Volumetric Survey
of
ALAN HENRY
RESERVOIR

July 2005 Survey

Prepared by:

The Texas Water Development Board

September 2006

Texas Water Development Board

J. Kevin Ward, Executive Administrator

Prepared for:

Brazos River Authority

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Executive Summary

In March of 2005, the Texas Water Development Board (TWDB) entered into agreement with the Brazos River Authority, for the purpose of performing a volumetric survey of Alan Henry Reservoir while the reservoir was near the top of the conservation pool elevation. This information was converted into updated Elevation-Volume and Elevation-Area Tables. The original design information for Alan Henry Reservoir is unavailable; therefore, the TWDB 2005 results are compared to the impoundment rights allowed by Permit to Appropriate State Water No. 4146. In addition, the TWDB established twenty-two sediment range lines to track sedimentation in the reservoir.

The results of the TWDB 2005 Survey indicate Alan Henry Reservoir has a volume of 94,808 acre-feet and encompasses 2,741 acres at conservation pool elevation, 2,220.0 ft above msl. Original reservoir volume, as per Permit to Appropriate State Water No. 4146 granted in 1984, was 115,937 acre-feet. This indicates the reservoir has experienced an 18% decrease in volume, or 21,129 acre-feet loss, since it was designed. The BRA states that the area of Lake Alan Henry is 2,884 acres at conservation pool elevation. The TWDB 2005 survey indicates a 5%, or 143 acre, loss in surface area at the conservation pool elevation.

Table of Contents

List of Tables

List of Figures

Appendices

Alan Henry Reservoir General Information

Alan Henry Reservoir is located in Garza and Kent Counties on the South Fork of the Double Mountain Fork of the Brazos River. See Figure 1, below.

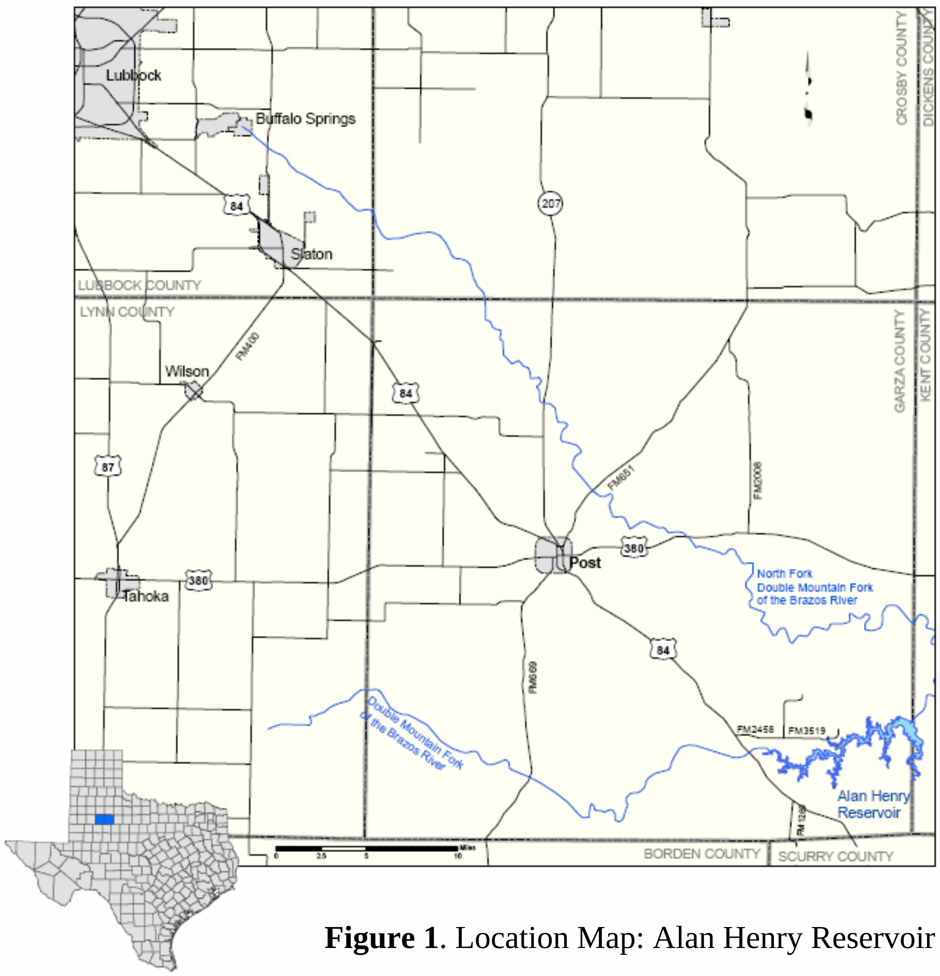


Figure 1. Location Map: Alan Henry Reservoir

Planning for the John T. Montford Dam and Alan Henry Reservoir began in the 1960's when city leaders realized that if the population of the City of Lubbock continued to grow as projected; the city would need another source for water. The application was granted and design work completed in the 1980's. Construction of the dam began in 1991, and was completed in October of 1993[1,2]. Currently, the City of Lubbock obtains 80% of its drinking water from Lake Meredith, north of Amarillo, and the other 20% from two ground water well fields in Bailey County (Muleshoe Area) and Roberts County (Pampa Area) that draw from the Ogallala Aquifer. Lake Alan Henry is a tertiary drinking water supply for future use.[1]

The City of Lubbock is located 65 miles Northwest of Alan Henry Reservoir, and is approximately 1,000 ft higher in elevation. Therefore, for Lubbock to use Alan Henry

Reservoir, the city needs three pump stations to take the water uphill to the city, a 65-mile pipeline to carry the water, and a new treatment plant to blend the Lake Alan Henry water with Bailey County well water. The treatment plant will be located in southwest Lubbock.[1]

Garza County and the majority of Alan Henry Reservoir are located within the Llano Estacado Regional Water Planning Group (LERWPG), Region O. LERWPG is a planning body only and does not hold any implementation authority. In the January 2006 Regional Water Plan, approved by the TWDB, there are two water management strategies involving Lake Alan Henry. The first is as a future water supply for the City of Lubbock. The second is to supply water to areas in close proximity to the lake under the jurisdiction of the Lake Alan Henry Water Supply District. The Lake Alan Henry Water Supply District was created through legislation enacted during the 78th Texas Legislative Session, 2003, for the purpose of supplying water from the lake to developing areas adjacent to and near the lake. Voters of the service area confirmed the District in 2004. The City of Lubbock, a wholesale water provider, and the Lake Alan Henry Water Supply District are currently in the process of negotiating a contract to supply water to the District. Figure 2 is a map of the Region O strategy and Lake Alan Henry Water Supply District Project.[3]

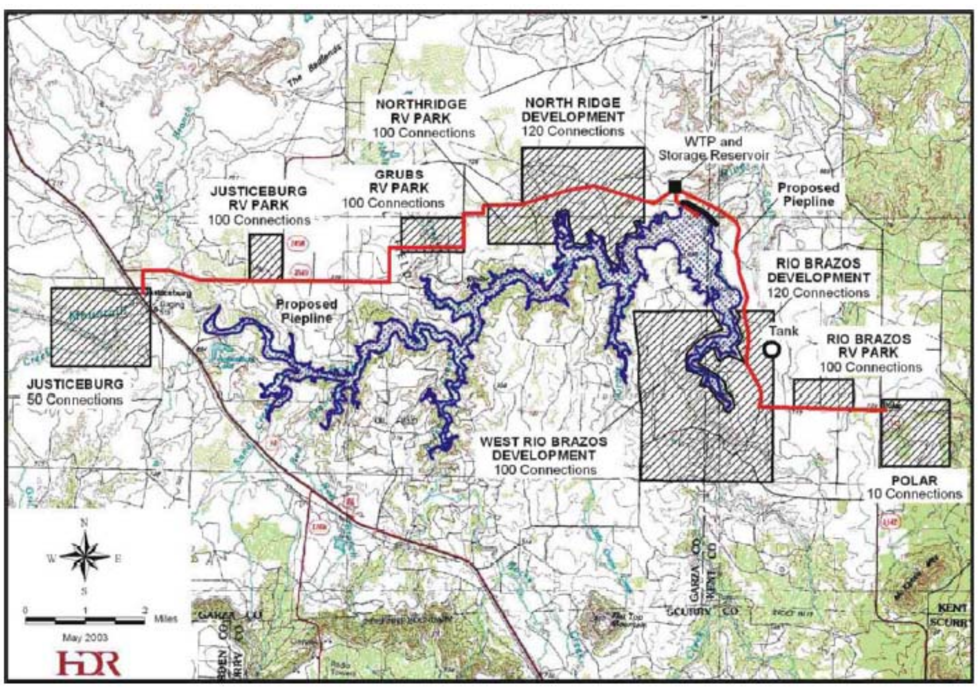


Figure 2. Lake Alan Henry Water Supply District Project Map, from the Region O Water Plan.[3]

Alan Henry Reservoir was built by the Brazos River Authority (BRA)[4] and operated by the BRA until 2005, when ownership and operation of the dam and reservoir became the responsibility of the City of Lubbock.[5] Water rights for Lake Alan Henry are as follows:

• **Permit to Appropriate State Water No. 4146**, granted August 6,1984, authorized the City of Lubbock to construct a dam and reservoir on the South Fork of the Double Mountain Fork of the Brazos River and impound therein not to exceed 115,937 acre-feet of water. The permit authorizes the City of Lubbock to divert and use not to exceed 35,000 acre-feet of water per annum from the reservoir for municipal purposes at a maximum diversion rate of 69.6 cfs. The City of Lubbock is also authorized to make secondary use of not to exceed 21,000 acre-feet of water per annum (treated sewage effluent) out of the maximum 35,000 acre-feet of water diverted for municipal purposes to irrigate 10,000 acres of land in Lubbock and Lynn Counties, Texas. In addition the permit authorizes the City of Lubbock to use the impounded water for non-consumptive recreational purposes.

• **Amendment to Water Use Permit No. 4146A**, granted May 2, 2005, recognizes that the Brazos River Authority (BRA) owns Permit No. 4146 with all the rights discussed above. The Amendment deletes the diversion point authorized by Permit 4146 and adds a diversion point at the existing diversion works of the dam, and adds a diversion segment on the north shore of Lake Alan Henry which includes the entire shoreline of the Sam Wahl Recreation Area in Garza County. The Amendment also requires the owner to implement water conservation plans.

• **Texas Commission on Environmental Quality (TCEQ) interoffice memorandum** dated December 19, 2005, from the Water Rights Permitting & Availability Section, Water Supply Division. This memorandum documents the change of ownership of Permit No. 4146A from the BRA to the City of Lubbock, a Texas home rule municipal corporation, by Agreement to Transfer Lake Alan Henry dated July 14, 2005; and Deed and Assignment Without Warranty and Bill of Sale dated August 16, 2005. The complete certificates and permits are on file in the Records Division of the TCEQ.

The following table is a list of pertinent data about the John T. Montford Dam and Alan Henry Reservoir.[1,6]

Table 1: Pertinent Data for the John T. Montford Dam and Alan Henry Reservoir

Owner:
City of Lubbock
Operator:
City of Lubbock
River Miles from Gulf: 1,056
Contributing drainage area (sq. miles): 394
Top of Conservation Pool Elevation: 2,220.0 ft above msl
Construction Facts
Composition: 6.5 Million cubic yards of soil, clay, and soil-cement
Height of Dam: 138 ft
Crest Elevation/ Top of Dam: 2,263 ft above msl
Length of Dam: 3,600 ft
Width of Dam: 1,000 ft wide at the base
Service Spillway (Concrete): Designed to pass 15.6 million gallons per minute
Emergency Spillway (Earthen): Designed to pass 211 million gallons per minute

Volumetric Survey of Alan Henry Reservoir

Introduction

In March of 2005, the Texas Water Development Board entered into agreement with the Brazos River Authority, for the purpose of performing a volumetric survey of Alan Henry Reservoir while the reservoir was near the top of the conservation pool elevation. This information was converted into updated Elevation-Volume and Elevation-Area Tables. Original design information is unavailable, therefore, the TWDB Survey results are compared to the permitted impoundment capacity in Permit to Appropriate State Water No. 4146 and new Sediment Range Lines have been established by the TWDB throughout Alan Henry Reservoir to track future sedimentation.

Bathymetric Survey

Bathymetric data collection for Alan Henry Reservoir occurred between July 7th and July 9th of 2005, while the water surface elevation was slightly below the conservation pool elevation of 2,220.0 ft above mean sea level (msl). The water surface elevation varied between 2,219.42 ft and 2,219.46 ft above msl during the TWDB survey. The survey team used one shallow water boat equipped with a depth sounder, velocity profiler, and integrated Differential Global Positioning System (DGPS) equipment to navigate along pre-planned range lines spaced approximately 500 feet apart in a perpendicular fashion to the original stream channel. During the 2005 survey, the team navigated over 129 miles of range lines and collected approximately 70,000 data points. Figure 3 shows the data points collected during the TWDB 2005 survey.

The depth sounder was calibrated each day using the velocity profiler to measure the speed of sound in the water column and a weighted tape or stadia rod to verify the depth reading. The average speed of sound through the water column varied between 4,858 and 4,913 feet per second during the 2005 survey.

Datum

The vertical datum used during this survey is that used by the United States Geological Survey (USGS) for the reservoir elevation gauge USGS 08079700 Lk Alan Henry Res nr Justiceburg, TX.[7] The datum for this gauge is reported as National Geodetic Vertical Datum 1929 (NGVD29) or mean sea level (msl), thus elevations reported here are in feet (ft) above msl. Volume and area calculations in this report are referenced to water levels provided by the USGS gauge. The horizontal datum used for this report is NAD83 State Plane Texas North Central Zone.

Survey Results

The results of the TWDB 2005 Survey indicate Alan Henry Reservoir has a volume of 94,808 acre-feet and encompasses 2,741 acres at conservation pool elevation, 2,220.0 ft above msl. This indicates the reservoir has experienced an 18% decrease in volume, or 21,129 acre-feet loss, when compared to the original reservoir volume of 115,937 acre-feet, as given in Permit to Appropriate State Water No. 4146. The BRA states that the area of Lake Alan Henry is 2,884 acres at conservation pool elevation.[6] The TWDB 2005 survey indicates a 5%, or 143 acre, reduction in surface area at the conservation pool elevation. Due to the likely differences in the methodologies used to calculate the reservoir's capacity between 1984 and 2005, comparison of these values is not recommended and is presented here for informational purposes only.[8] The TWDB considers the 2005 survey to be a significant improvement over previous methods and recommends that the same methodology be used to resurvey Alan Henry Reservoir in 5 to 10 years.

Data Processing

Model Boundary

The reservoir boundary was digitized from aerial photographs using Environmental Systems Research Institute's (ESRI) ArcGIS 9.1 software. The aerial photographs, or digital orthophoto quadrangle images (DOQs), used for Alan Henry Reservoir were Justiceburg and Justiceburg SE. These images were photographed on October 18, 2004. At the time of the photographs the water surface elevation measured 2,220.2 ft above msl, just above the conservation pool elevation. At the scale of the photographs, the difference between 2,220.0 ft and 2,220.2 ft is indiscernible; therefore the boundary was digitized at the land water interface from the photos, and assigned the conservation pool elevation of 2,220 ft.

The United States Department of Agriculture, Farm Service Agency's, Aerial Photography Field Office (APFO), National Agriculture Imagery Program (NAIP) acquires the photographic imagery during the agricultural growing seasons in the continental U.S.[9] The imagery resides in the public domain and can be downloaded from the Texas Natural Resources Information System (TNRIS) website at http://www.tnris.state.tx.us/. For more information visit the APFO website at http://www.apfo.usda.gov/NAIP.html or contact TNRIS.

Triangular Irregular Network (TIN) Model

Upon completion of data collection, the raw data files were edited using HydroEdit, an automated editing routine developed by the TWDB, to remove any data anomalies. The water surface elevations for each respective day are applied and the depths are converted to corresponding bathymetric elevations, exported, and converted to a shapefile using ArcCatalog. The ArcGIS 3D Analyst Extension is then used to create a Triangular Irregular Network (TIN) model of the bathymetry based on the sounding shapefile and the reservoir boundary files. The ArcGIS 3D Analyst Extension uses

Delaunay's criteria for triangulation to place a triangle between three non-uniformly spaced points, including vertices of the lines in the reservoir boundary file.[10] The Alan Henry Reservoir TIN Model was enhanced through the use of a Self-Similar Interpolation routine developed by the TWDB. See the following section on Self-Similar Interpolation and the Shallow Area Problem for more information.

Using Arc/Info software, volumes and areas are calculated from the TIN Model for the entire lake at one-tenth of a foot intervals, from elevation 2,140.8 ft to elevation 2,220.0 ft. The Elevation-Volume and Elevation-Area Tables, updated for 2005, are presented in Appendices A and B, respectively. An Elevation-Volume graph and an Elevation- Area graph are presented in Appendices C and D, respectively.

The TIN Model was interpolated and averaged using a cell size of 10 ft and converted to a raster. The raster was used to produce Figure 4, an Elevation Relief Map representing the topography of the reservoir bottom, Figure 5, a map showing shaded depth ranges for Alan Henry Reservoir, and Figure 6, a 10-ft contour map.

