpose of the survey was to determine the current storage volume of Lake Arlington utilizing a surveying system consisting of satellite surveying and digital depth sounding equipment, and digital terrain modeling software. Results from the survey indicate that the lake's capacity at the normal pool elevation of 550 feet to be 38,785 acre-feet. The conservation storage capacity was calculated to be 38,740 acre-feet. The estimated reduction in storage capacity, compared to the 1980 survey, can be estimated at 1,145 acre-feet, or 2.9 percent. Thus the average capacity loss during the 14 year period was calculated as 81.8 acre-feet per year. The overall loss since the reservoir was built was calculated at 6,925 acre-feet, or 187 acre-feet per year if results from this survey are compared to the original information on record for the reservoir.

It is assumed that the reduction in estimated storage capacity is due to both a combination of sedimentation, and improved data and calculation methods. Repeating this survey with the same calculation methodology in five to ten years or after major flood events should remove any noticeable error due to improved calculation techniques and will help isolate the storage loss due to sedimentation.

# 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

$$t_{30} = (30-1.2)/4832$$
$$= 0.00596 \text{ sec.}$$

For the water column from 2 to 45 feet: V = 4808 fps

$$t_{45} = (45-1.2)/4808$$
$$= 0.00911 \text{ sec.}$$

For a measurement at 20 feet (within the 2 to 30 foot column with V = 4832 fps):

$$D_{20} = [((20-1.2)/4832)(4808)]+1.2$$
$$= 19.9' \quad (-0.1')$$

For a measurement at 30 feet (within the 2 to 30 foot column with V = 4832 fps):

$$D_{30} = [((30-1.2)/4832)(4808)]+1.2$$
$$= 29.9' \quad (-0.1')$$

For a measurement at 50 feet (within the 2 to 60 foot column with V = 4799 fps):

$$D_{50} = [((50-1.2)/4799)(4808)]+1.2$$
$$= 50.1' \quad (+0.1')$$

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

RESERVOIR VOLUME TABLE

Nov 7 1994

LAKE ARLINGTON AUGUST 1994 SURVEY

VOLUME IN ACRE-FEET ELEVATION INCREMENT IS ONE TENTH FOOT

| ELEV. FEET | .0 | .1 | .2 | .3 | .4 | .5 | .6 | .7 | .8 | .9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 499 | | | | | | | | | | |
| 500 | | | | | | | | | | |
| 501 | | | | | 1 | 1 | 1 | 1 | 2 | 2 |
| 502 | 2 | 3 | 3 | 4 | 5 | 5 | 6 | 7 | 8 | 9 |
| 503 | 10 | 11 | 12 | 13 | 15 | 16 | 17 | 19 | 20 | 22 |
| 504 | 23 | 25 | 27 | 29 | 31 | 33 | 35 | 37 | 40 | 42 |
| 505 | 45 | 48 | 50 | 53 | 56 | 59 | 63 | 66 | 70 | 74 |
| 506 | 77 | 81 | 85 | 90 | 94 | 98 | 103 | 107 | 112 | 117 |
| 507 | 122 | 127 | 132 | 137 | 143 | 148 | 154 | 160 | 166 | 172 |
| 508 | 178 | 185 | 191 | 198 | 205 | 212 | 219 | 227 | 234 | 242 |
| 509 | 249 | 257 | 265 | 274 | 282 | 291 | 299 | 308 | 317 | 327 |
| 510 | 336 | 346 | 356 | 366 | 377 | 387 | 398 | 409 | 420 | 432 |
| 511 | 443 | 455 | 467 | 479 | 491 | 504 | 516 | 529 | 542 | 556 |
| 512 | 569 | 583 | 597 | 611 | 626 | 641 | 656 | 672 | 687 | 703 |
| 513 | 720 | 737 | 754 | 771 | 789 | 807 | 825 | 843 | 861 | 880 |
| 514 | 899 | 918 | 938 | 958 | 978 | 999 | 1019 | 1041 | 1062 | 1084 |
| 515 | 1106 | 1129 | 1151 | 1175 | 1198 | 1222 | 1246 | 1271 | 1296 | 1321 |
| 516 | 1346 | 1372 | 1398 | 1424 | 1450 | 1477 | 1503 | 1531 | 1558 | 1585 |
| 517 | 1613 | 1641 | 1670 | 1699 | 1728 | 1757 | 1787 | 1817 | 1847 | 1878 |
| 518 | 1909 | 1940 | 1972 | 2004 | 2036 | 2069 | 2103 | 2136 | 2170 | 2205 |
| 519 | 2240 | 2275 | 2311 | 2347 | 2383 | 2420 | 2457 | 2495 | 2533 | 2572 |
| 520 | 2612 | 2652 | 2694 | 2736 | 2779 | 2822 | 2867 | 2912 | 2958 | 3004 |
| 521 | 3051 | 3099 | 3148 | 3197 | 3247 | 3297 | 3348 | 3399 | 3451 | 3504 |
| 522 | 3557 | 3610 | 3664 | 3719 | 3774 | 3829 | 3885 | 3942 | 3999 | 4057 |
| 523 | 4115 | 4174 | 4233 | 4293 | 4354 | 4416 | 4478 | 4540 | 4603 | 4667 |
| 524 | 4731 | 4795 | 4860 | 4925 | 4991 | 5057 | 5123 | 5190 | 5257 | 5325 |
| 525 | 5393 | 5461 | 5530 | 5599 | 5669 | 5739 | 5810 | 5881 | 5952 | 6024 |
| 526 | 6096 | 6168 | 6241 | 6315 | 6388 | 6463 | 6537 | 6612 | 6687 | 6763 |
| 527 | 6839 | 6916 | 6993 | 7070 | 7148 | 7226 | 7305 | 7383 | 7463 | 7542 |
| 528 | 7622 | 7703 | 7783 | 7865 | 7946 | 8028 | 8110 | 8193 | 8276 | 8359 |
| 529 | 8442 | 8526 | 8611 | 8695 | 8781 | 8866 | 8952 | 9038 | 9124 | 9211 |
| 530 | 9299 | 9387 | 9476 | 9565 | 9654 | 9744 | 9835 | 9926 | 10017 | 10109 |
| 531 | 10201 | 10294 | 10388 | 10482 | 10577 | 10672 | 10767 | 10864 | 10960 | 11058 |
| 532 | 11155 | 11254 | 11353 | 11452 | 11552 | 11653 | 11754 | 11855 | 11957 | 12060 |
| 533 | 12163 | 12267 | 12371 | 12476 | 12581 | 12687 | 12794 | 12901 | 13009 | 13117 |
| 534 | 13226 | 13336 | 13447 | 13558 | 13670 | 13783 | 13896 | 14010 | 14125 | 14240 |
| 535 | 14356 | 14473 | 14590 | 14709 | 14828 | 14947 | 15068 | 15189 | 15310 | 15433 |
| 536 | 15556 | 15680 | 15804 | 15930 | 16056 | 16183 | 16310 | 16439 | 16568 | 16698 |
| 537 | 16829 | 16960 | 17093 | 17226 | 17360 | 17495 | 17630 | 17767 | 17904 | 18042 |
| 538 | 18181 | 18321 | 18461 | 18603 | 18745 | 18888 | 19032 | 19176 | 19321 | 19467 |
| 539 | 19614 | 19762 | 19910 | 20059 | 20209 | 20360 | 20511 | 20663 | 20816 | 20969 |
| 540 | 21123 | 21279 | 21435 | 21592 | 21750 | 21908 | 22067 | 22227 | 22387 | 22549 |
| 541 | 22711 | 22874 | 23038 | 23203 | 23368 | 23535 | 23701 | 23869 | 24036 | 24204 |
| 542 | 24372 | 24541 | 24710 | 24879 | 25049 | 25219 | 25389 | 25559 | 25730 | 25901 |
| 543 | 26072 | 26244 | 26416 | 26588 | 26761 | 26933 | 27106 | 27280 | 27453 | 27627 |
| 544 | 27802 | 27976 | 28151 | 28326 | 28501 | 28677 | 28852 | 29029 | 29205 | 29382 |
| 545 | 29559 | 29737 | 29915 | 30094 | 30273 | 30452 | 30632 | 30812 | 30991 | 31172 |
| 546 | 31352 | 31533 | 31714 | 31895 | 32077 | 32259 | 32441 | 32623 | 32805 | 32988 |
| 547 | 33171 | 33355 | 33538 | 33722 | 33906 | 34091 | 34275 | 34460 | 34645 | 34831 |