Self-Similar Interpolation and the Shallow Area Problem

A limitation of the Delaunay method for triangulation in the TIN Model results in artificially-curved contour lines extending into the reservoir where the reservoir walls are steep and the reservoir is relatively narrow. These curved contours are likely a poor representation of the true reservoir bathymetry in these areas. To ameliorate this problem, a Self-Similar Interpolation routine (developed by the TWDB) was used to interpolate the bathymetry in between many 500ft-spaced survey lines to increase the density of points input into the TIN Model. The increased point density alters the mean triangle shape from long and skinny to more equilateral, thus providing better representations of reservoir topography.[11] In areas where obvious geomorphic features indicate a high-probability of cross-section shape changes (e.g. incoming tributaries, significant widening/narrowing of channel, etc.), this self-similar assumption is not likely to be valid; therefore, self-similar interpolation was not used in areas of Alan Henry Reservoir where a high probability of change between cross-sections exists.[11] Figure 7 shows the resulting point density after the Self-Similar Interpolation routine was employed. The area interpolated equals 36.5% of the reservoir area (at conservation pool elevation).

Another limitation of the Delaunay method of TIN generation involves the calculation of areas and volumes in sections of the reservoir that were too shallow for bathymetric data collection by boat. This “shallow area problem,” as identified by the TWDB, is corrected using the HydroEdit interpolation routines developed by the TWDB. The Delaunay triangulation method, within ArcGIS, creates large flat triangles throughout these un-surveyed areas for which each corner of the triangle lies on the reservoir boundary. These triangles do not suggests any change in slope along the boundary and are assigned zero depths, causing an artificial spike in the elevation-area graphs at the last elevation interval for which reservoir areas are calculated. To correct this, the HydroEdit software program linearly interpolates elevations along connecting lines between the reservoir boundary vertices and their closest sounding points. These interpolated data points are used in conjunction with the surveyed sounding points and the Self-Similar Interpolated points to generate the TIN model. The additional data points result in a model with a more realistic representation of the reservoir bathymetry.[11] Figure 8 shows the resulting point density after the HydroEdit “Shallow Area Problem” routine was employed.

Sediment Range Lines

Information for the original design, including range lines, was unavailable. Therefore, the TWDB established twenty-two Sediment Range Lines in Alan Henry Reservoir to track sedimentation in the reservoir. Using ArcGIS, the TWDB staff established sediment range lines near the confluences of each stream, the main channel of the lake, and in bends in the main lake channel where water velocities would slow and drop any sediment load. The Sediment Range Line cross-sectional plots presented in Appendix E were extracted from the TIN Model. Appendix E also contains a map displaying the location of the range lines and a Table listing the endpoint coordinates of each line.

References

1. Lake Alan Henry, Official Website by City of Lubbock Parks and Recreation, http://www.lakealanhenry.org/, 3 April 2006.

2. Water Resources Data, Texas, Water Year 2002, Volume 3. San Jacinto River Basin, Brazos River Basin, San Bernard River Basin, and Intervening Coastal Basins, USGS

3.Llano Estacado Regional Water Planning Group (Region O) Homepage, 19 December 2005, http://www.llanoplan.org/, April 3, 2006.

4. BRA News Release, "FRASER ANNOUNCES ABILENE WATER AGREEMENT," 11 April 2005, http://www.brazos.org/newsArchive.asp, 3 April 2006.

5. Texas Commission on Environmental Quality Interoffice Memorandum from Water Rights Permitting and Availability Section, Water Supply Division, Subject: Change of Ownership, December 19, 2005.

6. Brazos River Authority, Water Supply and Reservoir Data, http://www.brazos.org/waterSupply.asp, 3 April 2006.

7. United States Geological Survey, http://tx.usgs.gov/ 11 July 2005.

8. Blanton III, James O. Bureau of Reclamation. 1982. "Procedures for Monitoring Reservoir Sedimentation."

9. U.S Department of Agriculture, Farm Service Agency, Aerial Photography Field Office, National Agriculture Imagery Program, http://www.apfo.usda.gov/NAIP.html, 2/10/06.

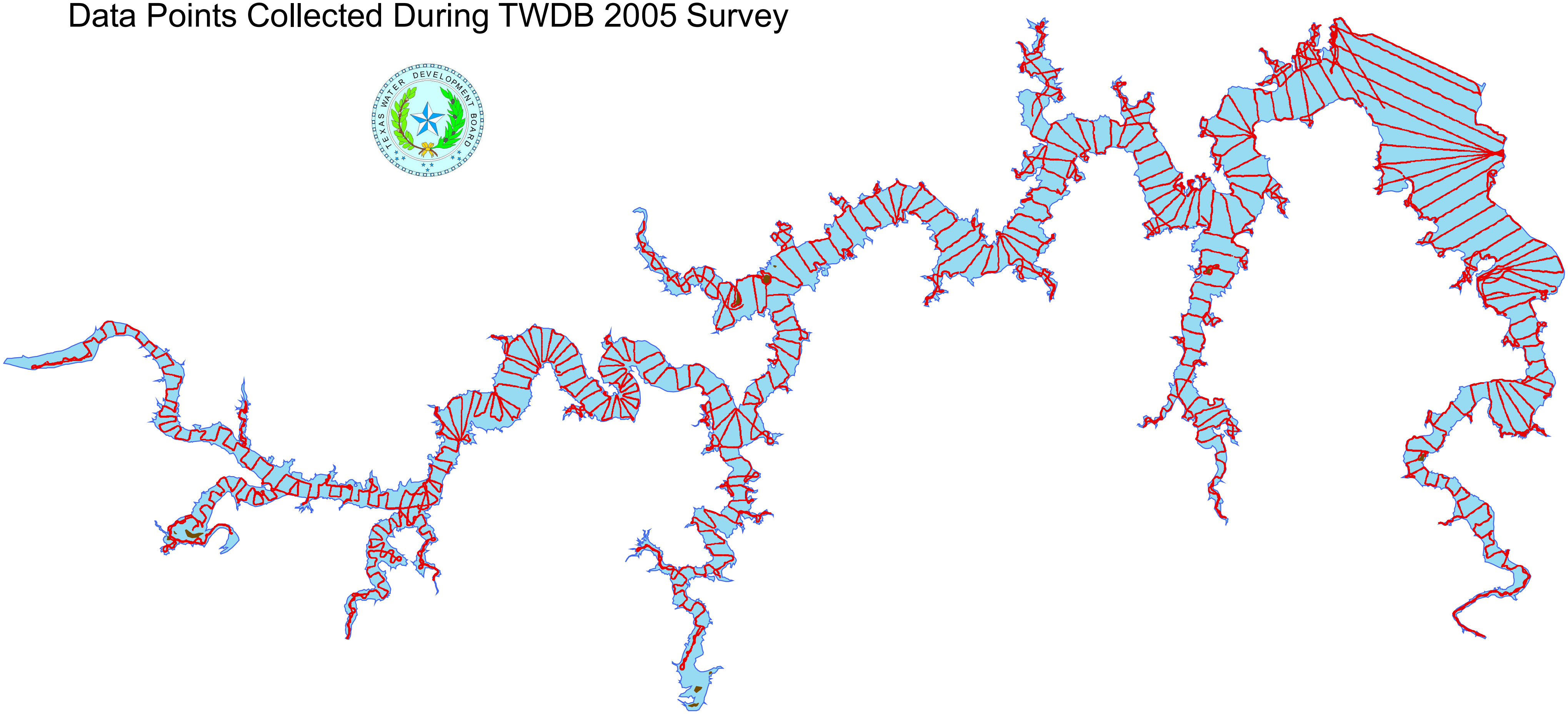
10. ESRI, Environmental Systems Research Institute. 1995. ARC/INFO Surface Modeling and Display, TIN Users Guide.

11. Furnans, Jordan. Texas Water Development Board. 2006. "HydroEdit User's Manual."

Figure 3

Alan Henry Reservoir

Data Points Collected During TWDB 2005 Survey



Legend

Data Points

Islands

Lake Boundary
Elevation: 2,220.0 ft

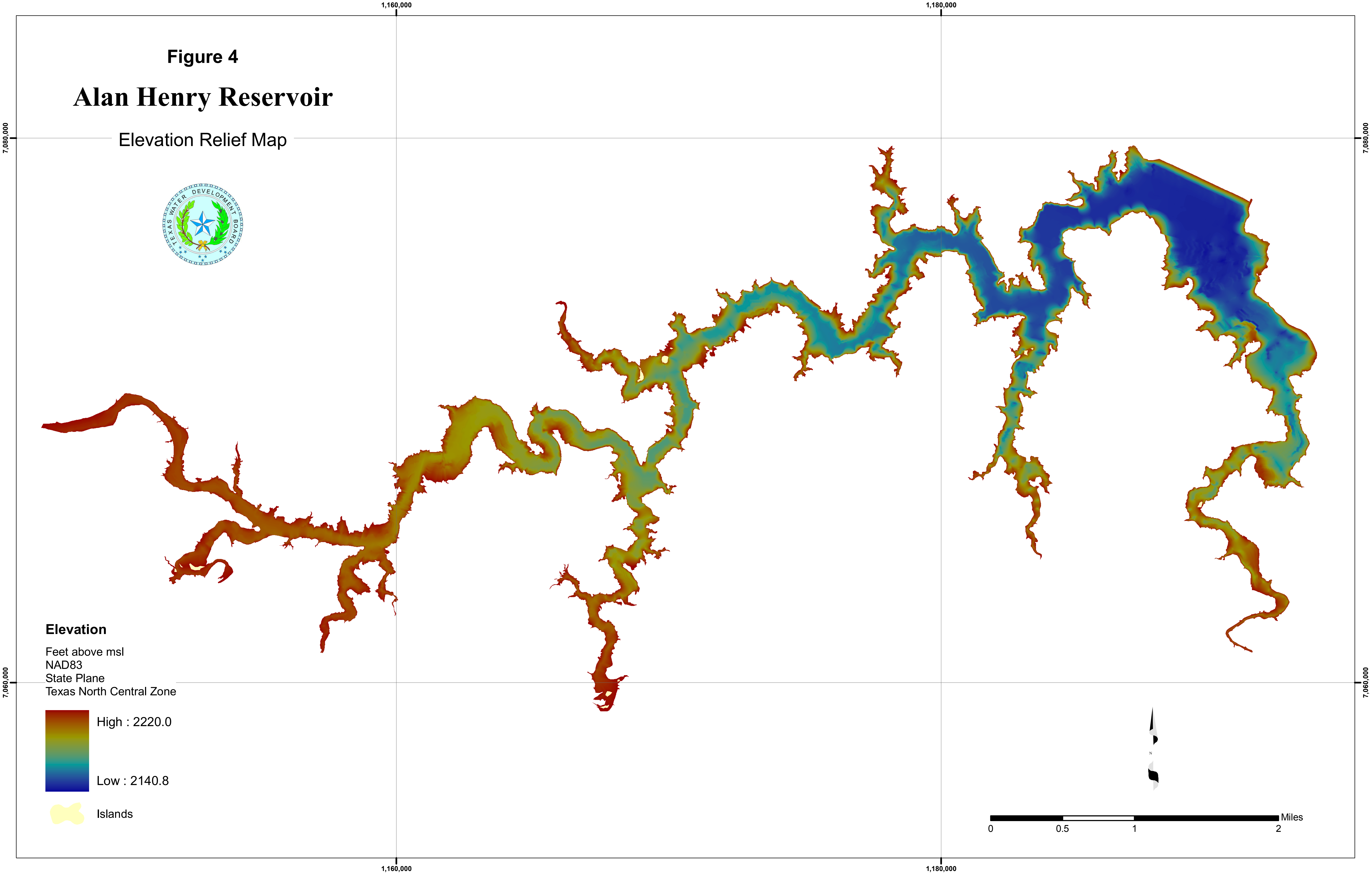


Figure 4
Alan Henry Reservoir
Elevation Relief Map
1,160,000
1,180,000
7,080,000
7,060,000
Elevation
Feet above msl
NAD83
State Plane
Texas North Central Zone
High : 2220.0
Low : 2140.8
Islands
Miles
0
0.5
1
2

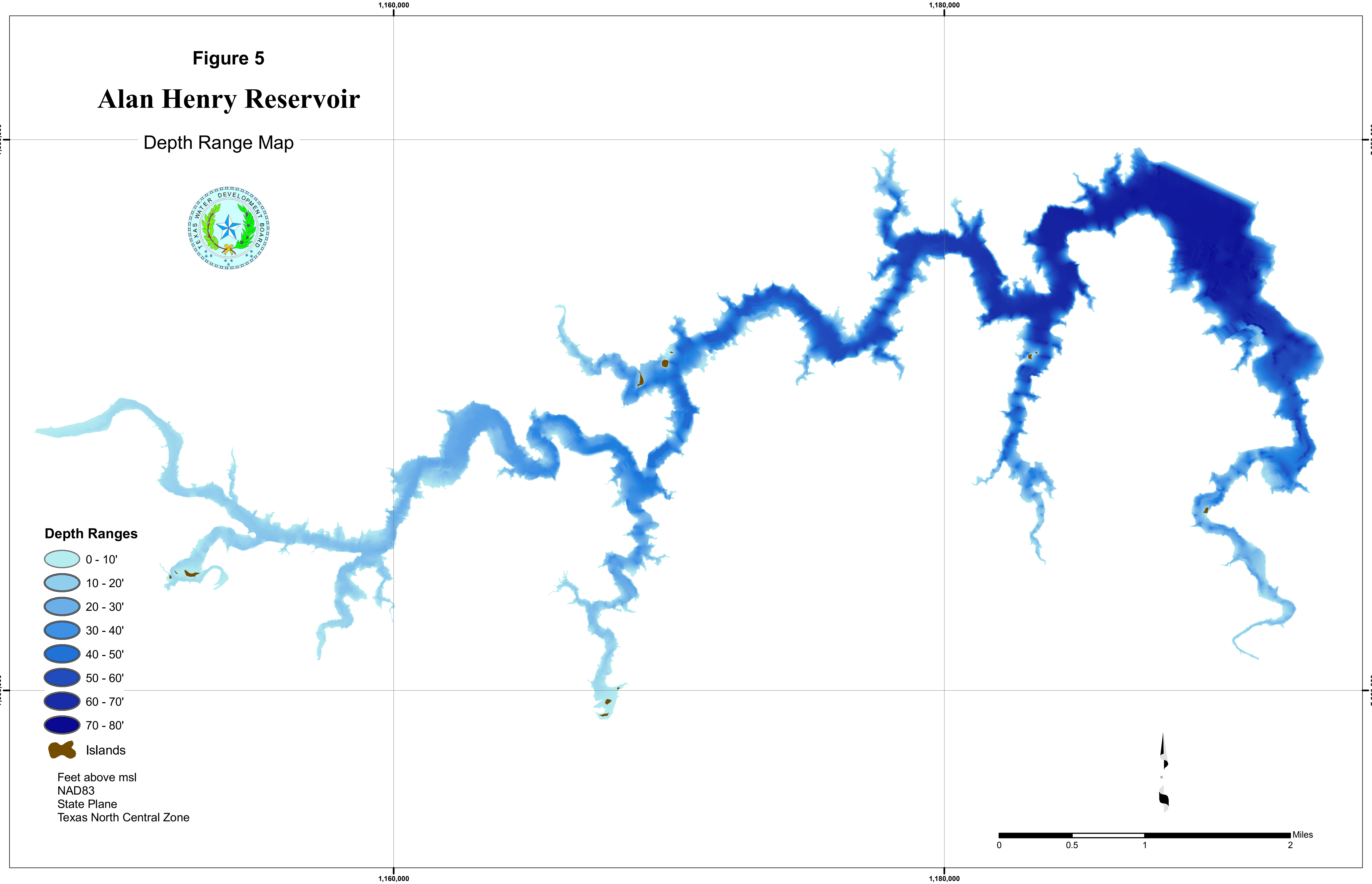
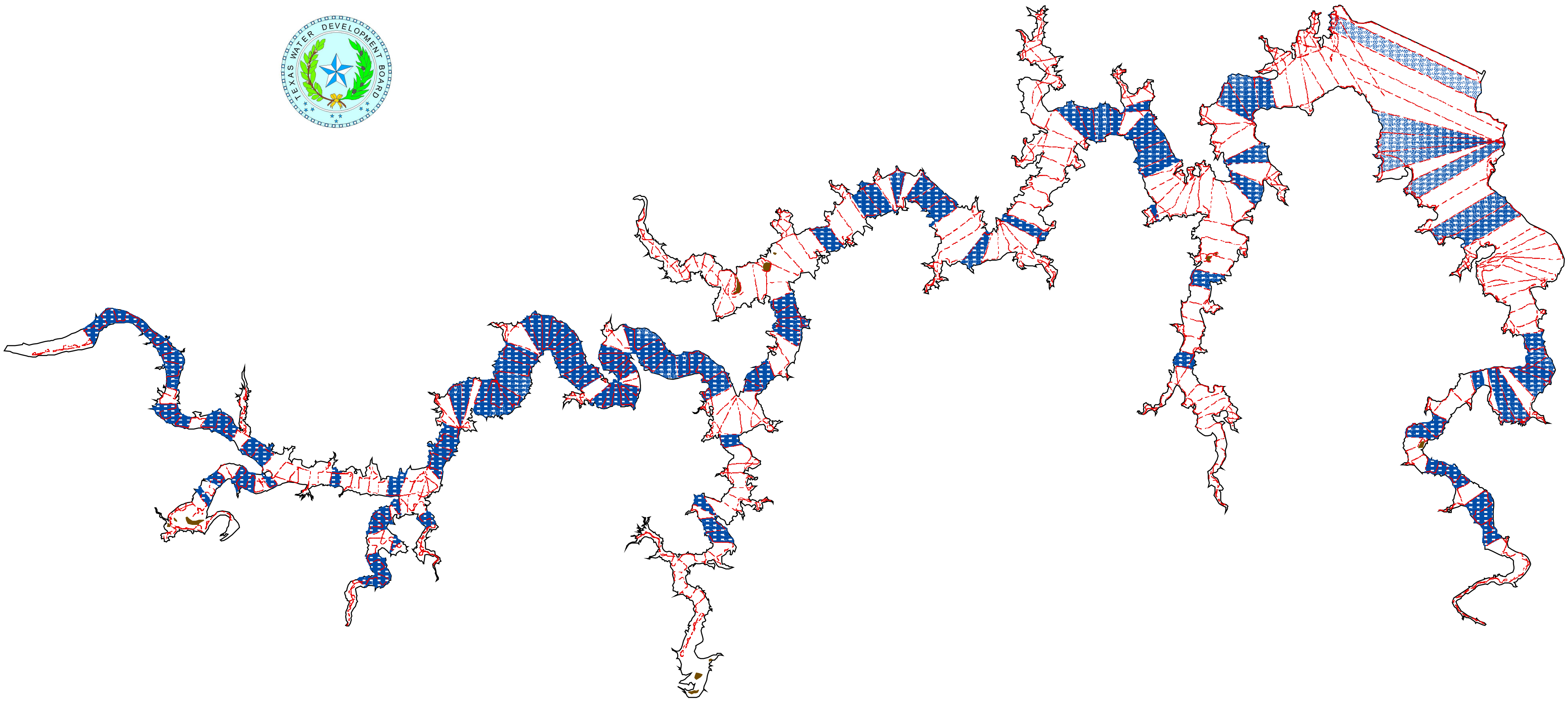