LAKE ARLINGTON AUGUST 1994 SURVEY

| | VOLUME IN ACRE-FEET | | | | ELEVATION INCREMENT IS ONE TENTH FOOT | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. FEET | .0 | .1 | .2 | .3 | .4 | .5 | .6 | .7 | .8 | .9 |
| 548 | 35016 | 35202 | 35388 | 35575 | 35761 | 35948 | 36136 | 36323 | 36511 | 36699 |
| 549 | 36887 | 37076 | 37265 | 37454 | 37643 | 37833 | 38023 | 38213 | 38403 | 38594 |
| 550 | 38785 | | | | | | | | | |

LAKE ARLINGTON AUGUST 1994 SURVEY

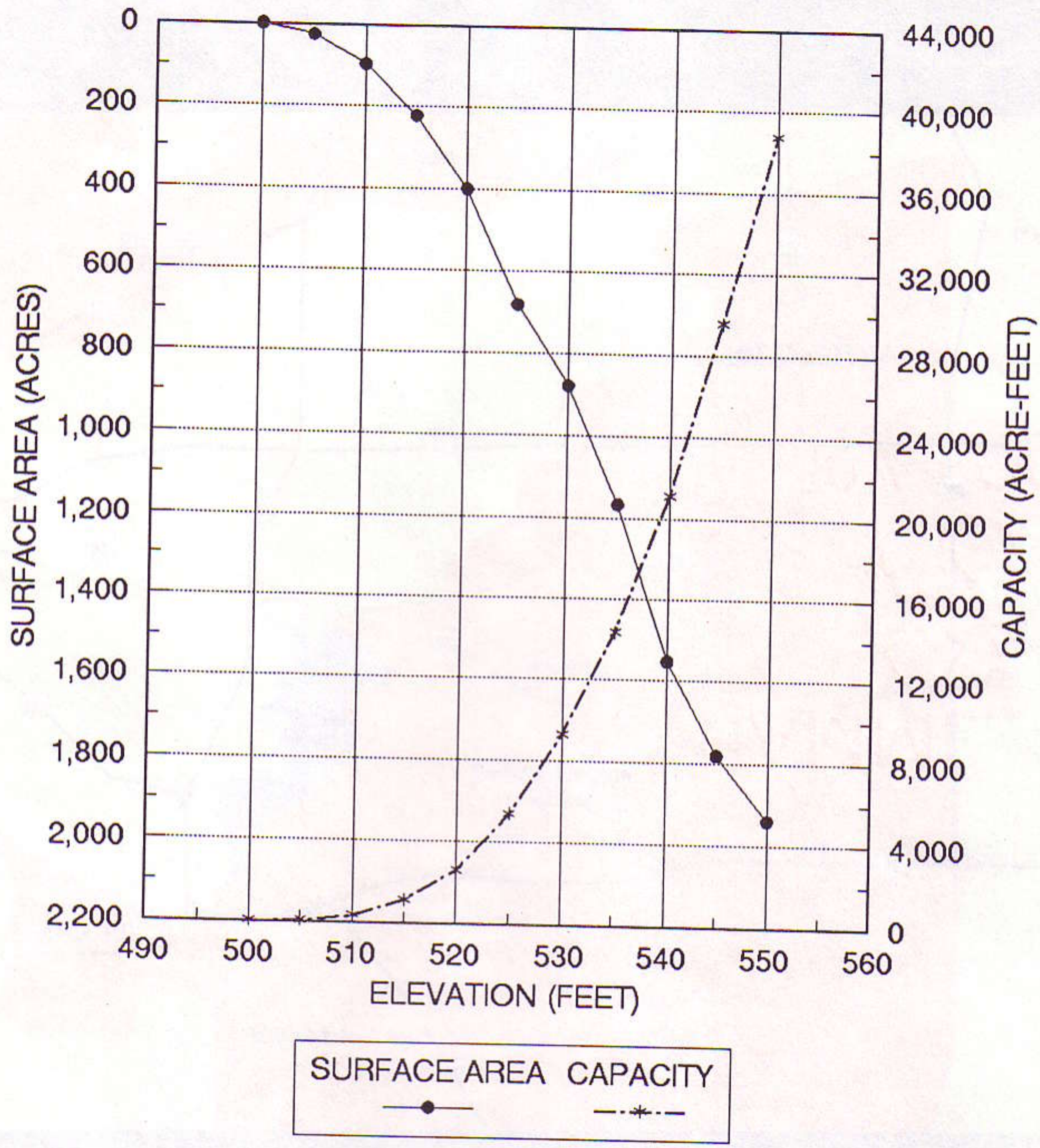
AREA IN ACRES ELEVATION INCREMENT IS ONE TENTH FOOT

| ELEV. FEET | .0 | .1 | .2 | .3 | .4 | .5 | .6 | .7 | .8 | .9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 499 | | | | | | | | | | |
| 500 | | | | | | | | | | |
| 501 | | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 4 |
| 502 | 5 | 5 | 6 | 6 | 7 | 8 | 8 | 9 | 9 | 10 |
| 503 | 10 | 11 | 12 | 12 | 13 | 14 | 14 | 15 | 16 | 16 |
| 504 | 17 | 18 | 19 | 20 | 20 | 21 | 22 | 23 | 24 | 25 |
| 505 | 26 | 27 | 29 | 30 | 31 | 32 | 34 | 35 | 37 | 38 |
| 506 | 39 | 40 | 41 | 42 | 43 | 45 | 46 | 47 | 48 | 49 |
| 507 | 50 | 51 | 52 | 53 | 55 | 56 | 57 | 59 | 61 | 62 |
| 508 | 64 | 65 | 67 | 68 | 70 | 71 | 73 | 74 | 75 | 77 |
| 509 | 78 | 80 | 82 | 83 | 85 | 87 | 89 | 91 | 93 | 95 |
| 510 | 97 | 99 | 101 | 103 | 105 | 107 | 109 | 110 | 112 | 114 |
| 511 | 116 | 118 | 120 | 122 | 124 | 126 | 128 | 130 | 132 | 134 |
| 512 | 137 | 139 | 142 | 145 | 148 | 150 | 153 | 156 | 159 | 163 |
| 513 | 166 | 169 | 172 | 174 | 177 | 179 | 181 | 184 | 186 | 189 |
| 514 | 192 | 194 | 197 | 201 | 204 | 207 | 210 | 213 | 216 | 220 |
| 515 | 223 | 227 | 230 | 234 | 238 | 241 | 244 | 247 | 250 | 252 |
| 516 | 255 | 257 | 259 | 262 | 264 | 267 | 269 | 272 | 275 | 277 |
| 517 | 280 | 283 | 286 | 289 | 292 | 295 | 298 | 301 | 305 | 309 |
| 518 | 312 | 316 | 320 | 323 | 327 | 331 | 335 | 339 | 343 | 347 |
| 519 | 351 | 355 | 358 | 363 | 367 | 371 | 375 | 380 | 386 | 393 |
| 520 | 400 | 408 | 416 | 425 | 433 | 440 | 448 | 455 | 462 | 468 |
| 521 | 475 | 482 | 488 | 495 | 501 | 506 | 512 | 517 | 522 | 527 |
| 522 | 533 | 538 | 543 | 548 | 553 | 558 | 563 | 568 | 574 | 579 |
| 523 | 585 | 591 | 598 | 605 | 612 | 618 | 623 | 628 | 633 | 637 |
| 524 | 641 | 646 | 650 | 654 | 658 | 662 | 667 | 671 | 675 | 678 |
| 525 | 682 | 686 | 691 | 695 | 699 | 703 | 707 | 711 | 715 | 719 |
| 526 | 723 | 727 | 731 | 735 | 739 | 743 | 747 | 751 | 756 | 760 |
| 527 | 764 | 768 | 772 | 775 | 779 | 783 | 787 | 790 | 794 | 798 |
| 528 | 802 | 806 | 809 | 813 | 817 | 820 | 824 | 827 | 831 | 834 |
| 529 | 838 | 842 | 845 | 849 | 852 | 856 | 860 | 863 | 868 | 872 |
| 530 | 878 | 883 | 888 | 893 | 898 | 903 | 907 | 912 | 917 | 922 |
| 531 | 927 | 932 | 938 | 944 | 949 | 954 | 960 | 965 | 970 | 975 |
| 532 | 981 | 986 | 991 | 997 | 1002 | 1008 | 1013 | 1018 | 1024 | 1029 |
| 533 | 1035 | 1040 | 1045 | 1051 | 1057 | 1062 | 1068 | 1075 | 1081 | 1089 |
| 534 | 1096 | 1103 | 1110 | 1116 | 1123 | 1130 | 1136 | 1143 | 1149 | 1156 |
| 535 | 1166 | 1173 | 1179 | 1186 | 1193 | 1200 | 1207 | 1214 | 1220 | 1228 |
| 536 | 1235 | 1242 | 1250 | 1258 | 1265 | 1273 | 1280 | 1288 | 1296 | 1304 |
| 537 | 1312 | 1319 | 1327 | 1335 | 1343 | 1352 | 1360 | 1369 | 1377 | 1386 |
| 538 | 1394 | 1402 | 1410 | 1418 | 1426 | 1434 | 1441 | 1449 | 1457 | 1465 |
| 539 | 1473 | 1480 | 1488 | 1495 | 1502 | 1509 | 1516 | 1523 | 1530 | 1537 |
| 540 | 1552 | 1559 | 1566 | 1573 | 1580 | 1587 | 1594 | 1602 | 1610 | 1618 |
| 541 | 1626 | 1635 | 1643 | 1651 | 1661 | 1667 | 1670 | 1674 | 1677 | 1681 |
| 542 | 1684 | 1688 | 1691 | 1694 | 1697 | 1700 | 1704 | 1707 | 1709 | 1712 |
| 543 | 1715 | 1718 | 1721 | 1723 | 1726 | 1729 | 1732 | 1735 | 1738 | 1740 |
| 544 | 1743 | 1746 | 1749 | 1752 | 1754 | 1757 | 1760 | 1763 | 1766 | 1768 |
| 545 | 1781 | 1783 | 1786 | 1789 | 1791 | 1794 | 1796 | 1799 | 1801 | 1804 |
| 546 | 1806 | 1809 | 1811 | 1814 | 1817 | 1819 | 1822 | 1824 | 1827 | 1829 |
| 547 | 1832 | 1835 | 1837 | 1840 | 1842 | 1845 | 1847 | 1850 | 1853 | 1855 |

LAKE ARLINGTON AUGUST 1994 SURVEY

AREA IN ACRES ELEVATION INCREMENT IS ONE TENTH FOOT

| ELEV. FEET | .0 | .1 | .2 | .3 | .4 | .5 | .6 | .7 | .8 | .9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 548 | 1858 | 1860 | 1863 | 1866 | 1868 | 1871 | 1874 | 1876 | 1879 | 1882 |
| 549 | 1884 | 1887 | 1890 | 1893 | 1895 | 1898 | 1901 | 1904 | 1907 | 1910 |
| 550 | 1939 | | | | | | | | | |