Figure 5
Alan Henry Reservoir
Depth Range Map
Depth Ranges
0 - 10'
10 - 20'
20 - 30'
30 - 40'
40 - 50'
50 - 60'
60 - 70'
70 - 80'
Islands
Feet above msl
NAD83
State Plane
Texas North Central Zone
1,160,000
1,180,000
7,080,000
7,060,000
Miles
0
0.5
1
2

Figure 7

Alan Henry Reservoir

Self-Similar Interpolation Routine Results



Legend

Data Points Collected During TWDB 2005 Survey

Data Points Added Using the HydroEdit Self-Similar Interpolation Routine

Islands

Lake Boundary Elev. 2,220 ft above msl

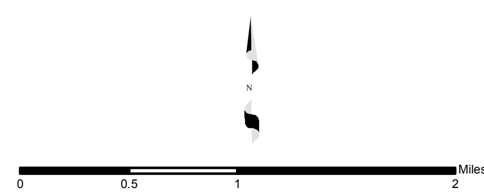
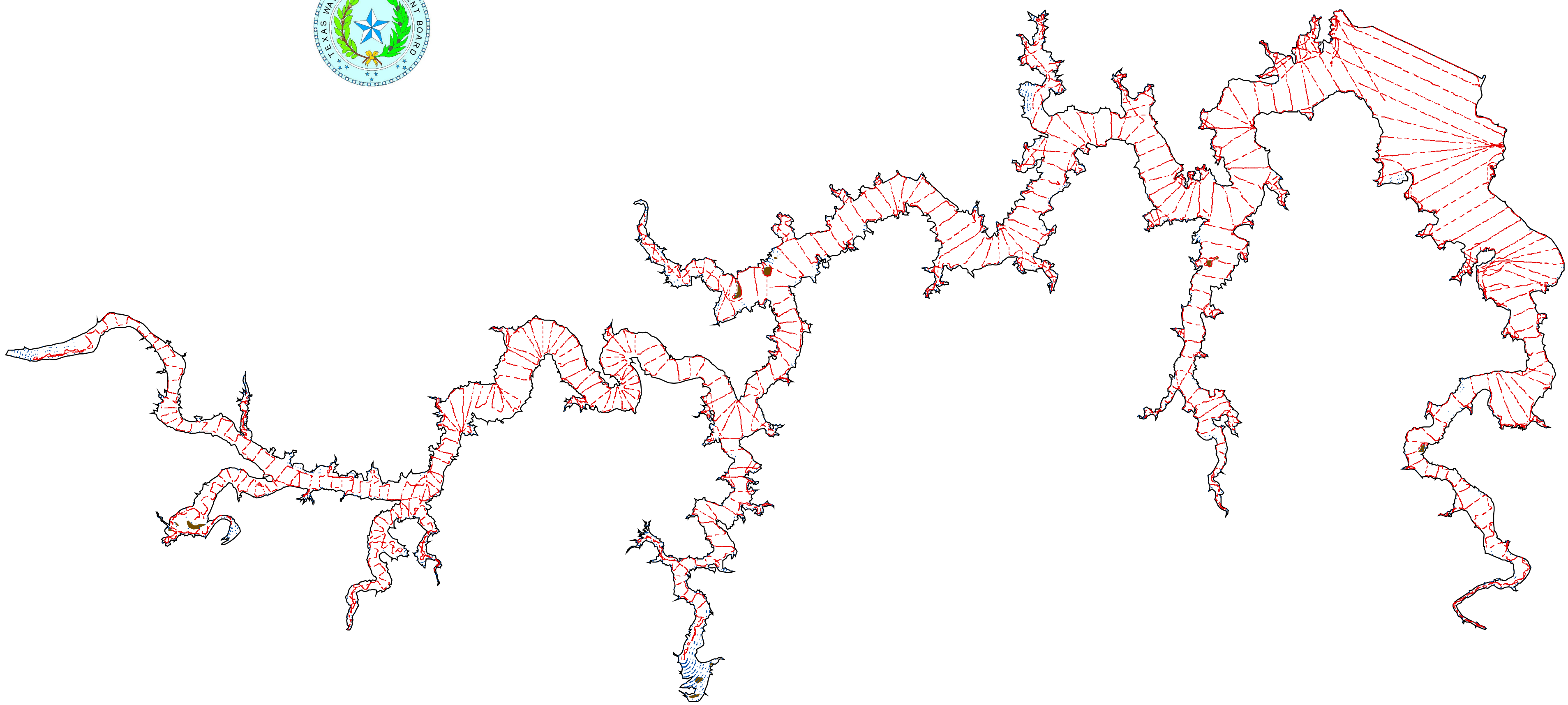


Figure 8

Alan Henry Reservoir

HydroEdit "Shallow Area Problem" Routine Results



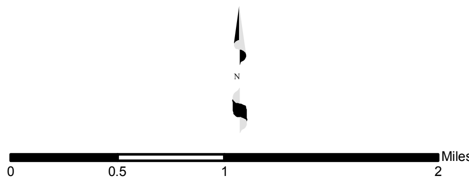
Legend

Data Points Collected During TWDB 2005 Survey

Data Points Added Using the HydroEdit
"Shallow Area Problem" Routine

Islands

Lake Boundary
Elevation 2,220 ft above msl



Appendix A

Alan Henry Reservoir

RESERVOIR VOLUME TABLE

TEXAS WATER DEVELOPMENT BOARD | JULY 2005 SURVEY

Conservation Pool Elevation 2,220.0'

VOLUME IN ACRE-FEET | ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2,140									0	0
2,141	0	0	0	0	0	0	0	0	0	0
2,142	0	0	0	0	0	0	0	0	0	0
2,143	0	1	1	1	1	1	1	2	2	3
2,144	3	4	5	6	7	9	10	12	14	17
2,145	19	22	25	29	34	39	46	54	62	72
2,146	83	95	108	121	136	152	168	185	203	222
2,147	242	262	282	303	325	348	371	394	418	443
2,148	468	494	519	546	572	599	626	654	682	710
2,149	739	768	797	827	858	889	921	953	985	1,017
2,150	1,050	1,082	1,116	1,149	1,182	1,216	1,250	1,285	1,319	1,354
2,151	1,389	1,424	1,460	1,496	1,532	1,569	1,606	1,644	1,682	1,720
2,152	1,759	1,797	1,836	1,876	1,915	1,955	1,995	2,036	2,077	2,118
2,153	2,159	2,200	2,242	2,285	2,327	2,370	2,413	2,457	2,500	2,544
2,154	2,588	2,632	2,677	2,722	2,767	2,812	2,858	2,903	2,949	2,996
2,155	3,042	3,089	3,136	3,183	3,231	3,279	3,327	3,375	3,424	3,473
2,156	3,523	3,572	3,622	3,673	3,723	3,774	3,825	3,876	3,927	3,979
2,157	4,031	4,083	4,135	4,188	4,241	4,294	4,347	4,401	4,455	4,509
2,158	4,563	4,618	4,672	4,728	4,783	4,839	4,894	4,951	5,007	5,064
2,159	5,121	5,178	5,235	5,293	5,350	5,409	5,467	5,525	5,584	5,643
2,160	5,703	5,762	5,822	5,883	5,943	6,004	6,065	6,126	6,188	6,250
2,161	6,313	6,375	6,438	6,501	6,565	6,628	6,692	6,757	6,821	6,886
2,162	6,951	7,017	7,082	7,149	7,215	7,282	7,349	7,416	7,484	7,552
2,163	7,621	7,690	7,759	7,829	7,898	7,968	8,039	8,109	8,180	8,251
2,164	8,322	8,394	8,465	8,537	8,609	8,682	8,754	8,827	8,900	8,973
2,165	9,047	9,121	9,195	9,269	9,344	9,419	9,494	9,569	9,645	9,720
2,166	9,796	9,873	9,949	10,026	10,102	10,180	10,257	10,334	10,412	10,490
2,167	10,569	10,647	10,726	10,805	10,884	10,963	11,043	11,123	11,203	11,283
2,168	11,364	11,445	11,526	11,608	11,689	11,771	11,854	11,936	12,019	12,102
2,169	12,185	12,268	12,352	12,436	12,520	12,604	12,688	12,773	12,858	12,943
2,170	13,029	13,115	13,200	13,287	13,373	13,460	13,546	13,633	13,721	13,808
2,171	13,896	13,984	14,072	14,161	14,249	14,339	14,428	14,517	14,607	14,697
2,172	14,787	14,878	14,969	15,060	15,151	15,243	15,335	15,426	15,519	15,611
2,173	15,704	15,797	15,891	15,984	16,078	16,172	16,266	16,360	16,455	16,550
2,174	16,645	16,740	16,836	16,932	17,027	17,124	17,220	17,317	17,414	17,511
2,175	17,609	17,707	17,804	17,903	18,001	18,100	18,199	18,298	18,398	18,497
2,176	18,597	18,697	18,798	18,899	18,999	19,101	19,202	19,304	19,406	19,508
2,177	19,610	19,713	19,816	19,919	20,022	20,126	20,230	20,334	20,438	20,542
2,178	20,647	20,753	20,858	20,964	21,069	21,176	21,282	21,389	21,496	21,603
2,179	21,711	21,819	21,926	22,035	22,143	22,252	22,361	22,470	22,580	22,689
2,180	22,800	22,910	23,020	23,131	23,242	23,353	23,465	23,577	23,689	23,801
2,181	23,914	24,027	24,140	24,253	24,366	24,480	24,595	24,709	24,824	24,939
2,182	25,054	25,170	25,285	25,401	25,518	25,634	25,751	25,868	25,986	26,104
2,183	26,222	26,340	26,458	26,577	26,696	26,816	26,936	27,056	27,176	27,296
2,184	27,417	27,539	27,660	27,782	27,903	28,026	28,149	28,271	28,394	28,518
2,185	28,641	28,766	28,890	29,014	29,139	29,264	29,390	29,516	29,642	29,768
2,186	29,895	30,022	30,149	30,276	30,404	30,532	30,660	30,788	30,917	31,046
2,187	31,176	31,306	31,436	31,566	31,696	31,827	31,959	32,090	32,222	32,353
2,188	32,486	32,618	32,751	32,884	33,017	33,151	33,285	33,419	33,554	33,689
2,189	33,824	33,959	34,095	34,231	34,367	34,504	34,641	34,778	34,916	35,054
2,190	35,192	35,331	35,469	35,609	35,748	35,888	36,028	36,169	36,310	36,451
2,191	36,592	36,734	36,876	37,018	37,161	37,304	37,447	37,590	37,734	37,878
2,192	38,023	38,167	38,312	38,458	38,603	38,750	38,896	39,043	39,190	39,337
2,193	39,485	39,633	39,781	39,930	40,079	40,229	40,379	40,529	40,680	40,831
2,194	40,982	41,134	41,286	41,439	41,592	41,745	41,899	42,053	42,207	42,362
2,195	42,517	42,672	42,828	42,984	43,141	43,298	43,455	43,613	43,771	43,930
2,196	44,089	44,248	44,408	44,568	44,729	44,890	45,052	45,213	45,376	45,538
2,197	45,702	45,865	46,029	46,194	46,358	46,523	46,689	46,854	47,021	47,187
2,198	47,354	47,522	47,689	47,857	48,026	48,195	48,364	48,533	48,704	48,874
2,199	49,045	49,216	49,387	49,559	49,731	49,904	50,077	50,250	50,424	50,598

Appendix A (Continued)

Alan Henry Reservoir

RESERVOIR VOLUME TABLE

TEXAS WATER DEVELOPMENT BOARD JULY 2005 SURVEY

Conservation Pool Elevation 2,220.0'

VOLUME IN ACRE-FEET ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2,200	50,773	50,948	51,123	51,298	51,474	51,650	51,827	52,004	52,181	52,359
2,201	52,537	52,716	52,894	53,074	53,253	53,433	53,614	53,794	53,975	54,156
2,202	54,338	54,520	54,703	54,886	55,069	55,252	55,437	55,621	55,806	55,991
2,203	56,177	56,363	56,550	56,737	56,924	57,112	57,301	57,489	57,679	57,868
2,204	58,058	58,249	58,440	58,631	58,823	59,015	59,208	59,401	59,595	59,789
2,205	59,984	60,179	60,374	60,570	60,766	60,963	61,160	61,358	61,556	61,754
2,206	61,954	62,153	62,353	62,554	62,754	62,956	63,158	63,359	63,562	63,765
2,207	63,969	64,173	64,377	64,583	64,788	64,994	65,201	65,408	65,616	65,824
2,208	66,032	66,242	66,451	66,662	66,872	67,083	67,295	67,507	67,721	67,934
2,209	68,148	68,363	68,577	68,793	69,009	69,226	69,443	69,661	69,879	70,097
2,210	70,317	70,537	70,756	70,977	71,198	71,420	71,642	71,864	72,088	72,311
2,211	72,535	72,760	72,985	73,211	73,437	73,664	73,891	74,119	74,347	74,576
2,212	74,805	75,035	75,266	75,497	75,728	75,960	76,193	76,426	76,660	76,894
2,213	77,129	77,364	77,599	77,836	78,072	78,310	78,548	78,786	79,025	79,264
2,214	79,504	79,744	79,985	80,226	80,468	80,710	80,954	81,197	81,441	81,684
2,215	81,929	82,175	82,420	82,667	82,913	83,160	83,408	83,656	83,905	84,153
2,216	84,403	84,654	84,904	85,155	85,406	85,658	85,911	86,164	86,417	86,671
2,217	86,926	87,181	87,436	87,692	87,948	88,205	88,463	88,720	88,979	89,238
2,218	89,497	89,758	90,018	90,279	90,540	90,803	91,066	91,329	91,593	91,857
2,219	92,122	92,388	92,654	92,921	93,188	93,457	93,726	93,995	94,265	94,536
2,220	94,808									

Appendix B

Alan Henry Reservoir

RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD JULY 2005 SURVEY

Conservation Pool Elevation 2,220.0'