# LAKE ARLINGTON

AUGUST 1994 SURVEY

Prepared by: TWDB November 1994

FIGURE 1

# LAKE ARLINGTON

Location Map

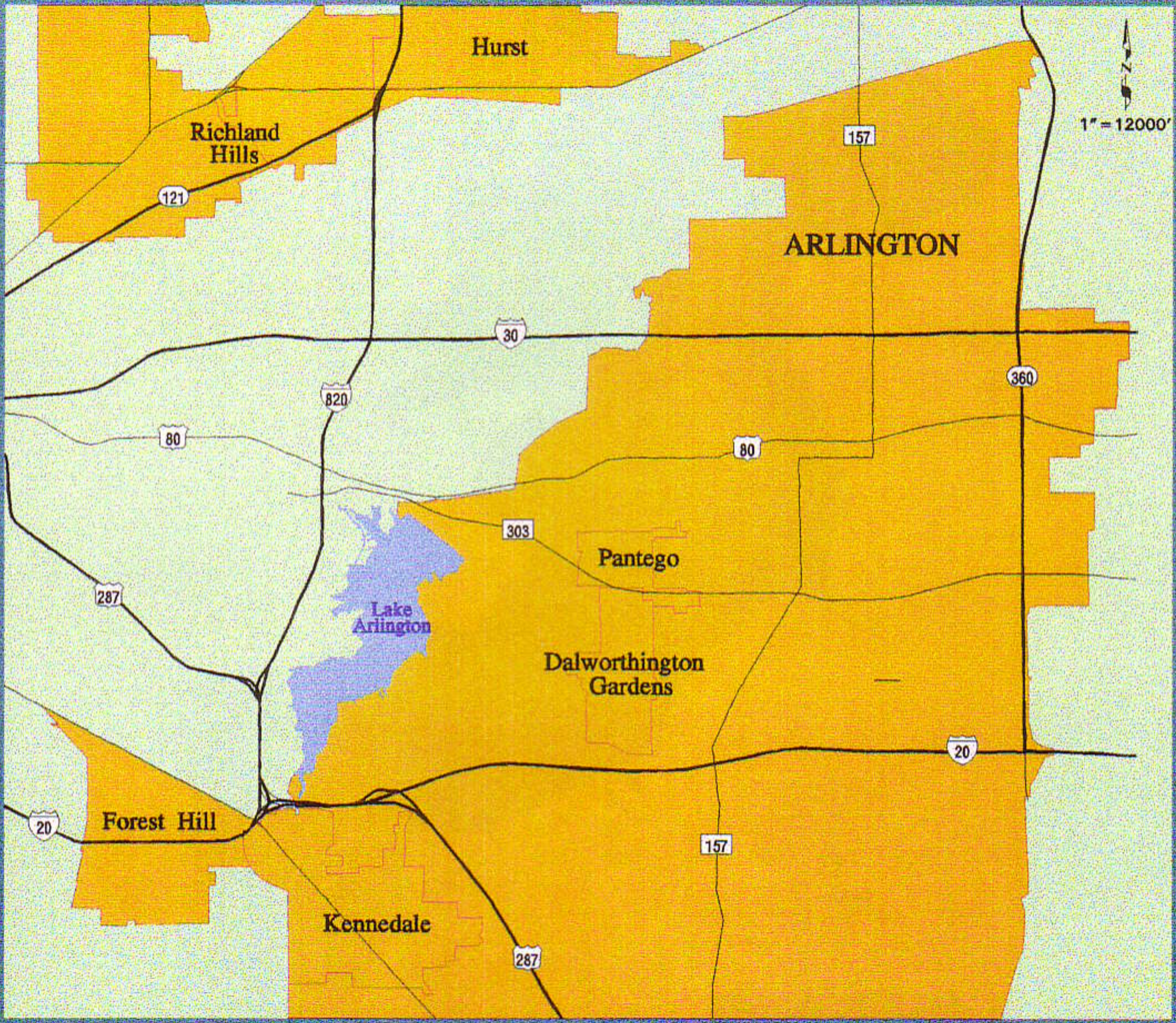



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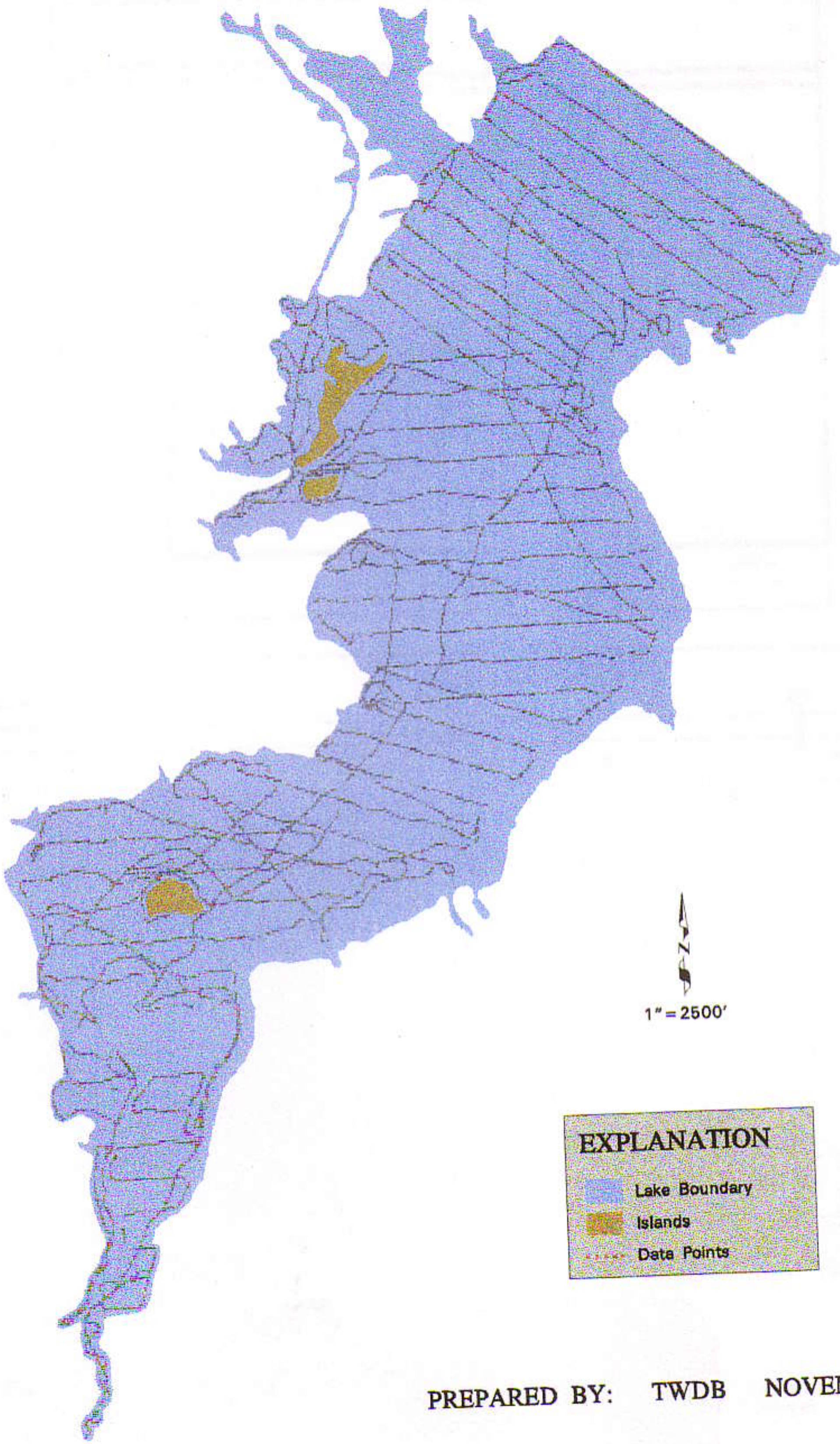
FIGURE 2

# LAKE ARLINGTON

Location of Survey Data

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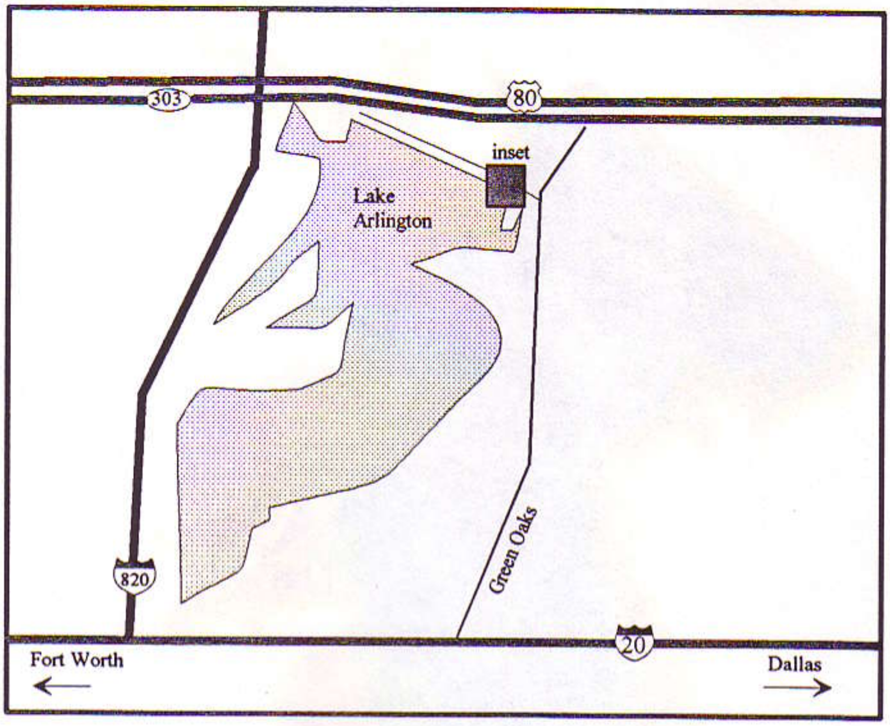
# FIGURE 3

# LAKE ARLINGTON

Location of control point # 014.