AREA IN ACRES ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2,140									0	0
2,141	0	0	0	0	0	0	0	0	0	0
2,142	0	0	0	0	0	0	0	1	1	1
2,143	1	1	1	2	2	2	3	3	4	5
2,144	6	8	10	12	14	16	18	20	22	24
2,145	27	30	35	41	50	61	72	82	92	104
2,146	114	122	132	143	151	160	169	177	184	191
2,147	197	203	209	215	222	228	233	238	244	249
2,148	253	257	260	264	267	270	274	277	281	285
2,149	289	294	298	303	309	313	317	320	322	325
2,150	327	329	332	335	337	339	342	345	347	349
2,151	352	355	358	362	366	370	374	377	381	384
2,152	387	389	392	394	397	400	403	406	409	411
2,153	414	417	421	424	427	430	433	435	437	440
2,154	442	444	446	449	452	454	457	459	461	464
2,155	466	469	472	474	477	480	483	487	490	493
2,156	496	498	501	503	506	508	511	514	516	518
2,157	520	522	524	527	529	532	534	537	540	542
2,158	545	547	550	553	555	558	560	563	565	568
2,159	570	573	575	577	580	582	584	587	589	592
2,160	595	598	601	604	607	610	613	616	619	622
2,161	624	627	630	633	636	639	642	644	647	650
2,162	653	656	659	662	666	670	673	677	680	684
2,163	687	690	693	696	699	701	704	706	709	711
2,164	714	716	718	721	723	725	727	729	732	734
2,165	737	740	742	745	747	749	751	754	756	759
2,166	761	763	766	768	770	772	775	777	779	782
2,167	784	786	788	790	793	795	798	800	803	805
2,168	808	810	813	816	819	821	824	826	828	830
2,169	833	835	837	839	842	844	847	849	851	853
2,170	856	858	860	862	865	867	869	872	874	876
2,171	879	882	884	887	889	892	894	896	899	902
2,172	904	907	909	912	914	917	919	922	924	927
2,173	929	932	934	936	938	940	943	945	947	950
2,174	952	954	957	959	962	964	966	969	971	974
2,175	976	979	981	983	986	988	991	993	996	998
2,176	1,001	1,003	1,006	1,008	1,010	1,013	1,016	1,018	1,020	1,023
2,177	1,025	1,028	1,030	1,032	1,035	1,037	1,039	1,042	1,044	1,047
2,178	1,050	1,053	1,055	1,058	1,061	1,064	1,066	1,069	1,071	1,074
2,179	1,076	1,079	1,081	1,084	1,086	1,089	1,091	1,094	1,096	1,099
2,180	1,101	1,104	1,106	1,109	1,112	1,114	1,117	1,119	1,122	1,124
2,181	1,127	1,130	1,132	1,135	1,138	1,140	1,143	1,146	1,148	1,151
2,182	1,153	1,156	1,159	1,162	1,165	1,168	1,171	1,173	1,176	1,179
2,183	1,182	1,184	1,187	1,190	1,193	1,196	1,198	1,201	1,204	1,207
2,184	1,210	1,213	1,216	1,218	1,221	1,224	1,227	1,230	1,233	1,236
2,185	1,239	1,242	1,245	1,248	1,250	1,253	1,256	1,259	1,262	1,264
2,186	1,267	1,270	1,273	1,276	1,278	1,281	1,284	1,287	1,290	1,293
2,187	1,296	1,299	1,302	1,304	1,307	1,310	1,312	1,315	1,318	1,321
2,188	1,324	1,326	1,329	1,332	1,335	1,338	1,341	1,344	1,347	1,350
2,189	1,353	1,356	1,359	1,362	1,365	1,368	1,371	1,374	1,378	1,381
2,190	1,384	1,387	1,390	1,394	1,397	1,400	1,403	1,407	1,410	1,413
2,191	1,416	1,419	1,422	1,425	1,428	1,430	1,433	1,436	1,439	1,442
2,192	1,446	1,449	1,452	1,455	1,459	1,462	1,466	1,469	1,472	1,476
2,193	1,479	1,483	1,486	1,490	1,494	1,497	1,501	1,505	1,508	1,512
2,194	1,516	1,520	1,524	1,527	1,531	1,535	1,538	1,542	1,545	1,549
2,195	1,553	1,557	1,560	1,564	1,568	1,572	1,576	1,580	1,584	1,588
2,196	1,592	1,596	1,600	1,604	1,609	1,613	1,617	1,622	1,626	1,629
2,197	1,633	1,637	1,641	1,645	1,649	1,652	1,656	1,660	1,664	1,668
2,198	1,672	1,676	1,679	1,683	1,687	1,691	1,694	1,698	1,702	1,706
2,199	1,710	1,713	1,717	1,721	1,724	1,728	1,732	1,735	1,739	1,743

Appendix B (Continued)

Alan Henry Reservoir

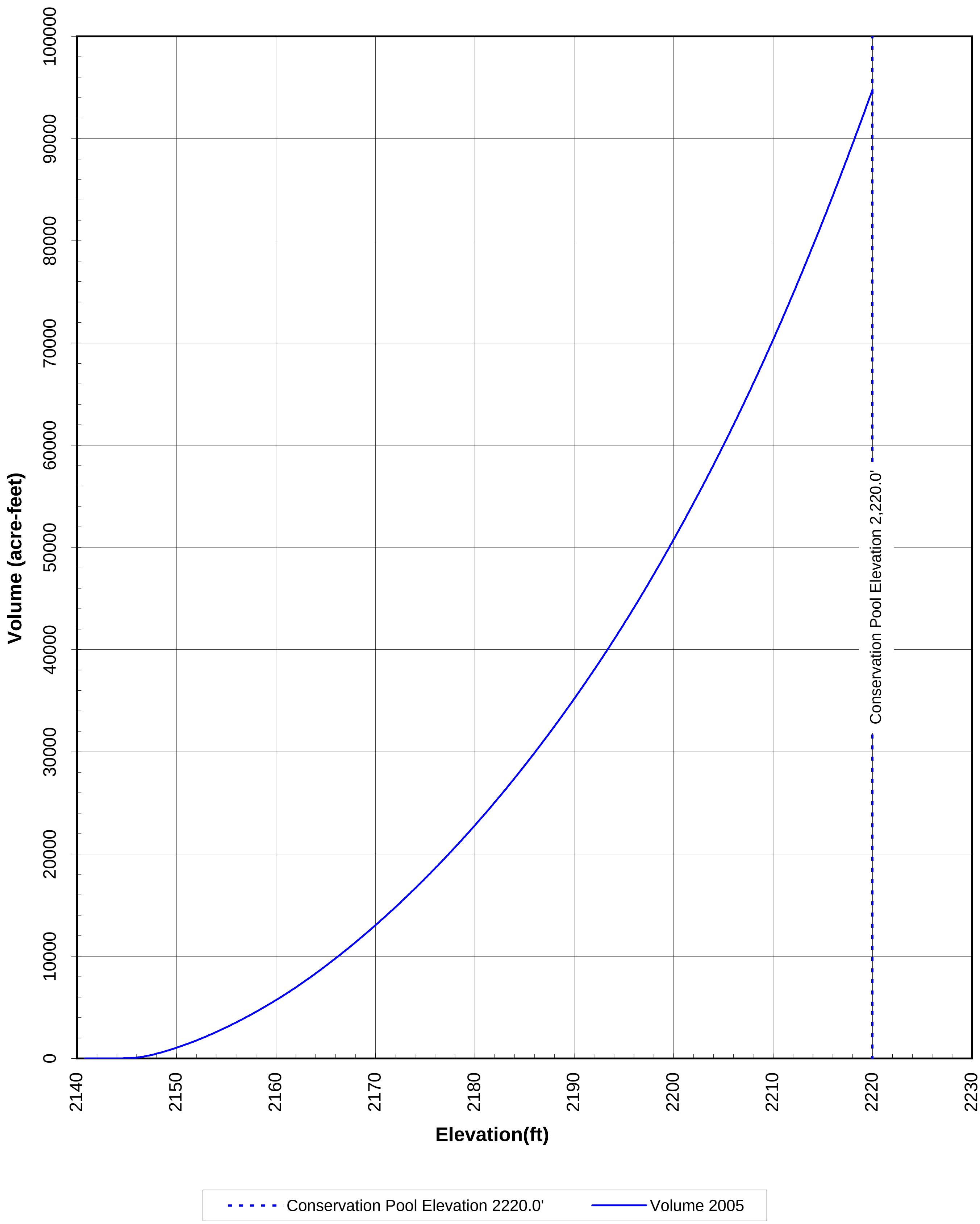
RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD — JULY 2005 SURVEY

Conservation Pool Elevation 2,220.0'

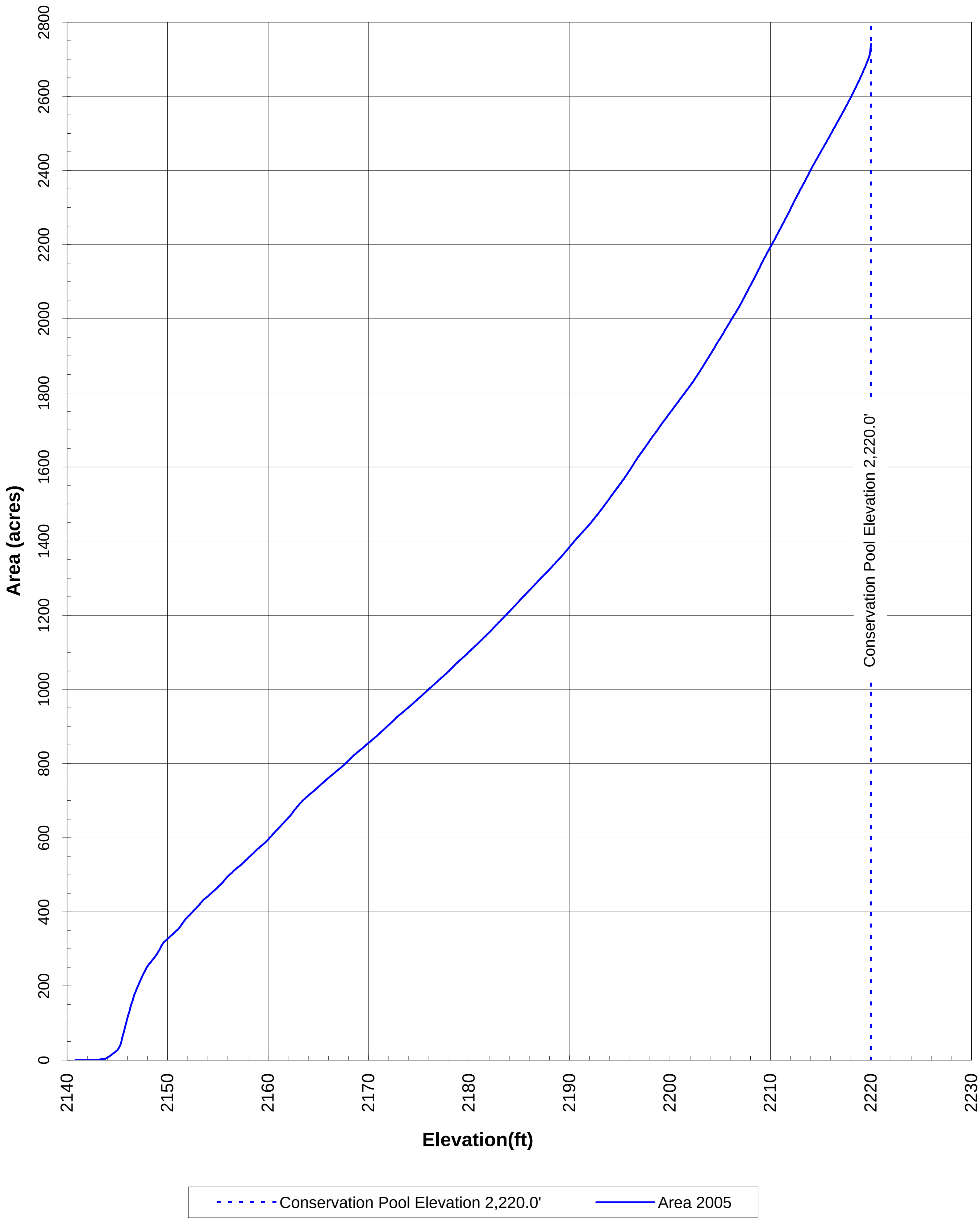
AREA IN ACRES — ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2,200	1,746	1,750	1,754	1,757	1,761	1,765	1,768	1,772	1,775	1,779
2,201	1,783	1,786	1,790	1,794	1,797	1,801	1,805	1,808	1,812	1,816
2,202	1,819	1,823	1,827	1,830	1,834	1,839	1,843	1,847	1,851	1,855
2,203	1,859	1,864	1,868	1,872	1,877	1,881	1,886	1,890	1,894	1,899
2,204	1,903	1,908	1,912	1,916	1,921	1,925	1,930	1,935	1,939	1,943
2,205	1,948	1,952	1,956	1,961	1,966	1,970	1,975	1,979	1,984	1,988
2,206	1,993	1,997	2,002	2,006	2,011	2,015	2,020	2,024	2,028	2,033
2,207	2,038	2,043	2,048	2,053	2,059	2,064	2,069	2,074	2,079	2,084
2,208	2,089	2,094	2,100	2,105	2,110	2,115	2,121	2,126	2,132	2,137
2,209	2,143	2,148	2,153	2,159	2,164	2,169	2,174	2,179	2,184	2,189
2,210	2,194	2,199	2,203	2,208	2,213	2,218	2,224	2,229	2,234	2,239
2,211	2,244	2,249	2,254	2,259	2,265	2,270	2,275	2,280	2,285	2,291
2,212	2,296	2,302	2,307	2,313	2,319	2,324	2,329	2,334	2,339	2,344
2,213	2,349	2,354	2,359	2,365	2,370	2,375	2,380	2,385	2,390	2,396
2,214	2,401	2,406	2,411	2,416	2,421	2,426	2,431	2,436	2,440	2,445
2,215	2,450	2,455	2,459	2,464	2,469	2,474	2,479	2,483	2,488	2,493
2,216	2,498	2,503	2,508	2,513	2,517	2,522	2,527	2,532	2,537	2,542
2,217	2,547	2,552	2,557	2,562	2,567	2,572	2,577	2,582	2,587	2,592
2,218	2,598	2,603	2,608	2,614	2,619	2,625	2,630	2,636	2,642	2,648
2,219	2,654	2,660	2,666	2,672	2,678	2,685	2,691	2,698	2,705	2,713
2,220	2,741									



Alan Henry Reservoir
July 2005
Prepared by: TWDB

Appendix C Elevation vs. Volume



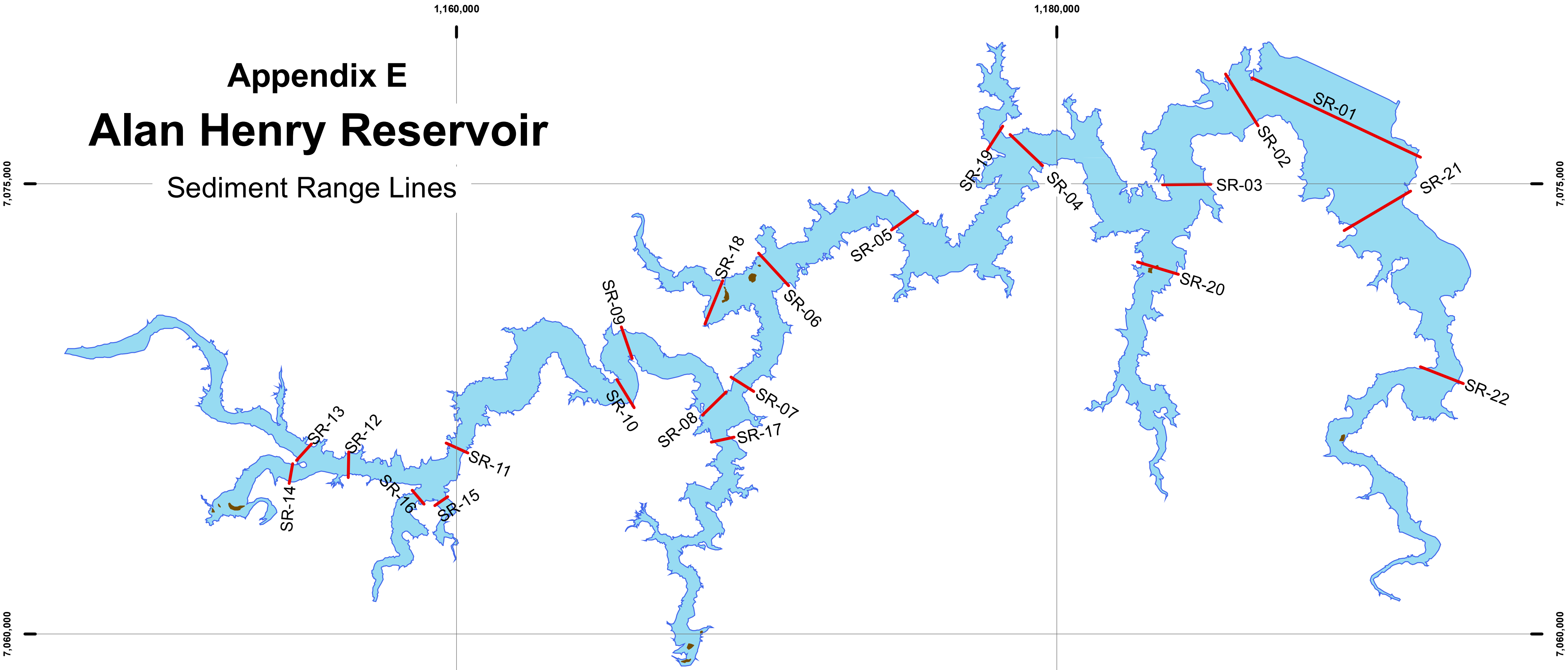
Alan Henry Reservoir
July 2005
Prepared by: TWDB