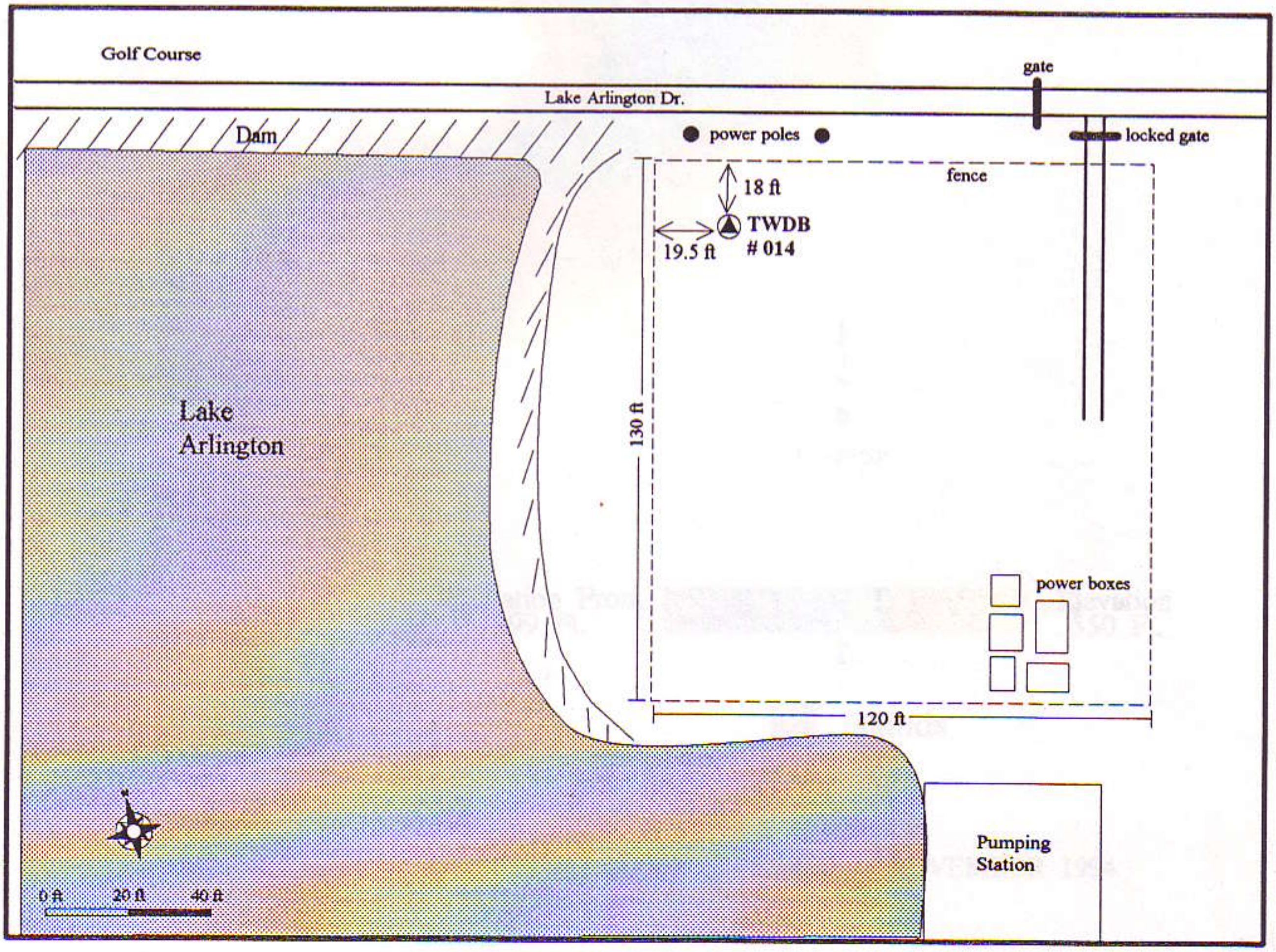



FIGURE 4

# LAKE ARLINGTON

Shaded Relief

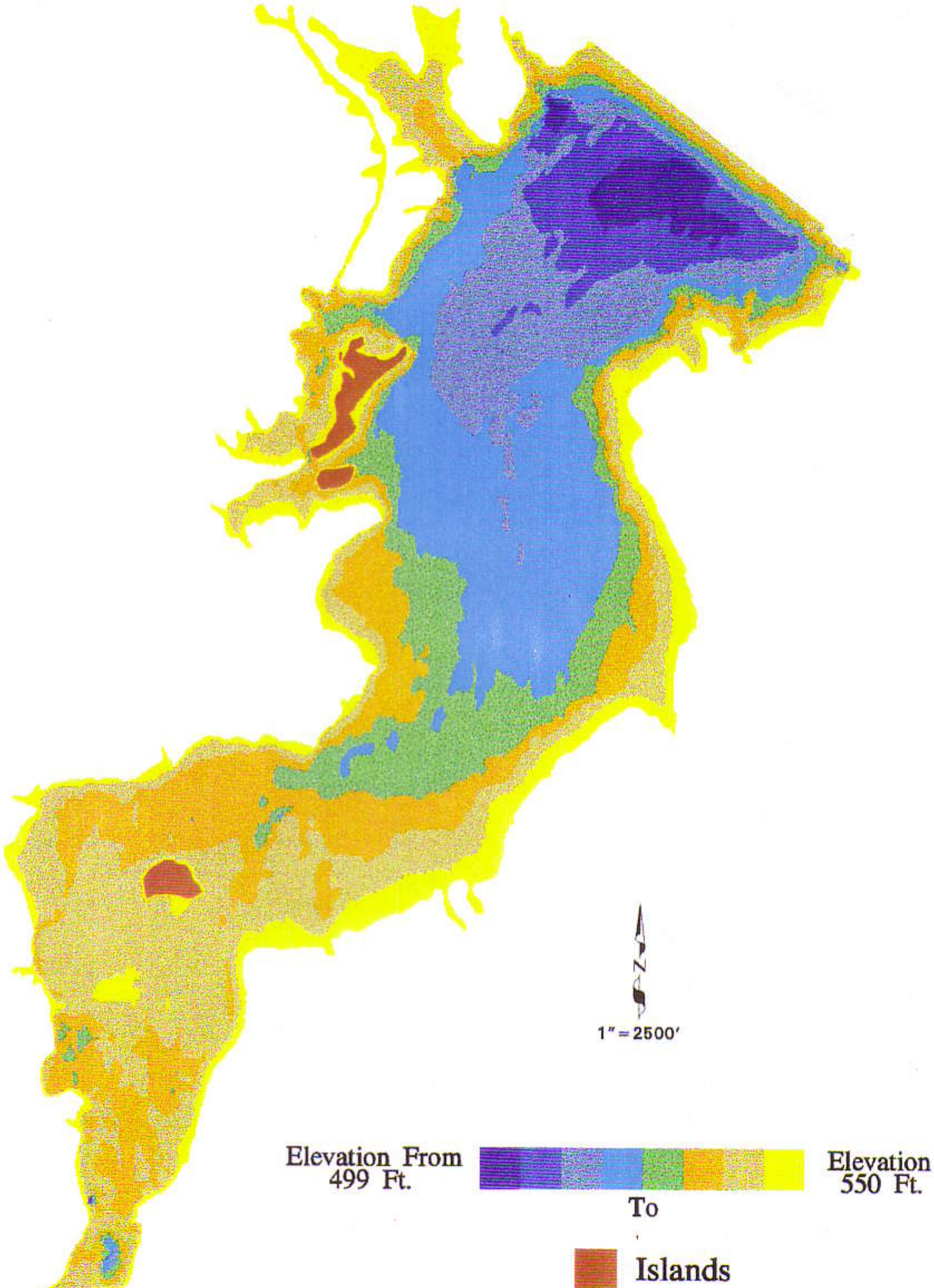



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FIGURE 5

# LAKE ARLINGTON

Depth Ranges