Appendix D Elevation vs. Area

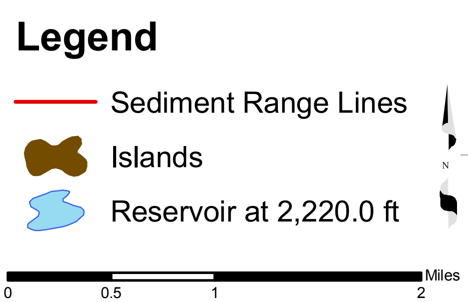
Appendix E

Alan Henry Reservoir

Sediment Range Lines

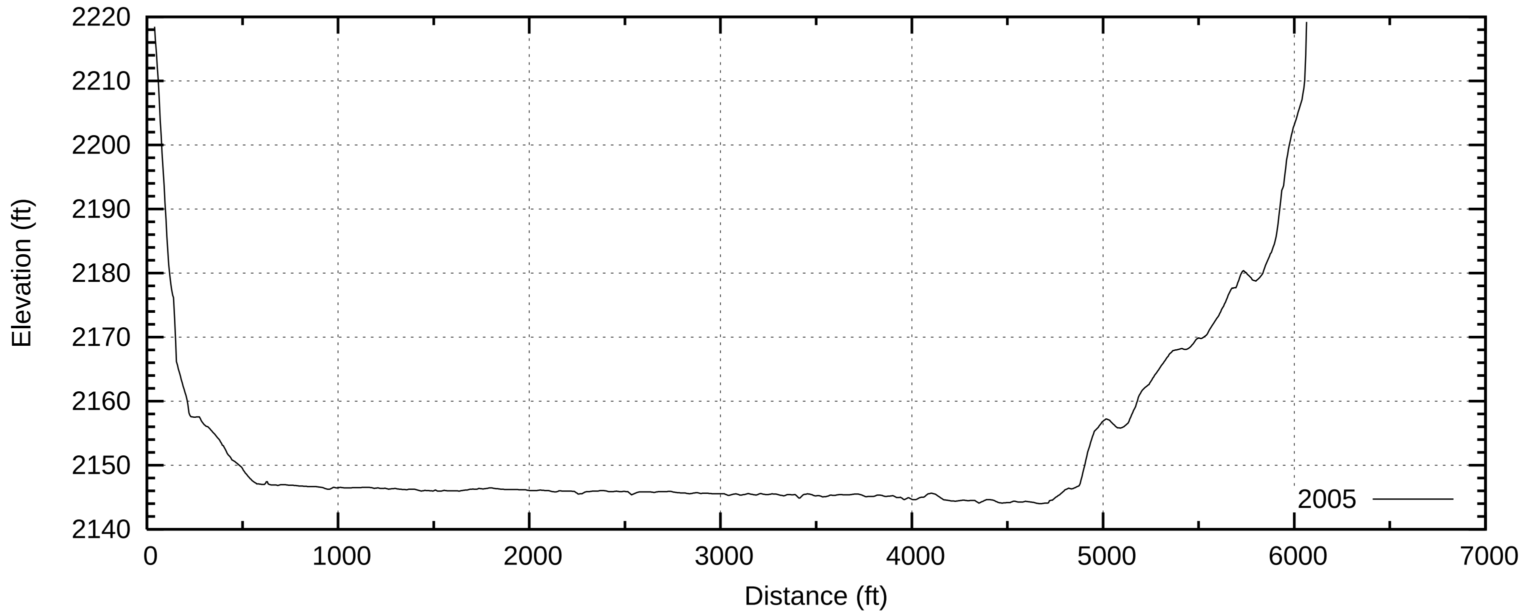


Endpoint Coordinates for Alan Henry Reservoir Sediment Range Lines est. 2006 TWDB Coordinates in NAD83 (feet) State Plane Texas North Central Zone							
Range	**L=Left R=Right**	**X**	**Y**	**Range**	**L=Left R=Right**	**X**	**Y**
SR-1	L	1,186,496.60691	7,078,530.17418	**SR-12**	L	1,156,408.49789	7,066,080.11369
	R	1,192,103.31509	7,075,896.94448		R	1,156,390.34971	7,065,227.14902
SR-2	L	1,185,621.48336	7,078,657.30517	**SR-13**	R	1,155,164.26962	7,066,335.75008
	R	1,186,696.31816	7,076,935.25801		L	1,154,671.45741	7,065,797.52053
SR-3	L	1,183,518.04319	7,074,970.50622	**SR-14**	L	1,154,539.33615	7,065,676.75112
	R	1,185,124.51672	7,074,993.62095		R	1,154,428.86340	7,065,015.72562
SR-4	L	1,178,444.36062	7,076,646.32392	**SR-15**	L	1,159,281.89041	7,064,288.26294
	R	1,179,519.19542	7,075,617.71858		R	1,159,714.82979	7,064,580.06789
SR-5	L	1,175,362.45263	7,074,088.81046	**SR-16**	L	1,158,528.53774	7,064,797.49119
	R	1,174,489.71679	7,073,461.61498		R	1,158,919.51824	7,064,328.31458
SR-6	L	1,170,073.15921	7,072,694.25225	**SR-17**	L	1,168,491.38240	7,066,407.57997
	R	1,171,057.09690	7,071,611.92078		R	1,169,249.75069	7,066,566.04499
SR-7	L	1,169,145.71202	7,068,555.06060	**SR-18**	L	1,168,864.35343	7,071,773.36783
	R	1,169,903.46899	7,068,093.87496		R	1,168,277.21472	7,070,341.24639
SR-8	L	1,168,990.43727	7,068,070.76023	**SR-19**	L	1,178,201.82458	7,076,913.63834
	R	1,168,204.53656	7,067,296.41686		R	1,177,689.70452	7,076,139.76802
SR-9	L	1,165,500.11351	7,070,231.98719	**SR-20**	L	1,182,689.56493	7,072,393.14076
	R	1,165,846.83441	7,069,191.82448		R	1,184,048.14408	7,071,988.36598
SR-10	L	1,165,349.02440	7,068,477.07963	**SR-21**	L	1,189,574.39519	7,073,446.47950
	R	1,165,922.45705	7,067,548.46109		R	1,191,788.28621	7,074,753.47540
SR-11	L	1,159,664.19158	7,066,359.72380	**SR-22**	L	1,192,107.48690	7,068,904.11188
	R	1,160,375.43798	7,066,040.02213		R	1,193,541.66260	7,068,353.95268