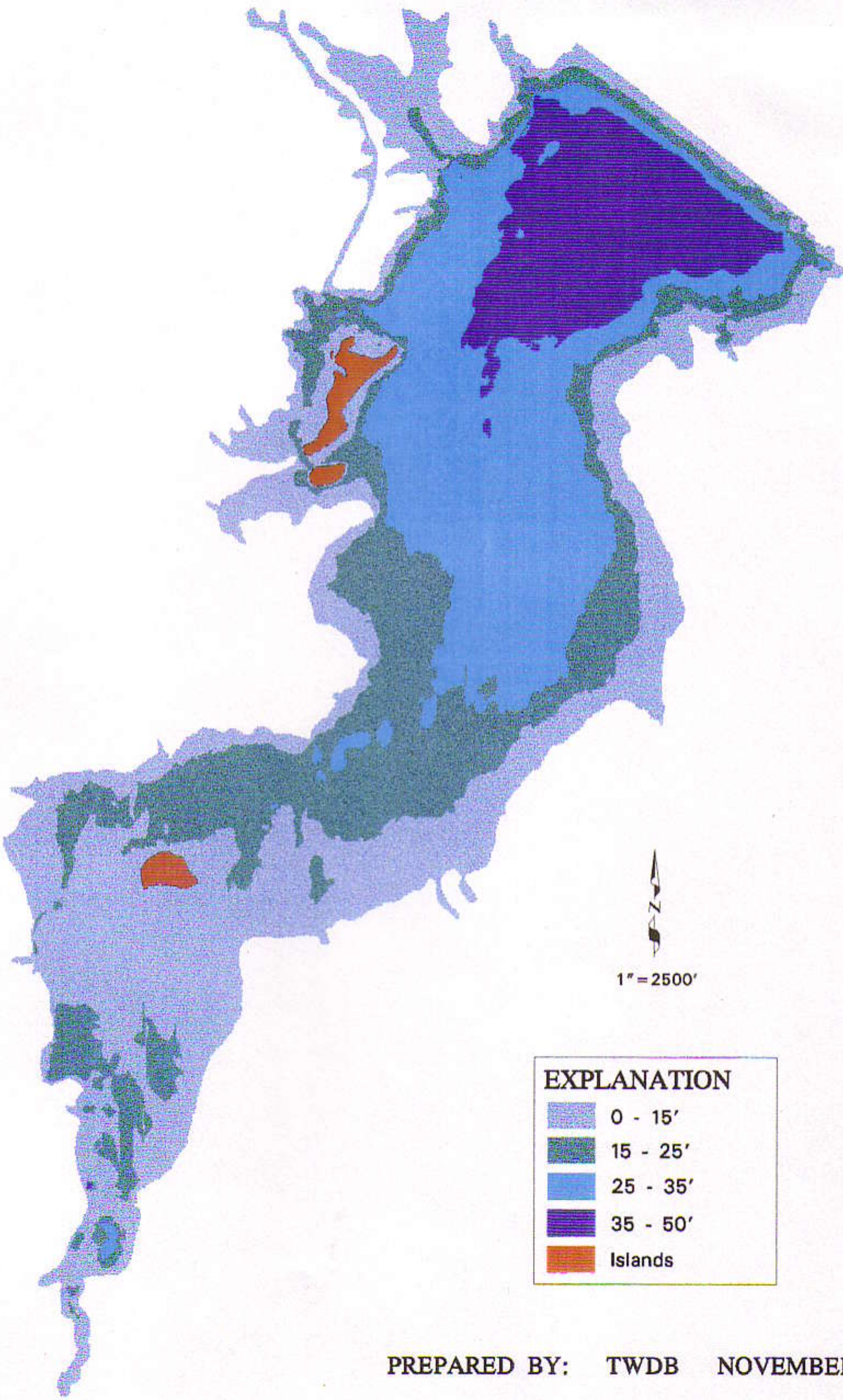


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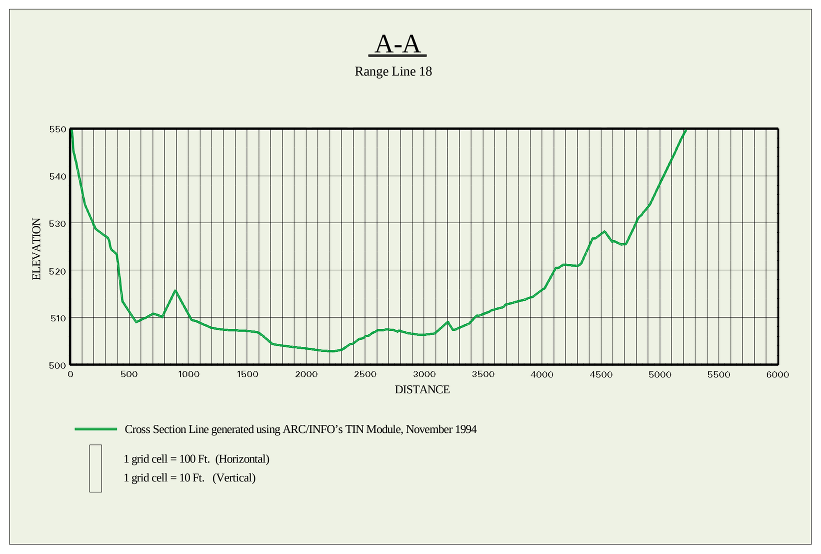
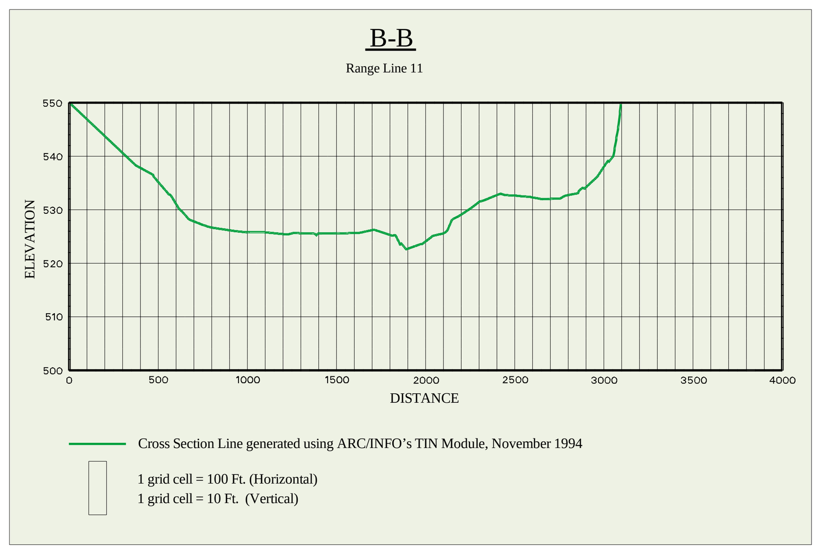
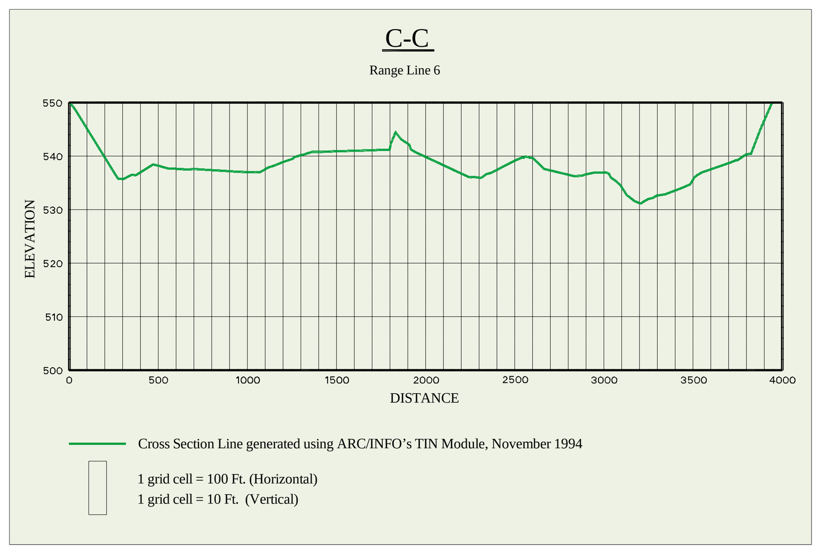
FIGURE 6

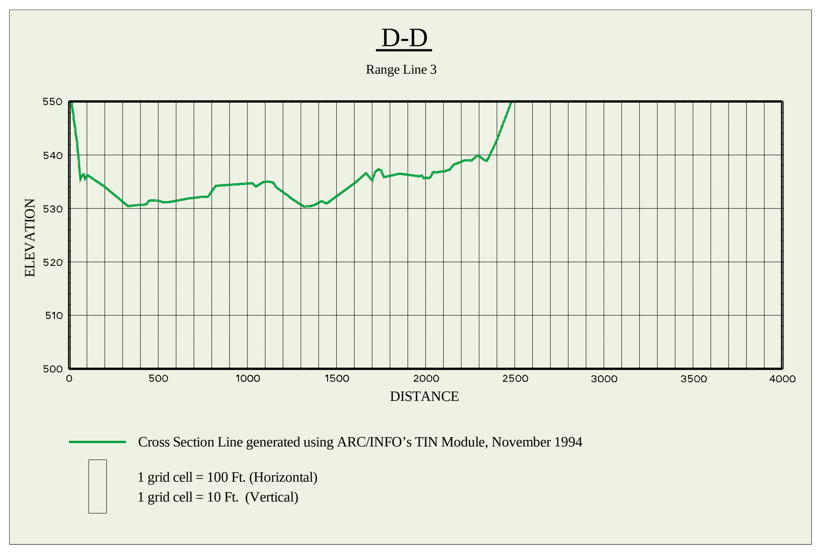
# LAKE ARLINGTON

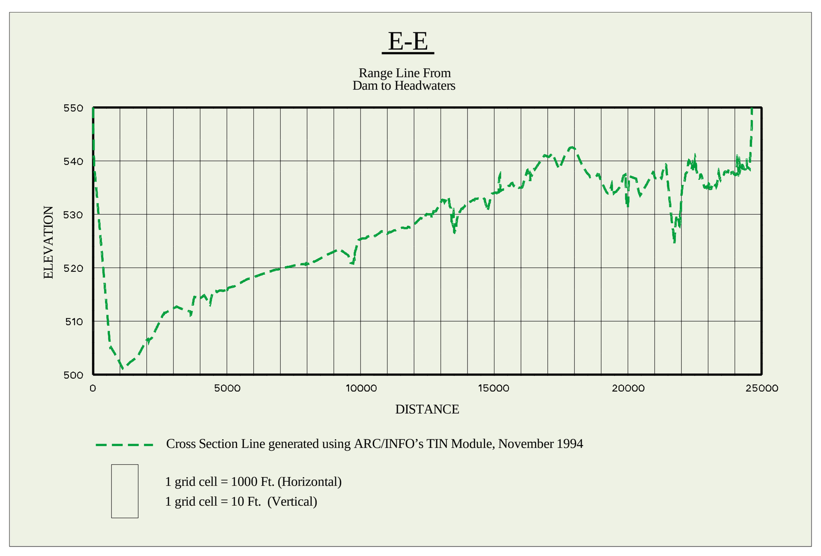
## Contour Map

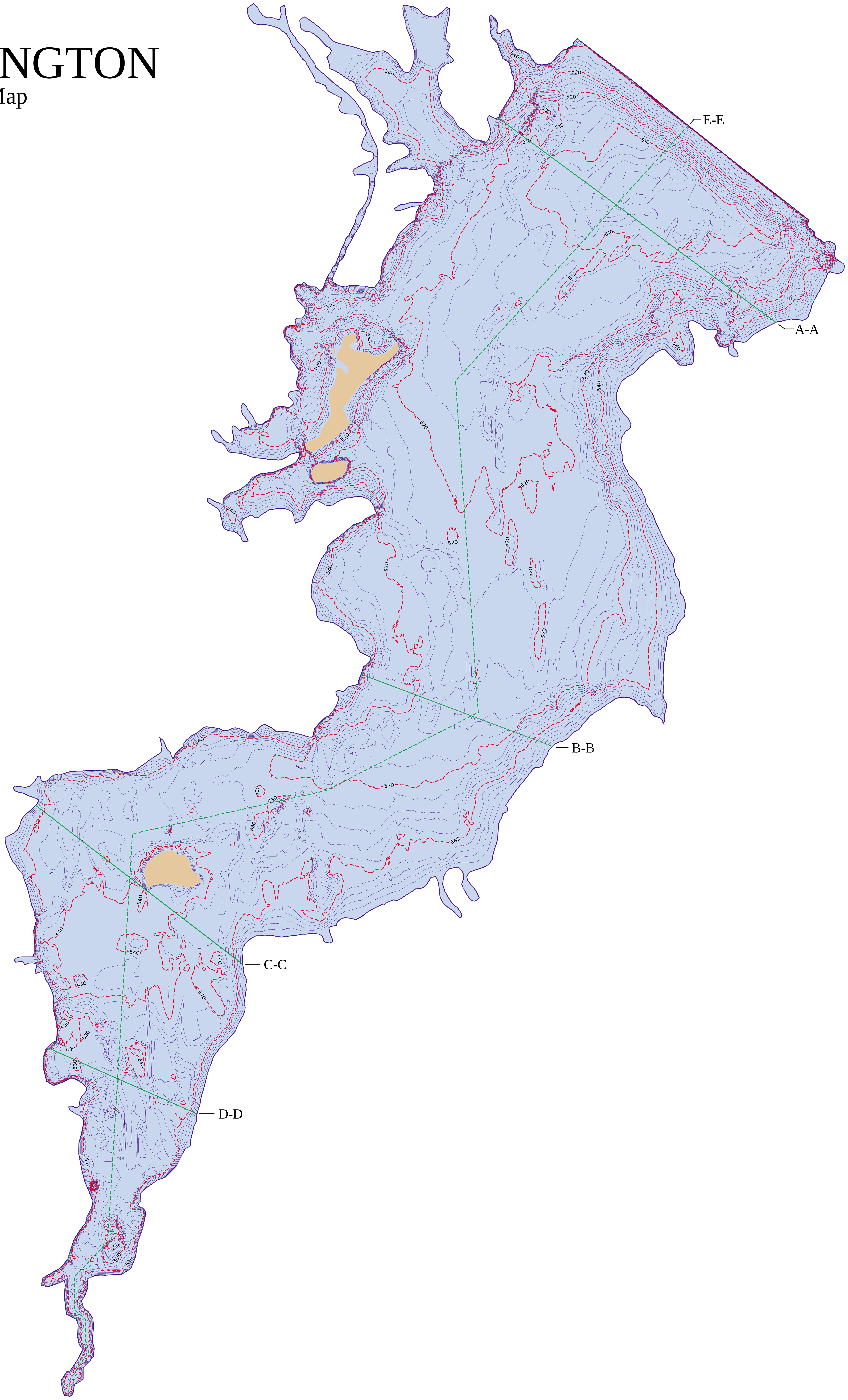


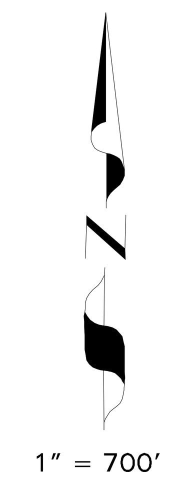




Tarrant County

EXPLANATION

- Lake Boundary
- Islands
- --000-- 10 Ft. Contour Lines with elevations
- Cross Section Line
- Cross Section Line From Dam to Headwaters

This map is the product of a hydrographic survey conducted to determine the capacity of the reservoir. 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: THE TEXAS WATER DEVELOPMENT BOARD

NOVEMBER 1994