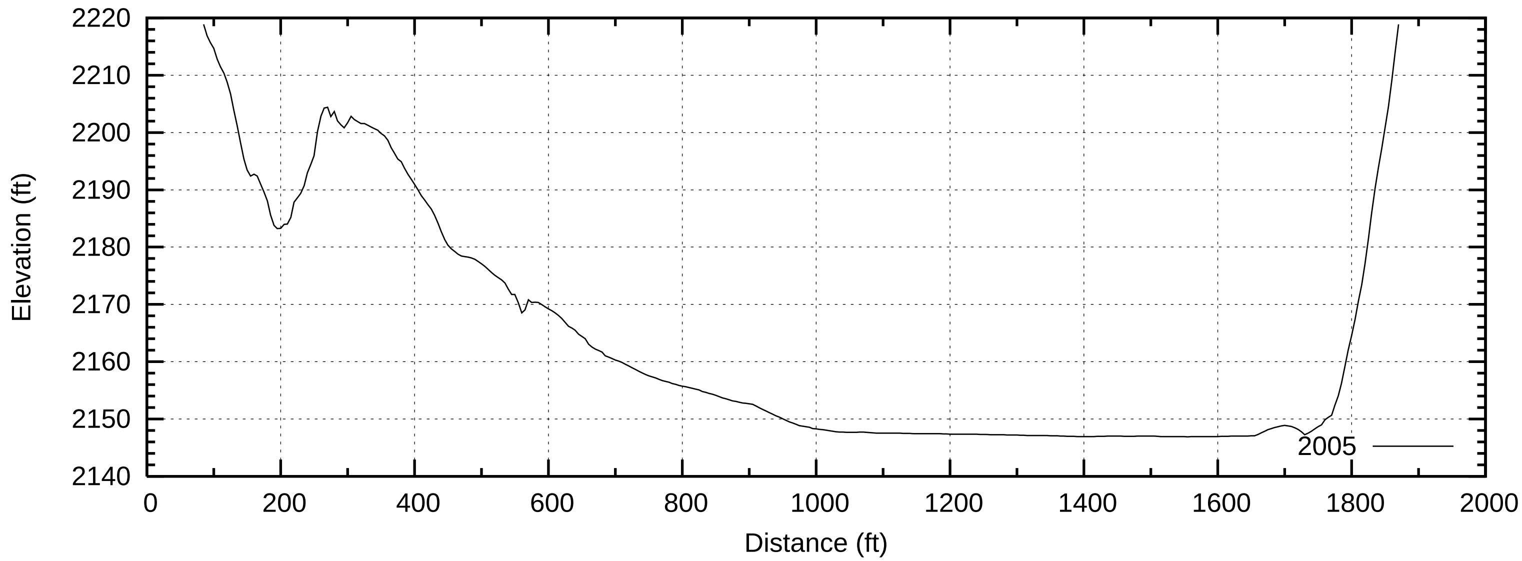


Alan Henry Reservoir

Range Line SR01

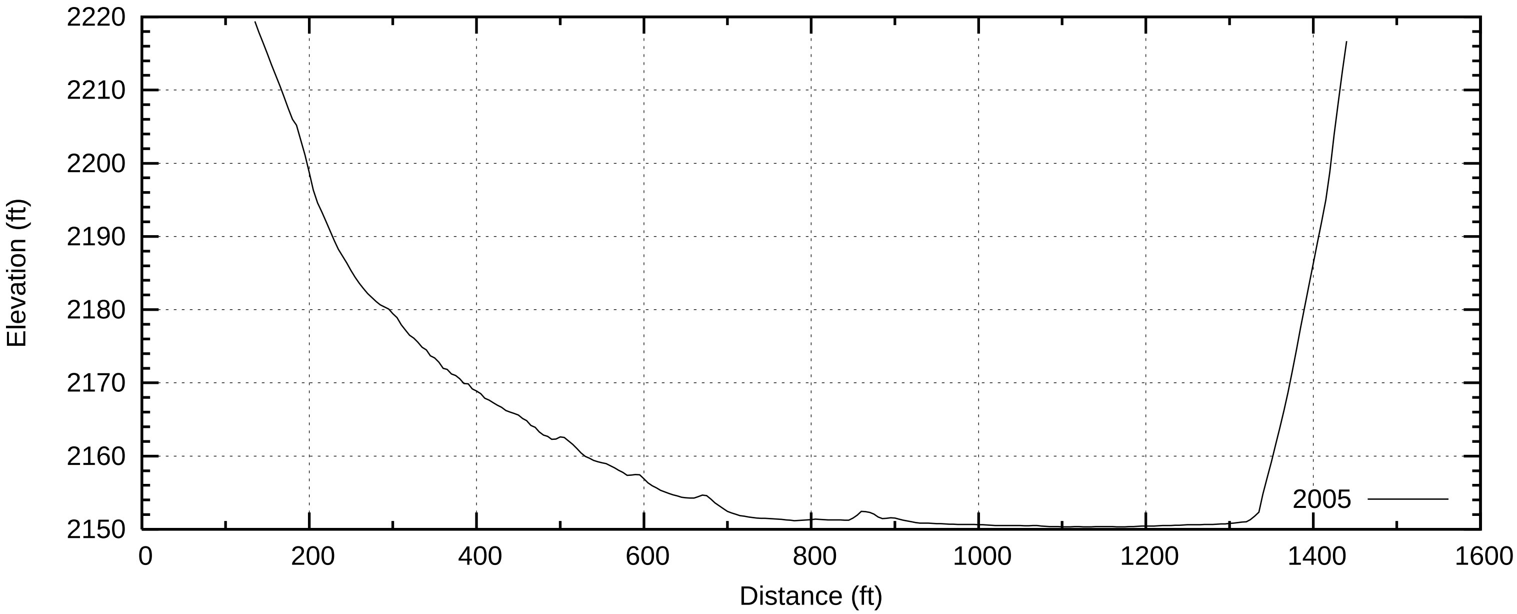


Range Line SR02

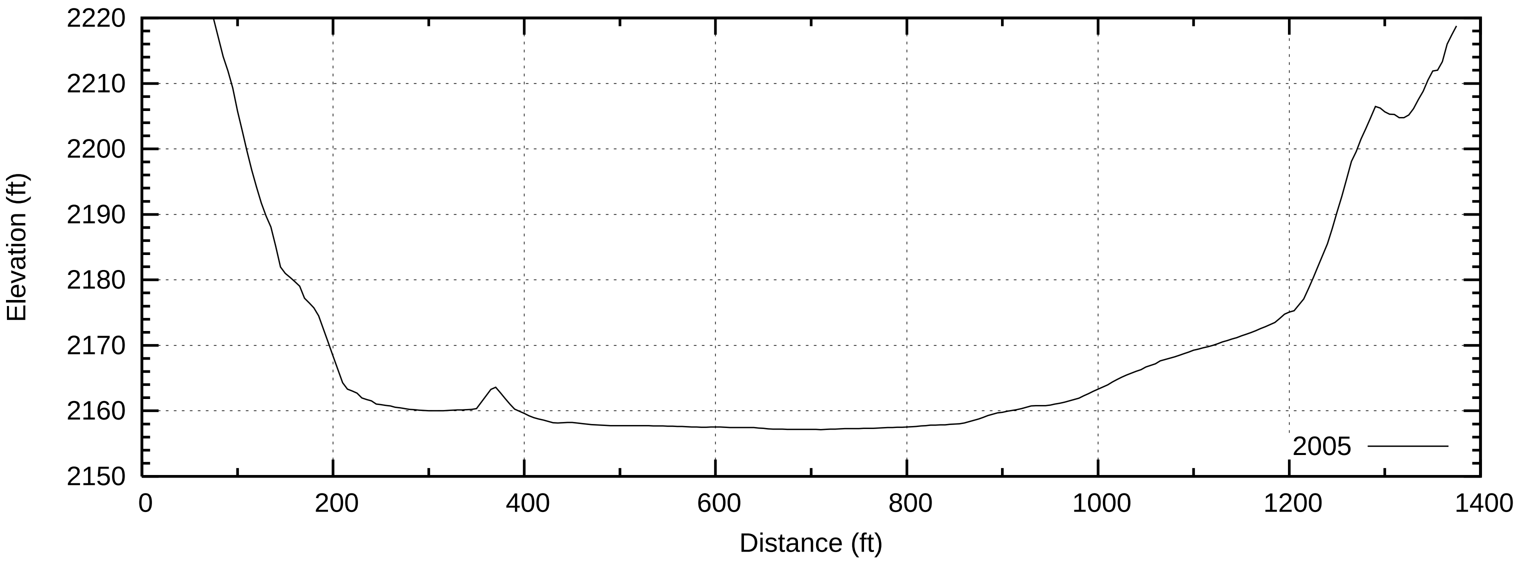


Alan Henry Reservoir

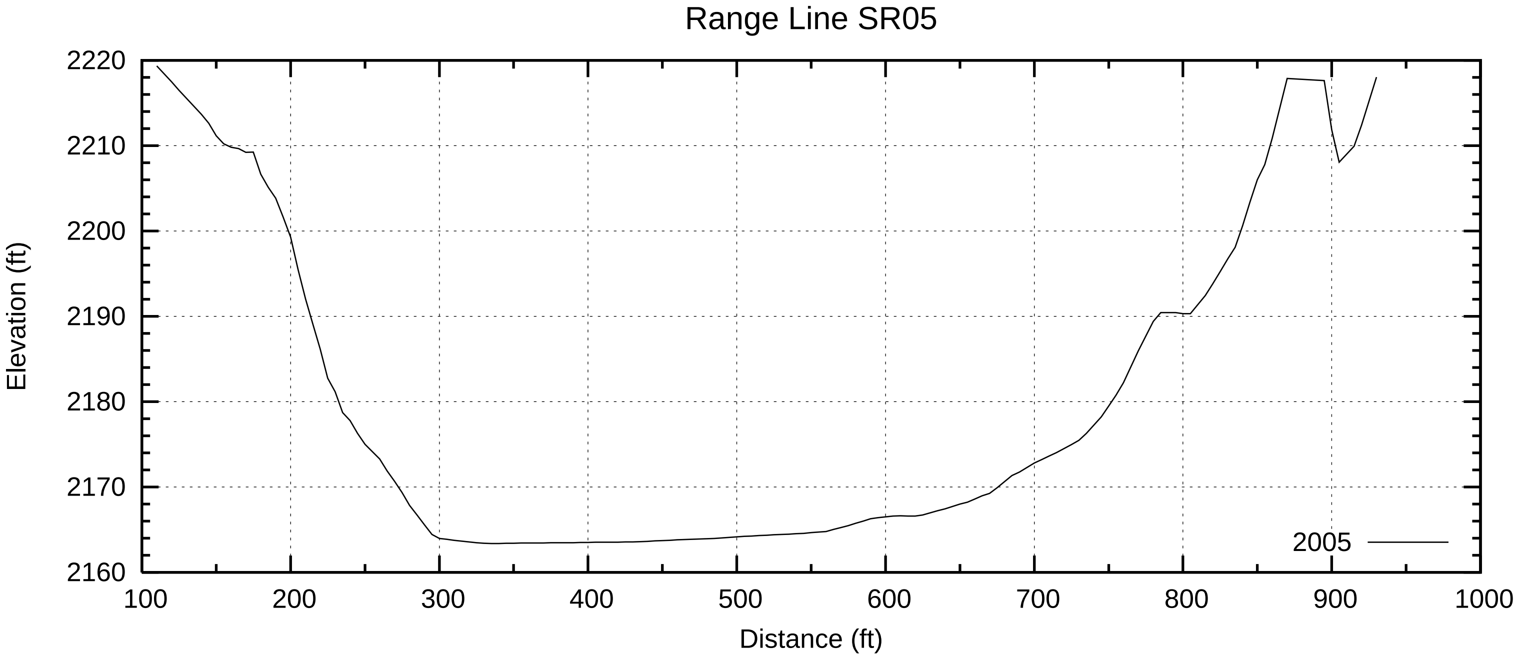
Range Line SR03

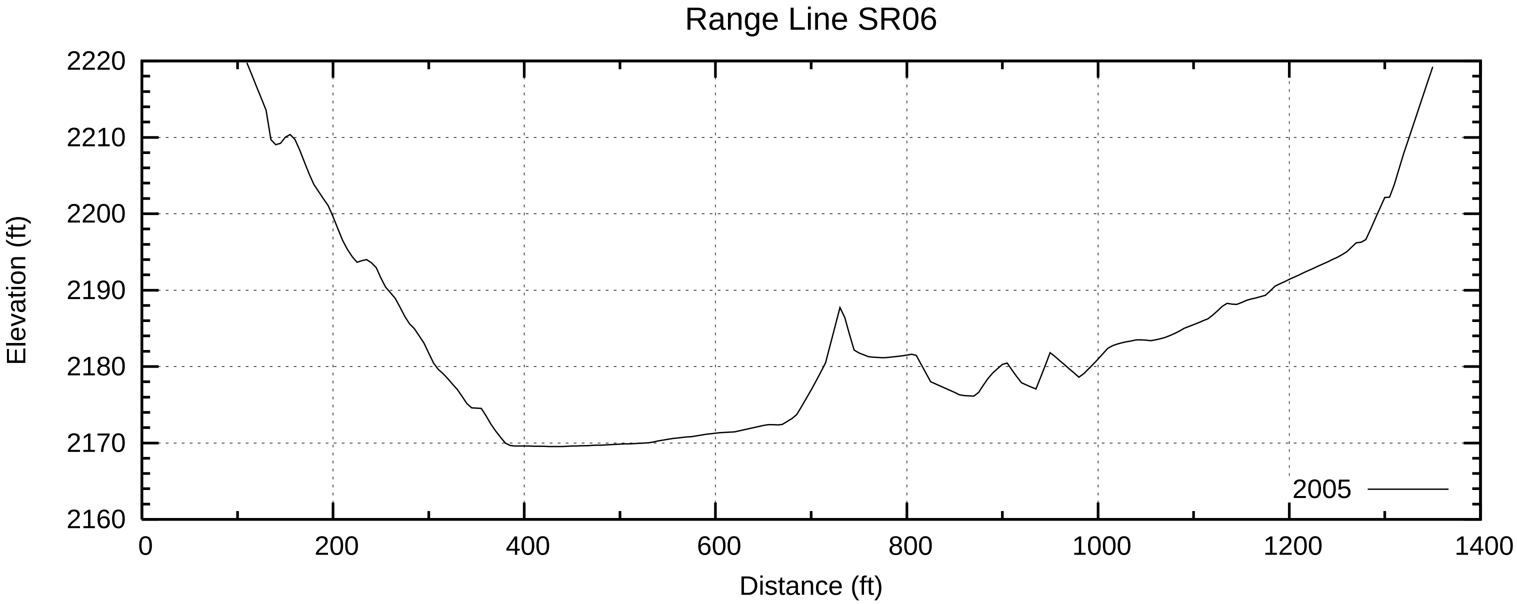


Range Line SR04



Alan Henry Reservoir

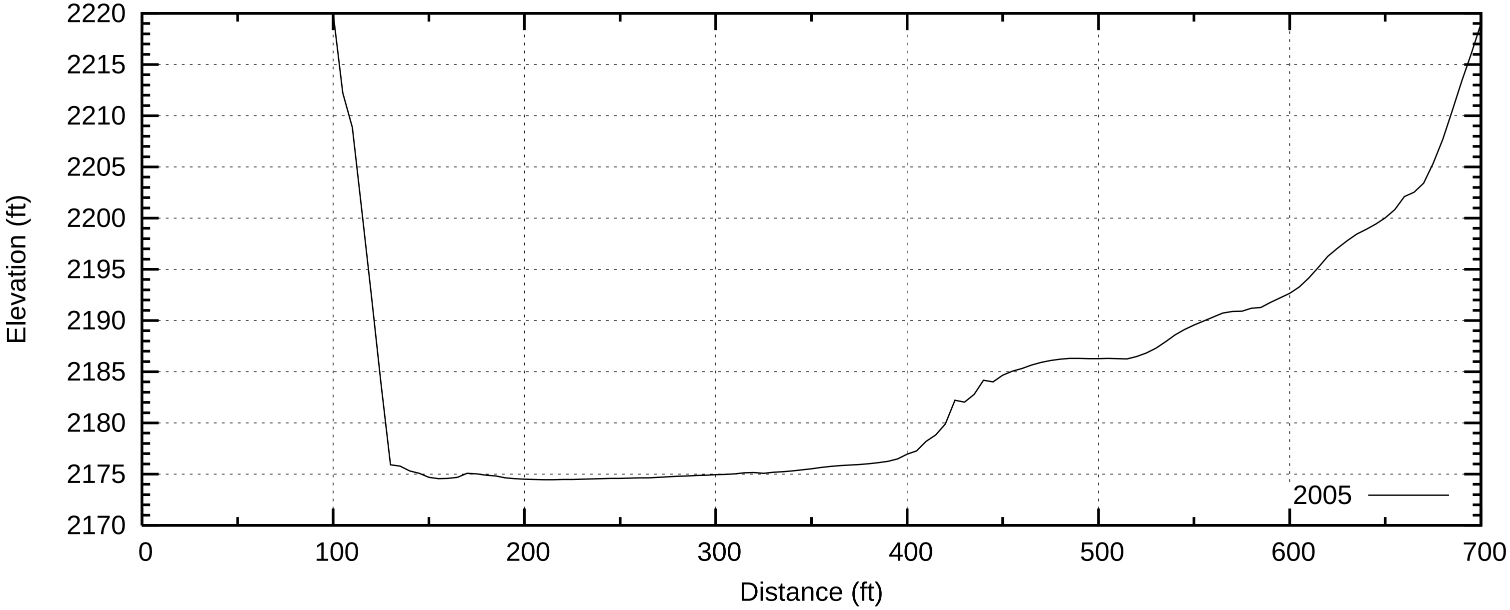




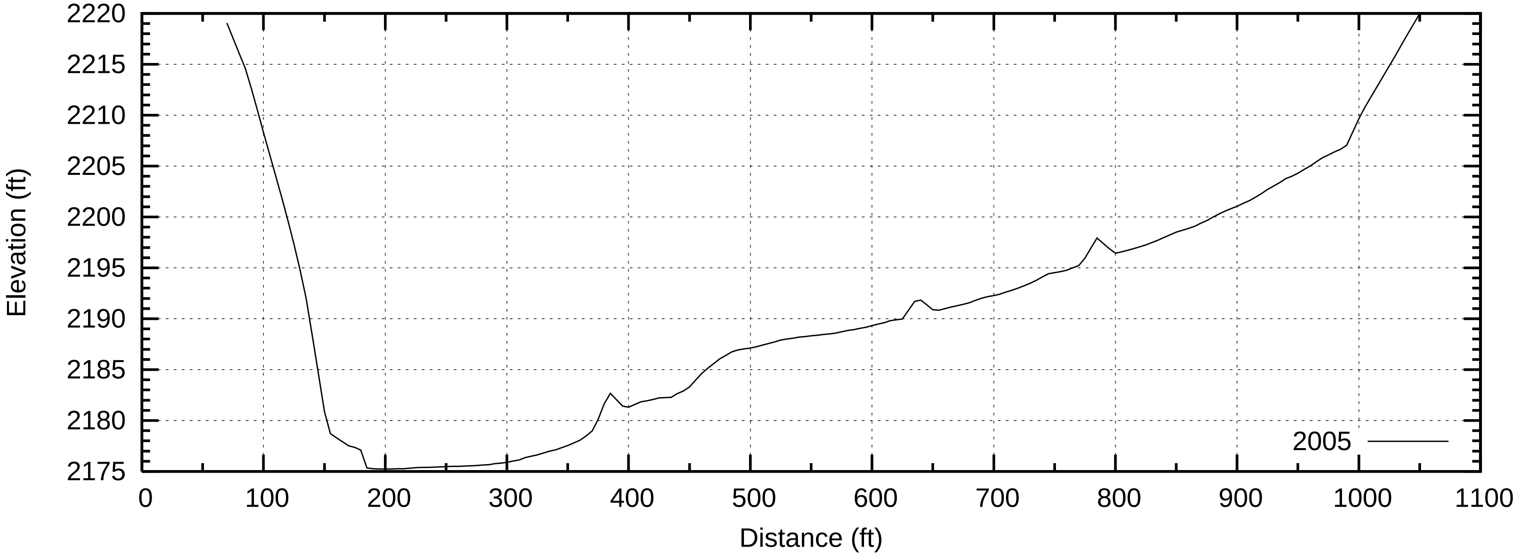
Appendix E

Alan Henry Reservoir

Range Line SR07

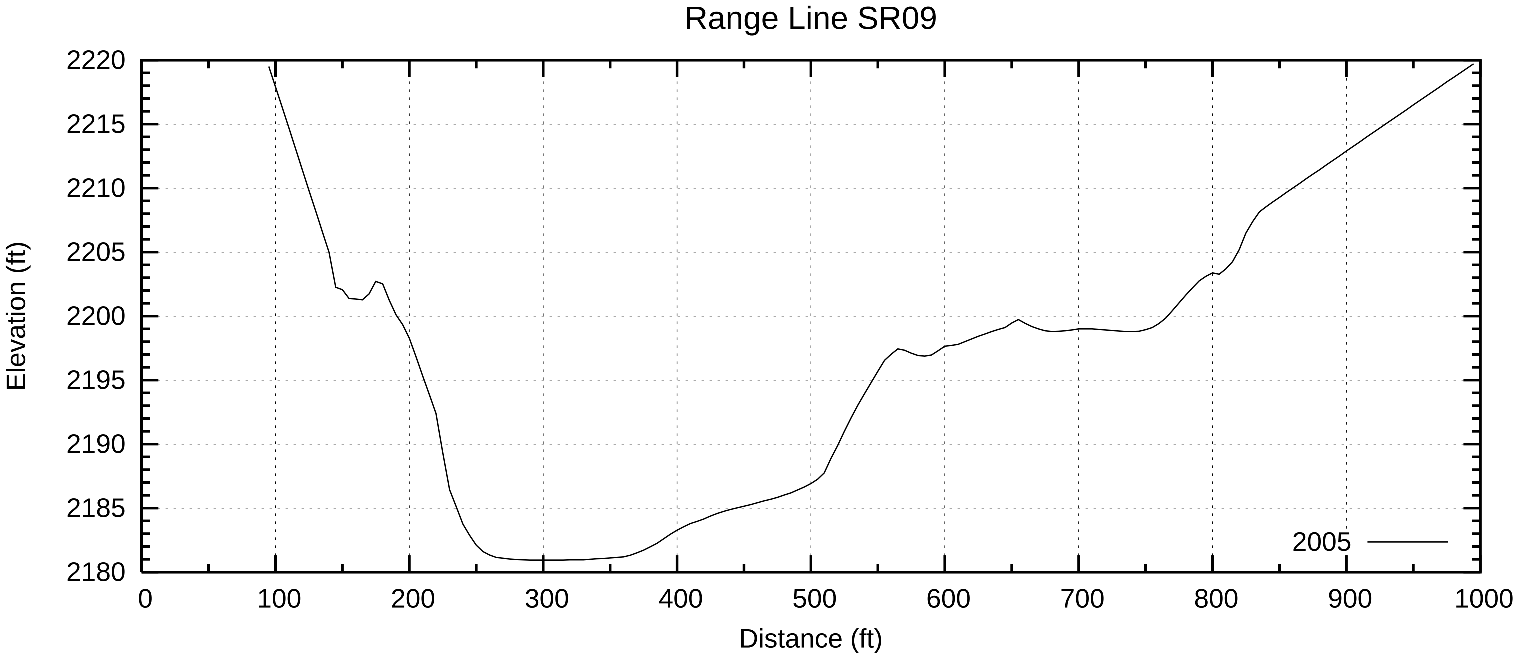


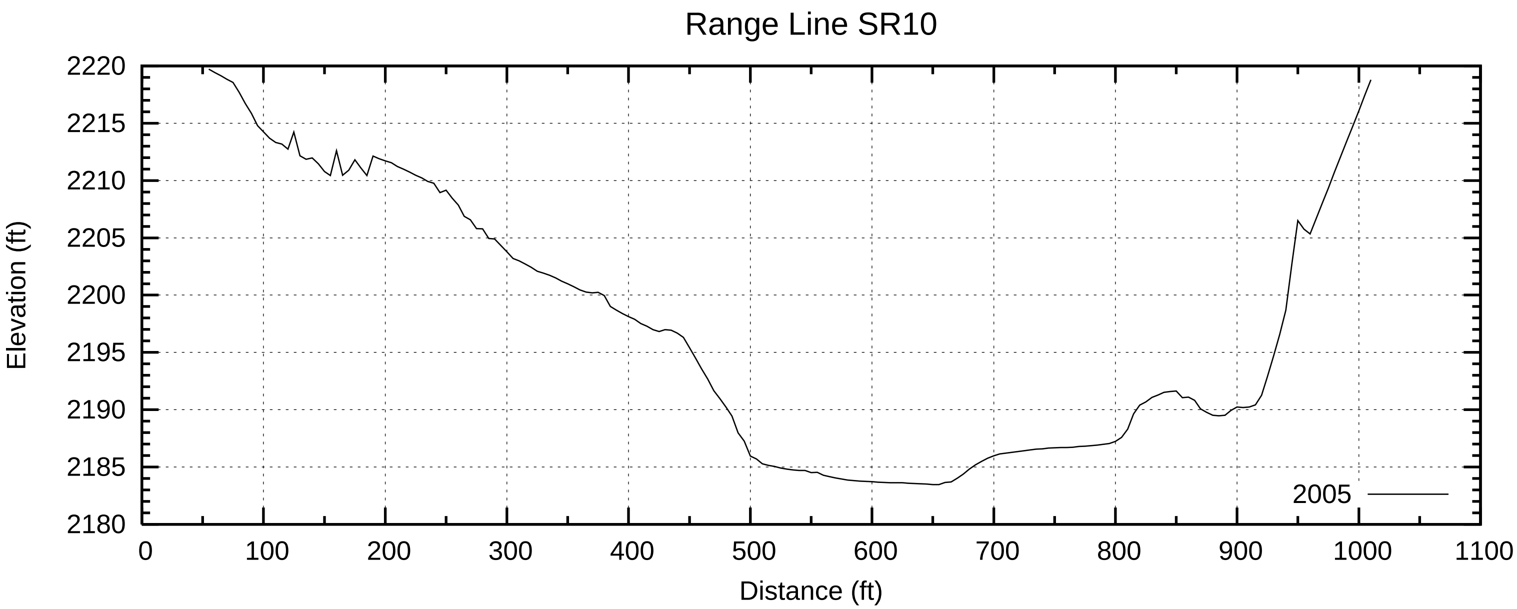
Range Line SR08



Appendix E

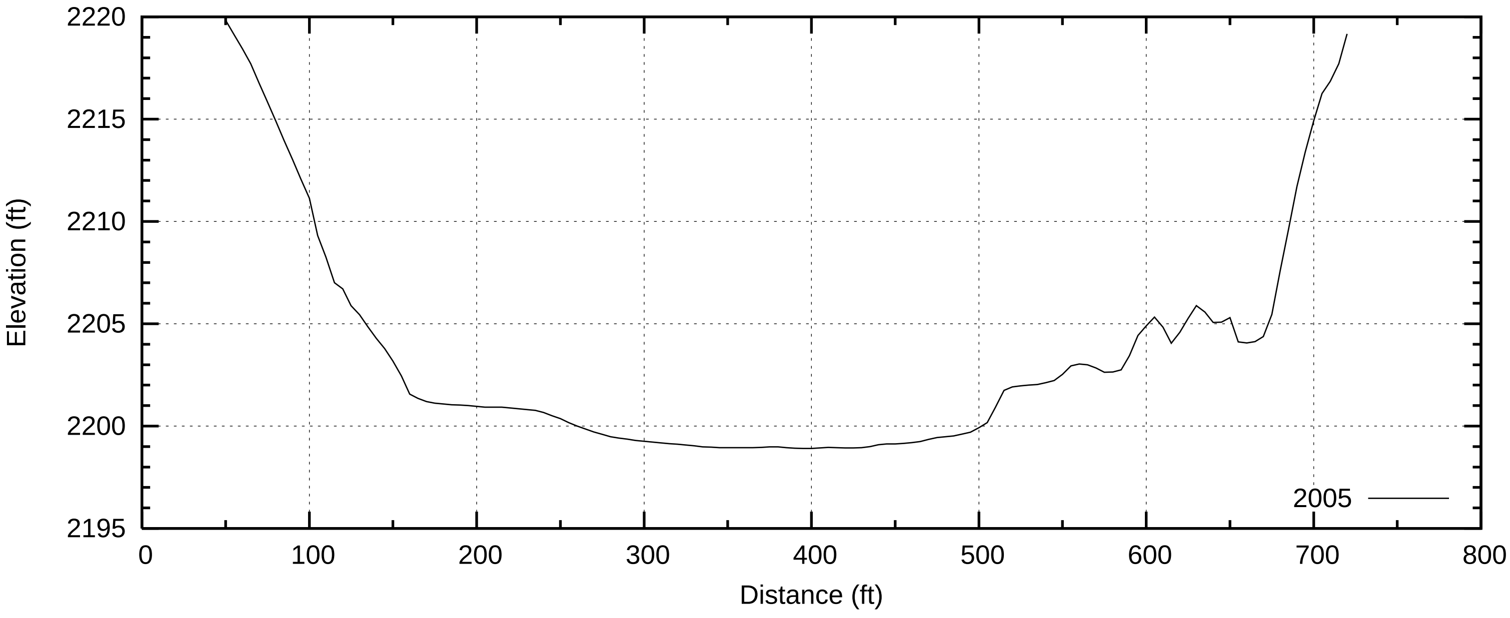
Alan Henry Reservoir



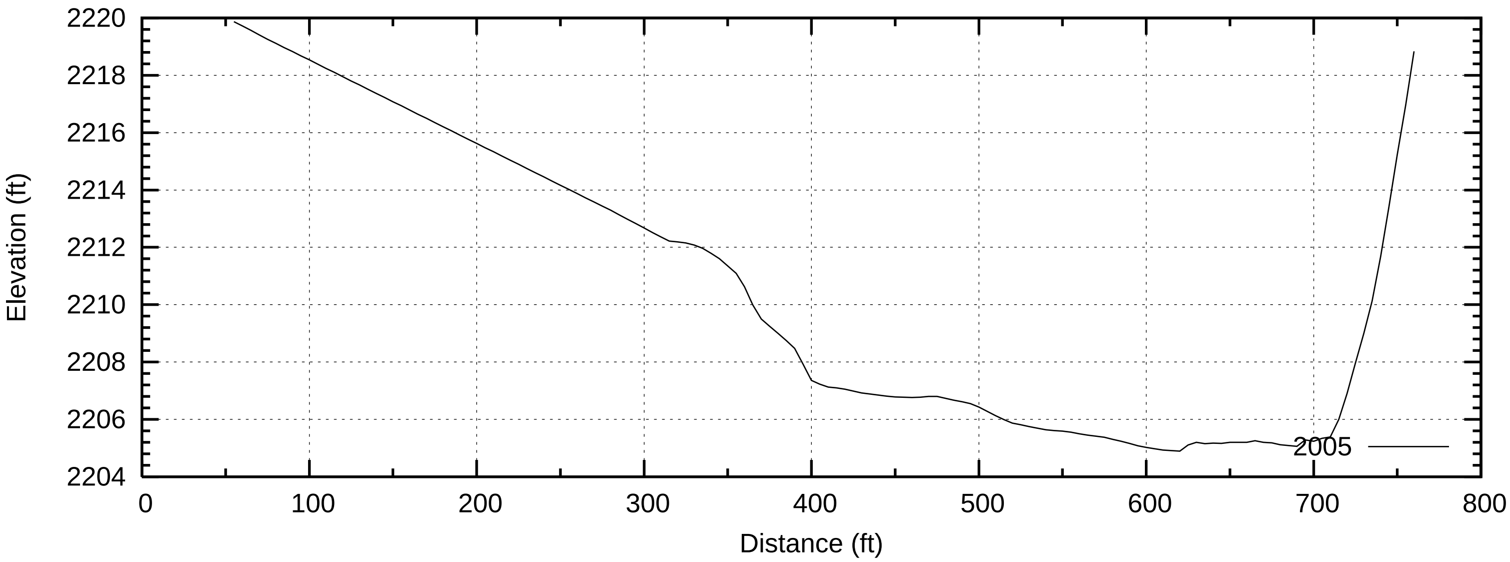


Alan Henry Reservoir

Range Line SR11

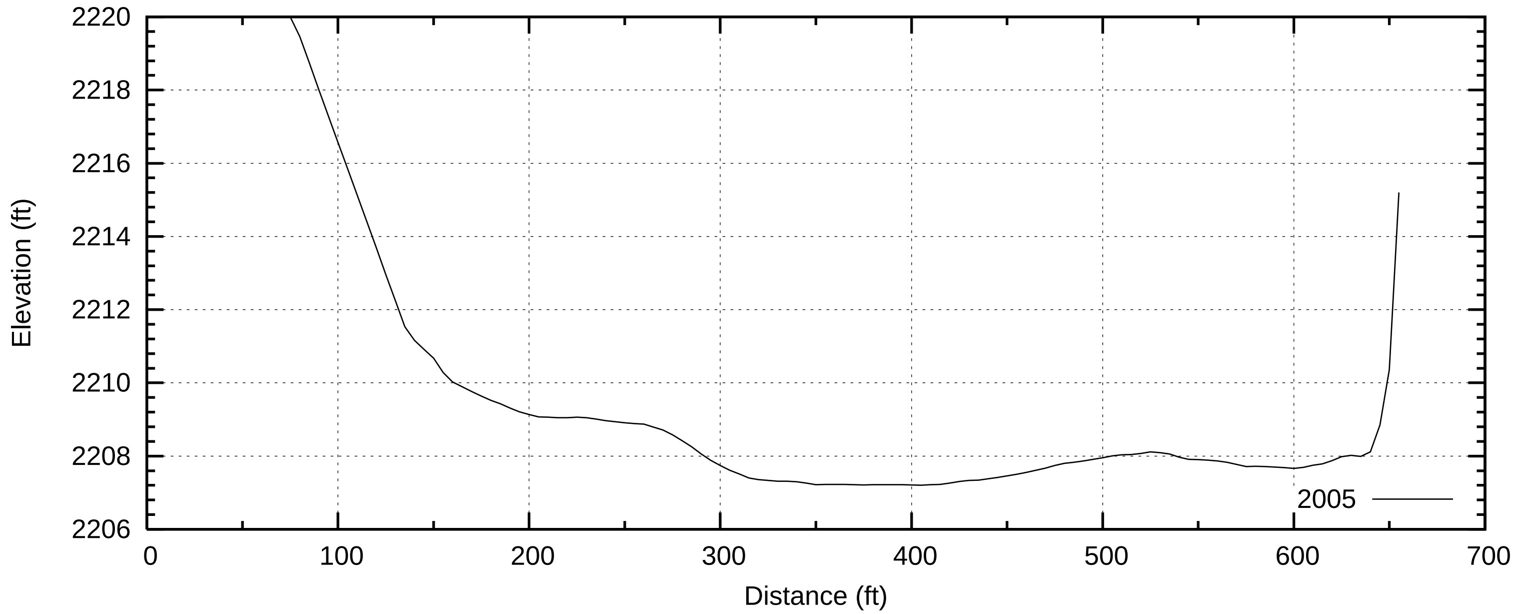


Range Line SR12

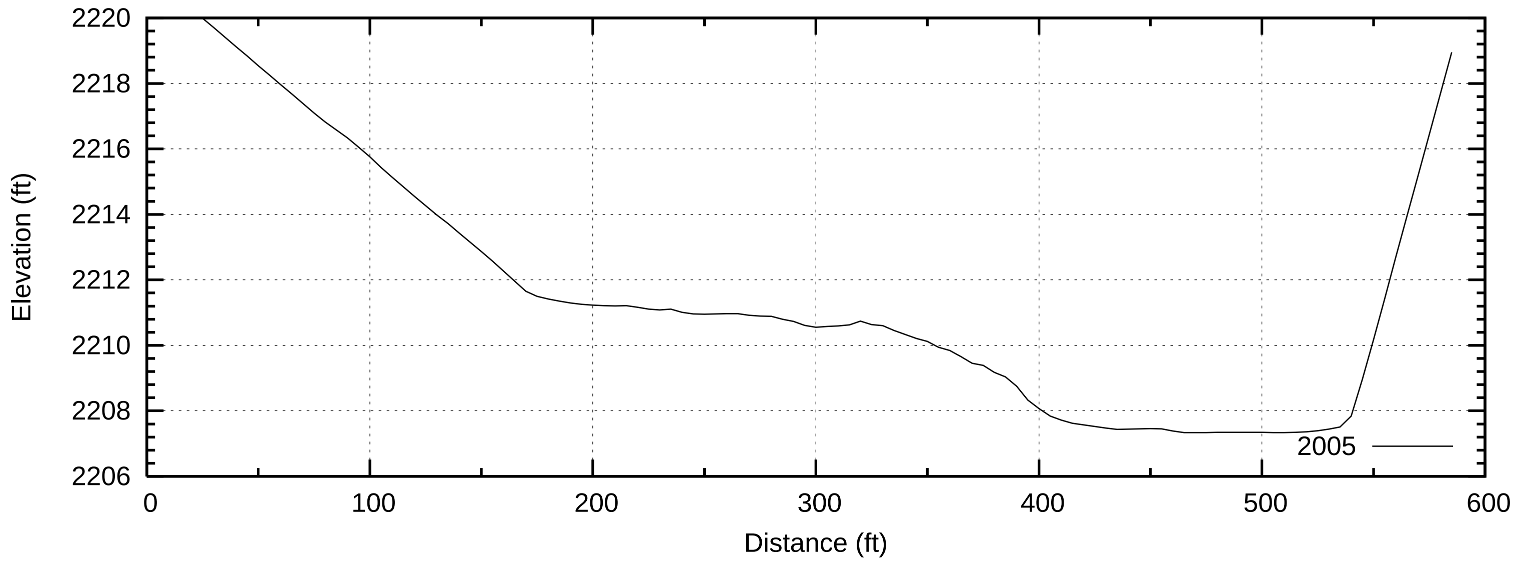


Alan Henry Reservoir

Range Line SR13



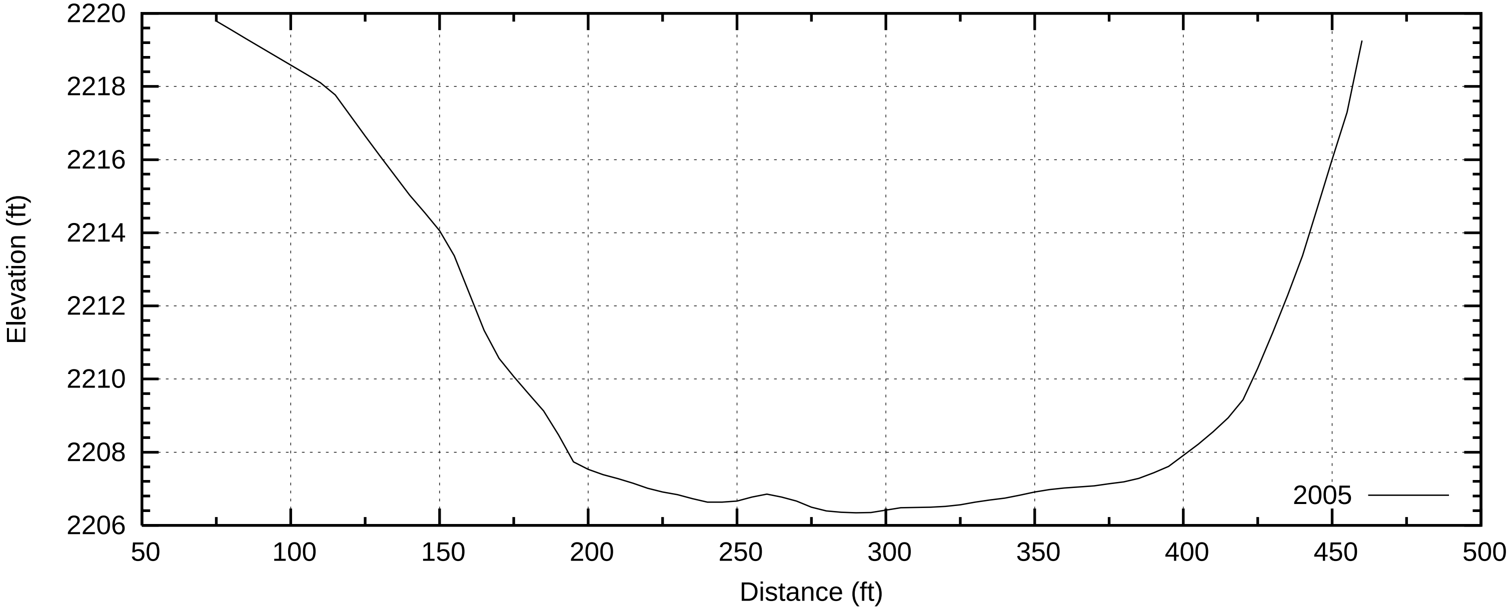
Range Line SR14



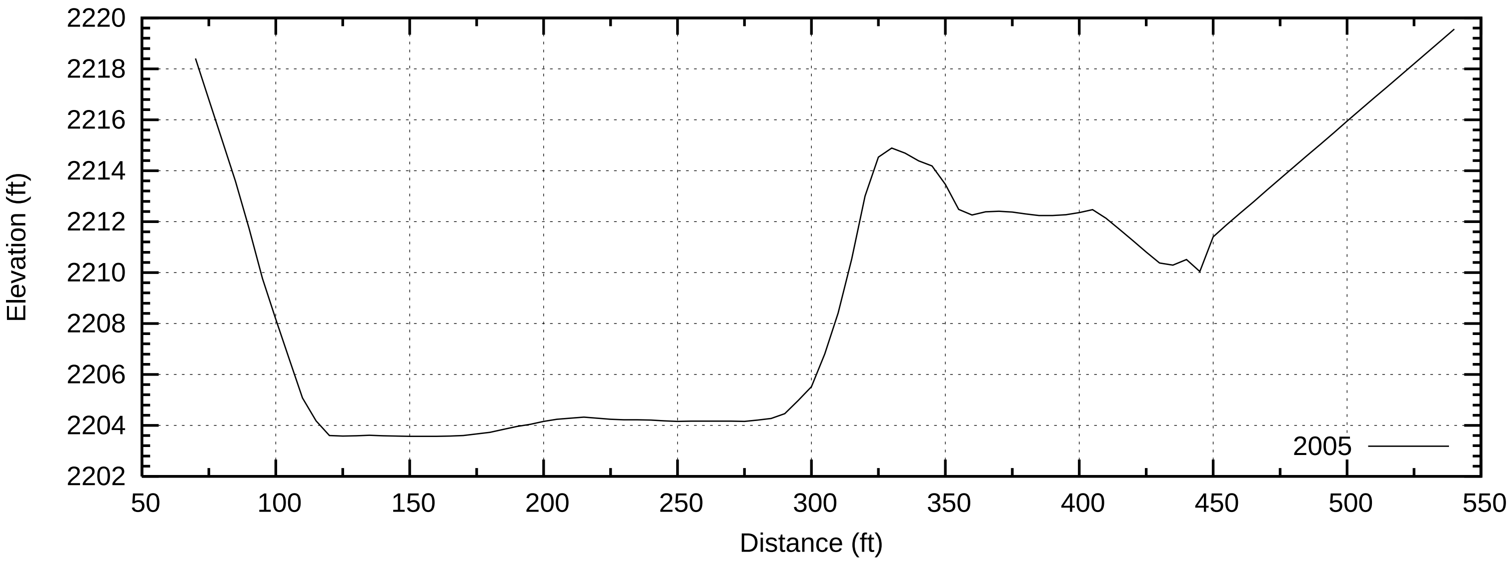
Appendix E

Alan Henry Reservoir

Range Line SR15



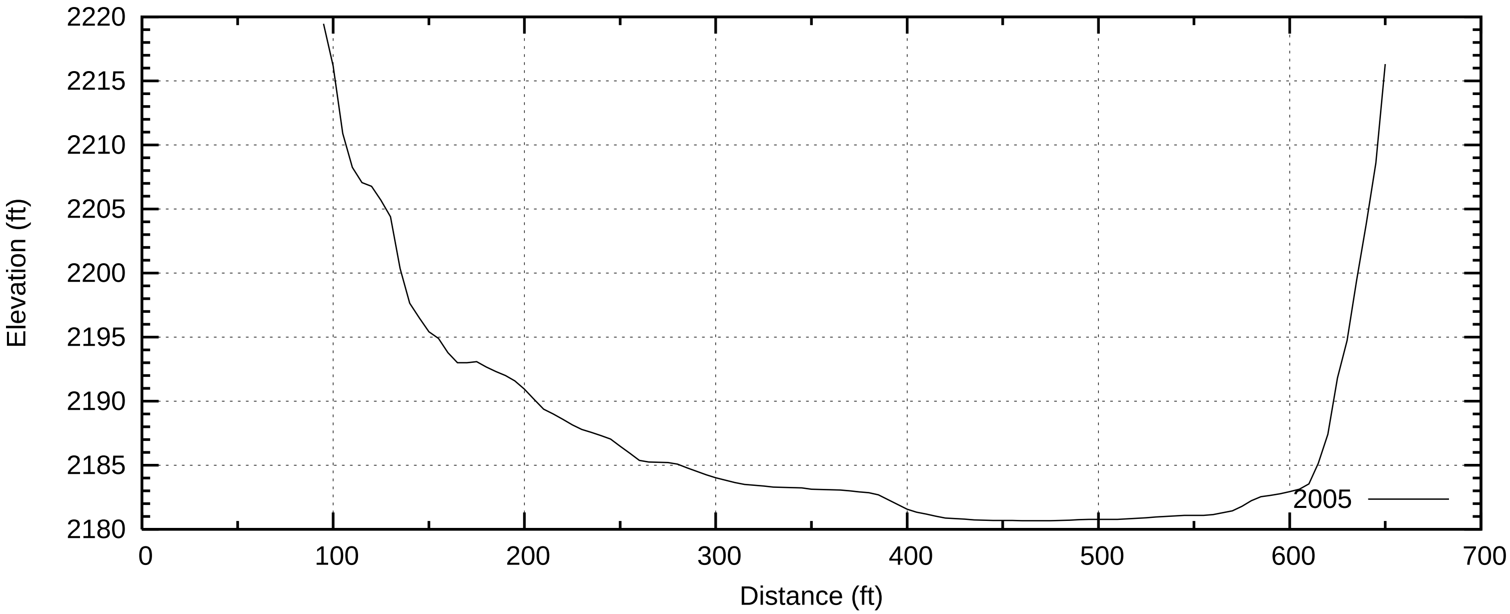
Range Line SR16



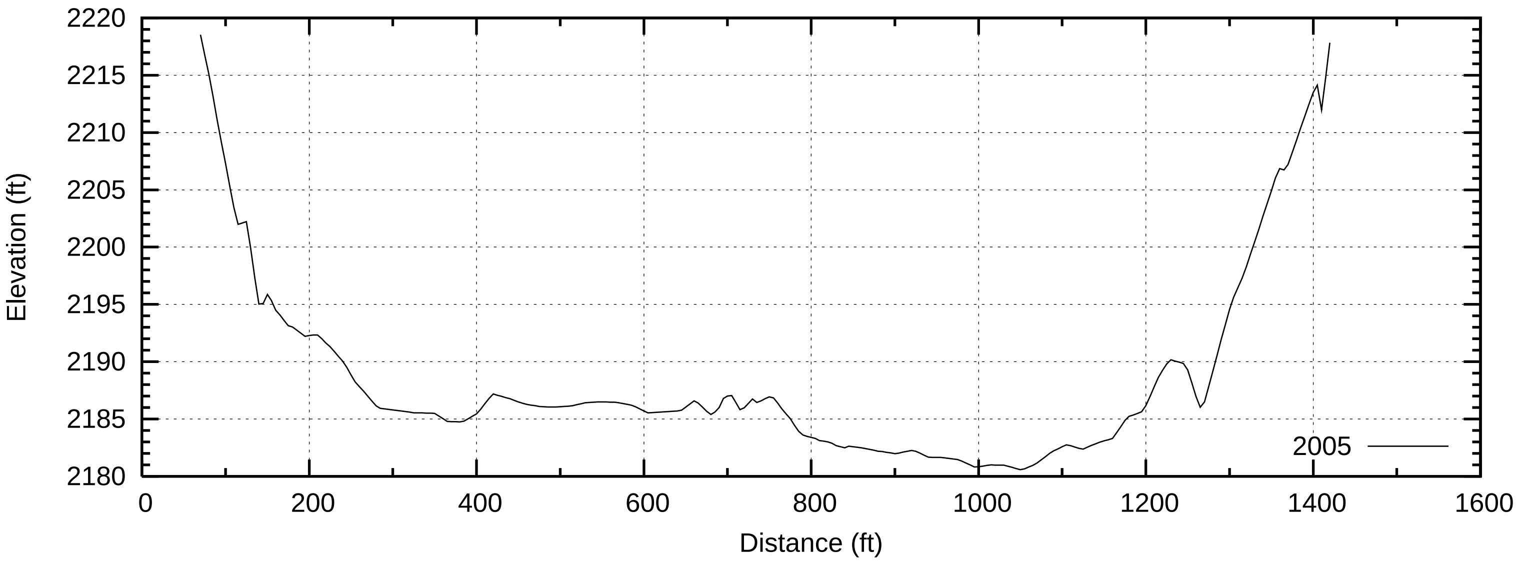
Appendix E

Alan Henry Reservoir

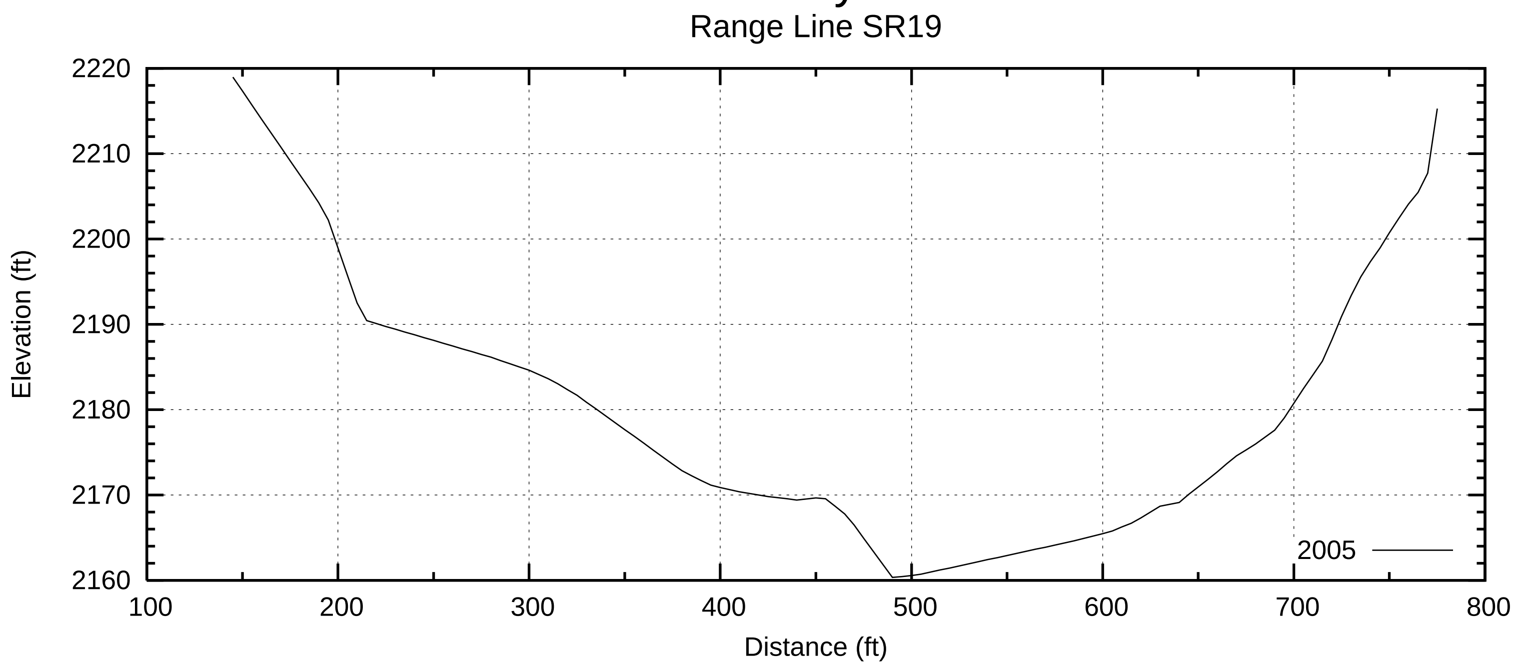
Range Line SR17

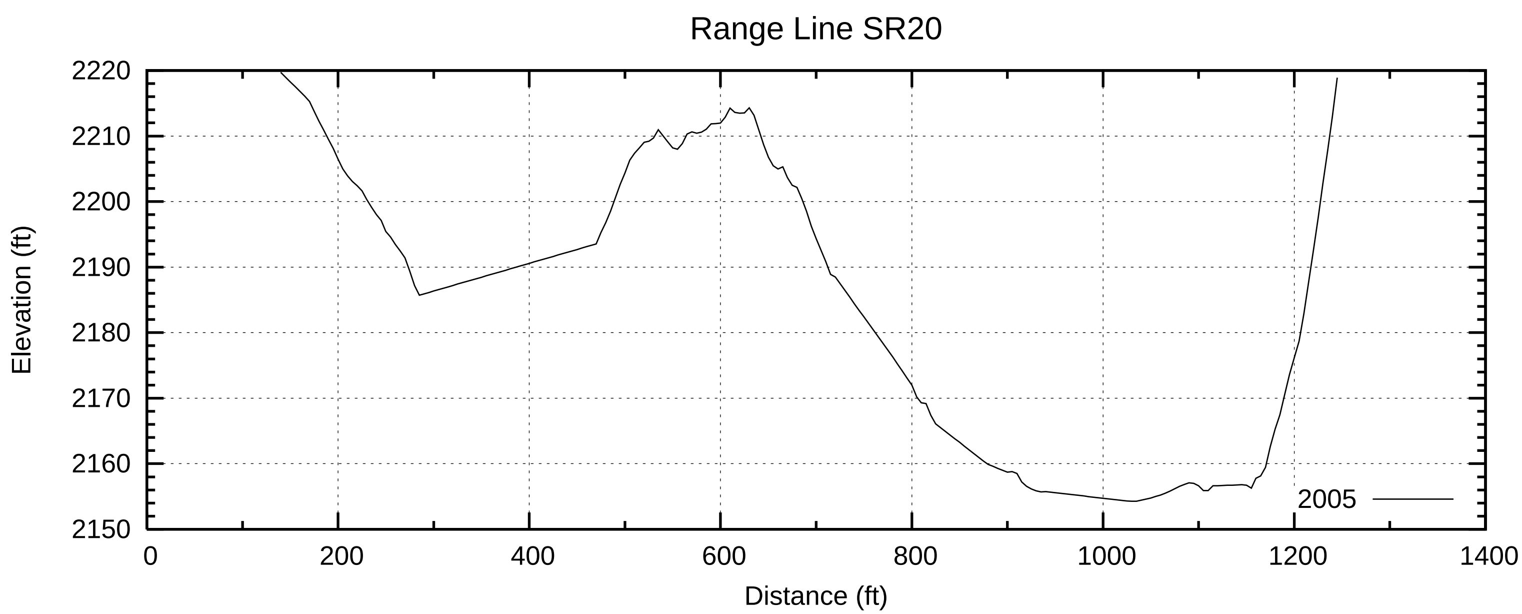


Range Line SR18



Alan Henry Reservoir

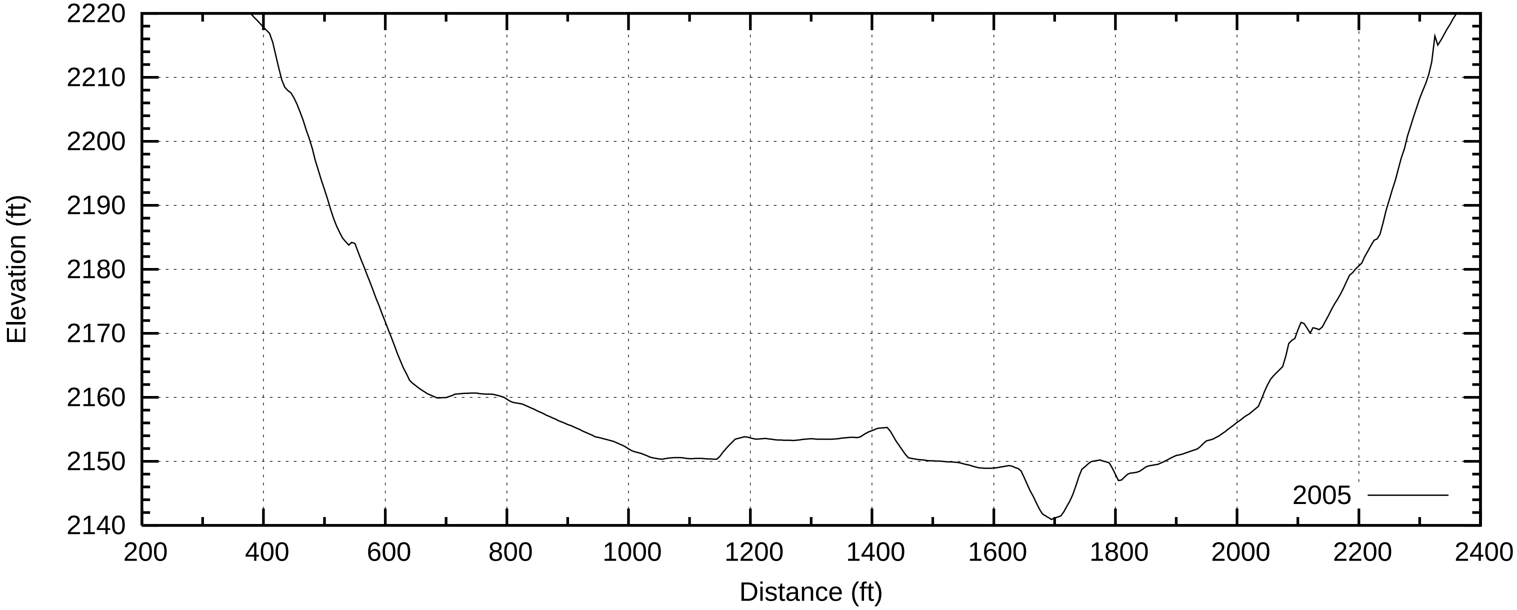




Appendix E

Alan Henry Reservoir

Range Line SR21



Range Line SR22

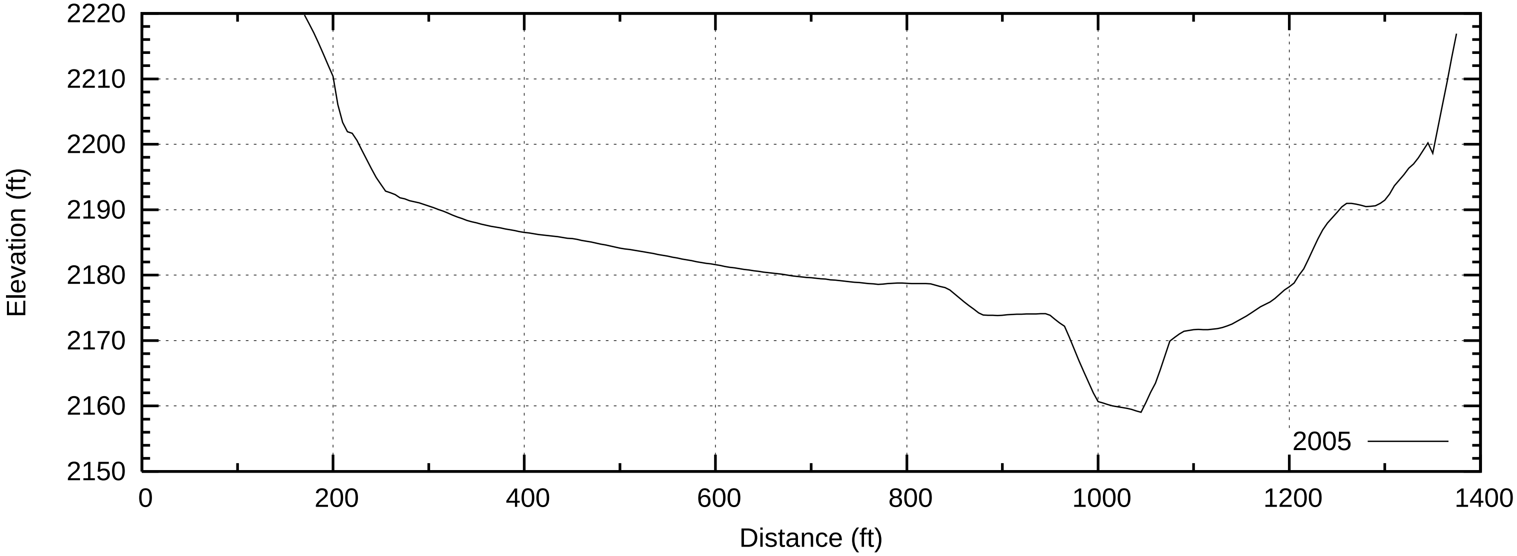


Figure 6

CONTOURS

2,150

2,160

2,170

2,180

2,190

2,200

2,210

2,220

Islands

Lake Boundary Elevation: 2,220.0 ft Conservation Pool Elevation

NAD83
State Plane
Texas North Central Zone

Garza and Kent Counties

This map is the product of a suvey conducted by the Texas Water Development Board's Hydrographic Survey Program to determine the capacity of Alan Henry Reservoir. The Texas Water Development Board makes no representation or assumes any liability.

ALAN HENRY RESERVOIR

10' - Contour Map

Prepared by: TEXAS WATER DEVELOPMENT BOARD July 2005 Survey